Logic in Reality

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FOREWORD

This book is both difficult and rewarding, affording a new perspective on logic and reality, basically seen in terms of change and stability, being and becoming. Most importantly it exemplifies a mode of doing philosophy of science that seems a welcome departure from the traditional focus on purely analytic arguments. The author approaches ontology, metaphysics, and logic as having offered a number of ways of constructing the description of reality, and aims at deepening their relationships in a new way. Going beyond the mere abstract and formal aspects of logical analysis, he offers a new architecture of logic that sees it as applied not only to the "reasoning processes" belonging to the first disciplinary group – ontology – but also directly concerned with entities, events, and phenomena studied by the second one – metaphysics. It is the task of the book to elaborate such a constructive logic, both by offering a logical view of the structure of the reality in general and by proffering a wealth of models able to encompass its implications for science.

In turning from the merely formal to the constructive account of logic Brenner overcomes the limitation of logic to linguistic concepts so that it can be not only a logic "of" reality but also "in" that reality which is constitutively characterized by a number of fundamental dualities (observer and observed, self and not-self, internal and external, etc.): indeed the analysis of "contradiction" plays a central role in the book. In this perspective logic is also rooted in physical reality, as conceived by modern physics: "Accordingly, my logic is not only a logic about theories of reality as conceptualized in philosophy and metaphysics. It is also a scientific or quasi-scientific concept, to the extent that, like symmetry for example, its principles are a reflection of the underlying physical structure of the universe that is independent of human experience that nevertheless derives from it''.

Brenner has a great deal to say about aspects of this logic of/in reality that relate it to standard logics as well as other disciplines: i) the centrality of axiomatics and the importance of building open and uninterpreted formal systems potentially able to account for real processes entities, properties, and dynamisms (chapters 1 and 2): ii) the role of a rigorous interpreted formal ontology as a "process ontology" (chapter 3), and iii) its relationship to the quantum-field equivalent of energy (chapter 4). Chapters 6, 7, and 8 reconsider, in term of both "logic in reality" and "new energy ontology", the problems of *Gestalt* and catastrophe theory, metaphysics (also the problem of naturalization of phenomenology is fruitfully taken into account), and physics, where a new relation between logic and space-time is suggested. To take another example, a concept of "relative identity" is presented to convey those features that classical identity cannot account for in the case of quantum entities. But more important for the reader is the structure of his overall argumentation strategy. Implicit in Brenner's work is an interdisciplinary commitment very rare in the current research in logic and epistemology: logic is grounded in many ways, but most essentially, for Brenner, it derives its rational basis from its participation in the most important achievements of current culture and science. It is this insight which drives the remainder of the text, which includes numerous examples of successful logical modelling; and within the context of this successful practice, the author expands the traditional logical power of logic in a number of significant ways. He spends considerable time on the analysis of many non-classical logics, abduction, quantum and relativistic physics, Hegelian philosophy, non-standard analysis and traditionally debated philosophical problems such as the analytic/synthetic distinction, determinism/indeterminism, and the concepts of "causality" and of "scientific explanation".

Brenner's text is extremely complex; it is full of information about the widest range of issues relevant to his concerns. He has complex and critical presentations of various areas of current fields of philosophical, cognitive, and scientific knowledge. This presents one of the major problems for the reader. Since his argument is based on numerous examples of partially successful cognitive strategies and sees their partial success as a justification for his project, the book overwhelms the reader with references. Of course, if the reader is appropriately grounded in the vast literature that Brenner affords in a bibliography, the reference to particulars can be very deeply informative. The rest of us must rely on the sheer weight of putative examples, still extremely informative and epistemologically rewarding. Brenner offers such an account, and it is the connection between the account and the examples that ultimately gives his work its power in depicting a new perspective on "reality". His concern with the actual practice of logic helps him to see the roots of reality in the manipulation of the wide interdisciplinary interplay I have indicated above. Brenner offers a truly novel contribution to the problem of reality by looking broadly to see its relational aspects within the entire context of logic, set theory, metaphysics, ontology, physics and biology, rather than narrowly as in the traditional logical and analytic approaches.

This excellent and demanding book opens up the door to a deeply informed attitude in logic and epistemology, requiring of philosophers that they do more than analyze concepts, demanding that they become familiar with the wealth of actual knowledge gathering practices available in the special disciplines. This is not to substitute description for normativity, but rather reconceptualizes what the grounds of normativity are. The author has provided a fine contribution to the renaissance of logical research aiming at directly elucidating the ancient philosophical concept of "reality".

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I wish also to thank Jean-Paul Bertrand, former Editor of Éditions du Rocher, Paris, for permission to reproduce the formulas of Lupasco's calculus from those editions of Lupasco's works, and Décio Krause for permission to reproduce citations from Niels Bohr's work published in one of his papers. Finally, readers will note that I have made extensive use of the articles in *SYNTHESE* and entries in the *Stanford Encyclopedia of Philosophy*, and I would like express my appreciation to the editors of these authoritative 'synthetic' sources.

INTRODUCTION

1. REALITY AND LOGIC

This is a book about a theory of reality – about a theory of change and stability, being and becoming. Humans are unique in having the capacity of experiencing reality and representing and recording it symbolically, and the recorded forms of symbolic representations constitute human knowledge organized into disciplines, scientific, philosophical, artistic and religious. These have been developed in an attempt to explain and understand the phenomena of existence in all their diversity and complexity. Innumerable approaches, more or less formal, have been developed to try to organize and make sense out of the processes, properties, relations, structures, actions, thoughts, interactions, in a word the physical and mental entities that constitute reality in every day human existence and experience.It is possible to look at the subjects and objects of knowledge and the methods for their study as lying on a scale between reality itself and the most abstract representations that are made of it, language and mathematics. All models of reality, as models, require a degree of abstraction. If one excludes, for the time being, non-linguistic representations of reality such as art, all knowledge is constituted by sets of statements of some kind. Starting from the side of language, farthest removed from reality, the statements consist of propositions about abstract, ideal entities; descriptions or models of reasoning processes; philosophical or metaphysical descriptions of reality; and finally, descriptions of reality based on experiment, the domain of science. Increases in knowledge related to statements or beliefs about reality are involved in linguistic processes such as making arguments, inferences and judgments. Science involves increases in knowledge about reality itself, the states of real physical and non-physical systems.

The purpose of this book is to reexamine the relationships between the different disciplines concerned with the description of reality: (1) ontology, the study of being, what there is, as a systematic approach to the construction of models of reality; (2) metaphysics, which is concerned with the fundamental structure of reality as a whole[1]; and (3) logic. Both ontology and metaphysics apply to all knowledge and reasoning.

Logic, however, is considered to apply in a formal manner to the first group of reasoning processes but not to the second, that is, as being limited essentially to the linguistic and mathematical domains, not those of entities, events or phenomena studied by metaphysics and science. Despite the large number of important practical applications of standard logics, for example, in computer science

[1] "Metaphysics is a universal discipline, in which everything, including the status and validity of ontology and metaphysics itself, is a proper subject of study" (Lowe 2002).

and artificial intelligence, the underlying body of logic has not undergone major modifications in the direction of a *logical* view of the structure of reality in general, and its implications for science. The reasons for this are primarily historical: logic has been thought of as the study of reasoning and the construction of adequate, formal descriptions of the modes of reasoning, e.g., deduction, induction and abduction, and the logical operations, e.g. implication, that characterize it. Modern logic was developed with the objective of modeling mathematical reasoning in as general a way as possible, without limitations as to what reality might be like. Due to their complexity, diversity and appearance of random or, at the very least, of chaotic behavior, phenomena as such have been generally considered outside the purview of logic.

In contrast to the abstractions that have constituted logic, real phenomena refer *directly* to human observation and human ratiocination, and the introduction of logical considerations in the corresponding disciplines, phenomenology and epistemology, has proven extremely complicated. The gap between reality – real entities – and propositions about reality remains the source of a large number of metaphysical problems. Talking about a logic of/in reality might thus be considered either a contradiction or a vague metaphor, referring, but only informally, to some of the regularities in nature and science that one observes.

There is, however, no theoretical reason why this should be so. One thesis of this book is that the limitation of logic to linguistic concepts, which do not and in fact cannot apply to real entities, should be removed. The discussion can also center, and perhaps should center, on the non-abstract and often conflictual changes characterizing real entities or phenomena as objects of analysis, while retaining the advantages of the formal structure, rigor and generality of the logical approach. An improved reflection of reality is, in a nutshell, what I claim my proposed logic of/in reality (LIR) may bring to the table.

I take a view of reality that is neither idealist nor reductionist-materialist. I will identify structures and principles in it that are not designed to analyze or insure the truth-value or the pattern of inference of a set of propositions but which have, nevertheless, equivalent explanatory power and categorial authority. For example, reality seems to be characterized and/or constituted by a number of fundamental dualities: there is the reality that is and is not accessible to our senses; the dualities of observer and observed, self and non-self, internal and external and so on. The principles of the theory that I propose, that I consider logical principles, nevertheless refer, as directly as possible, to such dualities and the relations between them as providing a coherent picture of reality, human experience and the mechanisms of change. I consider that the system of thought or discipline that best captures these principles is still a logic, a logic, however, that has its origin in the characteristics of physical reality, as conceived by modern physics, although it is obviously dependent on human mental and linguistic processes to describe those characteristics.

Accordingly, my logic is not only a logic about theories of reality as conceptualized in philosophy and metaphysics. It is also a scientific or quasi-scientific concept, to the extent that, like symmetry for example, its principles are a reflection of the underlying physical structure of the universe that is independent of human experience that nevertheless derives from it. Throughout this book, when I talk about the *physical* structure of the world, I mean that all metaphysical, philosophical but also logical concepts should be compatible with, those of fundamental physics. Thus, a logico-metaphysical concept that meets this criterion also implies a change in the way one looks at the role which logic has had of organizing our reasoning. One must start by being sensitive to the biases that have been built into the analysis of reasoning due to the ubiquity of the essentially classical principles of standard predicate, intuitionist and paraconsistent logic.

2. THE OBJECTIVE AND PLAN OF “LOGIC IN REALITY”

The title of this book, “Logic in Reality” (LIR) is thus intended to imply both (1) that the principle of change according to which reality operates is a *logical* principle embedded in it, *the* logic in reality; and (2) that what logic really *is* involves this same real physical-metaphysical but also logical principle. The first objective of this book is, therefore, is to construct such a logic of and in reality. Once this logic and its related ontology are in hand, I will show that they can provide some important insights into aspects of reality that have remained at the level of intuition. In particular I will be in a position to define the basis and structure of a necessary relation between reality and appearance. I will also show that many positions in philosophy and science have been blocked by classical logical descriptions of the domain of these theories and the consequent classical ontologies, that is, the categorizations that are made of the domains.

I will begin Chapter 1 with an informal axiomatic characterization of LIR and some initial indications as to why these axioms have been selected. The non-classical calculus to be used will be introduced. I will then briefly review the structure and major components of standard logics, showing which components can and cannot apply to LIR, or the significant reinterpretations of them that are required. The major groups will appear in the following sequence: deductive; paraconsistent; quantum; inductive – probabilistic.[2] The chapter concludes with a more formal axiomatization based on a model of probabilistic logic. The differences between my logical system *qua* system with that of both classical and non-classical logics will quickly become apparent, but the parallels that remain will be part of the justification for the consideration of LIR as a logic.

In Chapter 2, I discuss LIR as an uninterpreted formal system, including details of the non-classical calculus applied to the logical operations of implication,

[2] The sequence reflects the place of the logics on the ‘line’ mentioned in paragraph 1: each logic has aspects that bring it, somewhat, closer to reality. LIR can thus be seen as continuing this process.

conjunction and disjunction. In this theory, standard truth-values are replaced by logical values that reflect the state variables of the phenomenon under study in a novel way.

Chapter 3 develops LIR as a formal ontology and an interpreted formal system, with definitions of the critical concepts of dynamics, process and property. Ontological predicates are introduced to construct LIR as a process ontology, or process-ontological model of reality. An LIR approach to the question of being in relation to reality is compared with recent work grounding being in classical logic, and the concept of LIR as a metalogic is discussed.

Chapter 4 sets out the critical foundational notion of LIR, namely, that its fundamental postulate is based on the existence of energy, or better, its quantum field-theoretic equivalent, as the unique material category. The properties and processes associated with it as well as its most important formal categories are developed, recognizing that the domain of entities involved is that of all real, physical phenomena, as well as of non-real (imaginary or fictional) entities *qua* their creation. The categorial approach insures that LIR, as an ontological theory, has the necessary correlations to language and inference. The fit between the axioms of LIR and the New Energy Ontology (NEO) I define accordingly concludes the first part of the book.

The second part uses LIR and NEO re-examine problems in a number of philosophical and scientific domains. Chapter 5 is a transition chapter that sets forth the core thesis of LIR and provides views of key philosophical tools necessary for its development. The task of providing adequate structure to my categorization of reality is undertaken and compared with concepts from *Gestalt* and catastrophe theory. The ontological recategorization that LIR makes possible leads to reexamination of some issues in ontology itself. A basis for the links between LIR as metaphysics and LIR as ontology will be proposed.

Chapter 6 discusses the relation between the principles of LIR and metaphysics, and its application to the major philosophical issues of causality, determinism and realism in science. I will position LIR as a broad system, an axiomatic metaphysics, for talking about both philosophical theories and real-world processes. The chapter concludes with a brief discussion of the application of LIR to issues in philosophy and the naturalization of phenomenology. Chapter 7 develops the relation between LIR and modern physics. I suggest that LIR can clarify issues of complementarity, structural realism and metaphysical relations at macroscopic as well as microscopic scales, and the correspondence of LIR to some current concepts of space-time and cosmology is proposed. These three chapters suggest a convergence of metaphysics and physics, for which LIR provides a logical bridge.

Chapter 8 shows how the fundamental principles of LIR can define emergence and be applied to emergent phenomena at the increasingly complex levels of life and evolution. The book concludes with some speculations about the potential consequences of the applications of LIR in philosophy and science and the proposal of a more challenging role for this extended logic in the development of knowledge.

Based on the metaphysical arguments to be developed in this book, many fundamental questions and assumptions may require a degree of redefinition, and their origin in nature and their justification may be found elsewhere than is commonly suggested. I have made an effort to avoid reasoning according to the standard dichotomies, e.g., determinism *vs.* indeterminism. I thus ask the reader, even if he or she has strong views on specific issues (of which determinism is a good example), to take an attitude of openness and tolerance toward what may be unexpected or unusual in my thesis. I say this from direct experience, since even the *discussion* of some form of contradiction or constitutive opposition as basic to nature often encounters resistance that goes far beyond dispassionate and reasoned debate. I undertake to do the same with regard to my inevitable critics. But it may be considered a strength (or weakness?) of my theory that it is one that explicates and integrates its own potential critique.

I will naturally be comparing LIR with existing theories, but my intention is not to prove that any particular theory is incorrect, except in the sense that its domain of application should be clearly limited to abstract systems. For theories, views, approaches, etc. that are closer to LIR in spirit, my objective will be to support their insights and intuitions and show how they might be improved or generalized.

I will close this Introduction with a few words about the logical and philosophical environment in which this book is appearing. In his Introduction to a recent compendium that assesses current philosophy and logic (van Benthem 2006), the logician van Benthem argued for a natural and respectable process of growth of logic, in line with that in other disciplines, and cautioned against arbitrary replacement or competition. The articles (which date back to 2002), reflect this: none go far outside established paradigms of non-classical logics applied to aspects of truth, proof, category theory and complementarity in physics, among others. In philosophy on the other hand, three significant representatives of the Anglophone analytical tradition take a less conservative attitude. Mulligan et al. (2006) castigate analytical philosophy for its failure to accept the challenge of providing an adequate picture of reality. Continental philosophy is also criticized for its lack of rigor and subordination to political agendas, which makes *its* use of scientific concepts anecdotal. Ladyman and Ross (2007) and their colleagues are also critical of any metaphysics or philosophy that relies on intuitions or concepts that do not take into account the most recent advances in fundamental physics. In their "naturalization of metaphysics", they propose a picture of the world that raises the scientific standard for any theory that purports to describe and/or explain aspects of reality.

The theory in this book takes these various attitudes into account. Accordingly, much of Chapter 1 is devoted to showing the principled relation to standard non-classical logics of the extension of logic that Logic in Reality represents. Attention is paid to indications within standard logics that such extensions might be envisaged. Thus, in making the novel moves of extending logic to reality, and in showing its linkage to metaphysics and science, I have tried to maintain a degree of formal justification that members of the analytical philosophy community could accept, in accordance with the Mulligan *et al*. critique.

References

Ladyman, James and Don Ross. 2007. *Every Thing Must Go. Metaphysics Naturalized*. Oxford: Oxford University Press.

Lowe, E. J. 2002. *A Survey of Metaphysics*. Oxford: Oxford University Press.

Mulligan, Kevin, Peter Simons and Barry Smith. 2006. What's Wrong with Contemporary Philosophy? *Topoi* 25: 63–67.

Van Benthem, Johan. 2006. Introduction: Alternative Logics and Classic Concerns. In *The Age of Alternative Logics*, eds. J. van Benthem, G. Heinemann, M. Rebuschi and H. Visser. Dordrecht, The Netherlands: Springer.

1 LOGIC IN REALITY (LIR) AS A FORMAL LOGIC

Abstract This chapter establishes the logic of and in reality (LIR) as a formal logic, whose axioms are given first in standard form. An initial discussion of reality and levels of reality is provided as the basis for the extension of logic to real entities, phenomena and processes. A semantics for LIR is proposed and then compared with the logical concepts and processes underlying classical bivalent logic. Comparisons are also made with many of the major kinds of classical and non-classical logics, including fuzzy and modal logics, in order to bring out the critical differences that a departure from logic as a linguistic system entails. The closer relation of LIR to inductive, abductive logics and quantum logics and probability is suggested, and the LIR axioms are restated in formal probabilistic terms.

1.1 INITIAL AXIOMATIZATION: THE FUNDAMENTAL POSTULATE

Logic and metaphysics began, in antiquity, as ways of reasoning about nature, or reality. However, relatively early, logic developed into simply a tool for determining the truth or falsity of propositions. Deductive reasoning *per se* was disconnected both from processes of scientific inference and from ordinary experience. The most common current definition of logic is that it is an analytical theory intended to formalize principles of valid reasoning as well as a theory of valid inference to provide insight into the foundations of mathematics. Logical relations, it is alleged, can obtain only between propositions, not between concrete entities, nor between abstract entities that are not propositional in nature. Examples of standard logics are classical term or syllogistic logics and their recent modifications, first and higher order predicate logics, modal logics, and ampliative adaptive logics. Further, most such propositional logics are based on the principles of bivalence, absolute non-contradiction and the law of the excluded middle. These three principles can be summarized by the corresponding axioms of classical logic, as follows:

CL1: *Identity*: A is (is identical with) A (or B): A = A or A = B.[1]
CL2: *Non-Contradiction*: A is not non-A (not (A and non-A)). Arguments that lead to contradiction are *prima facie* false.
CL3: *Excluded Middle*: there exists no third term T that is at the same time A and non-A (A or non-A).

All standard logics provide for the addition of additional axioms, and/or for recasting the indicated axioms in other terms in order to define the logic more completely. The term bivalent classical logic refers to a logic with two values, true and false, with a middle term excluded and proof by refutation by reduction to the absurd or contradiction. This form of logic was and is so successful in practice in describing a wide variety of phenomena that it has come to be considered as an *a priori*, corresponding in some way to the laws of thought and reason. The prestige it has acquired thereby has resulted in the maintenance of most of its principles even within the major developments in logic of the last fifty years, such as paraconsistent and paracomplete (intuitionist) logics. This has blocked a path toward a potentially deeper understanding of the principles of bivalent logic and occulted the negative effects of their misapplication in society.

In my opinion, this situation is the major driving force for the development of a logical theory that will enable a better, since more direct, description of 'what happens' in reality. Standard propositional and predicate logics, as well as the newer paraconsistent and paracomplete logics, all exclude some or other essential aspects of reality. For example, among the important properties of logic in the standard acceptation is that of topic-neutrality. This says essentially that it makes no difference what it is one is thinking or reasoning about. Provided one follows the rules of deduction and keeps the meanings of certain general terms fixed – the logical constants – the truth of a conclusion from true premises is guaranteed.

A somewhat broader conception is that logic is the study of the most general features or forms of thoughts and judgments (Hofweber 2005). One can assume, however, that 'form' is concerned with what a judgment is about, rather than the judgmental proposition itself, and one can associate form with the reality that is being judged, including the real mental process that making a judgment involves. On this basis, reality itself has a logical form or structure, which implies a basis for logic in real-world phenomena, and its use for their description.

I thus claim that logic not only should but *can* be extended to reality, provided one takes into account, and gives proper metaphysical weight to, some of its characteristics that have tended to be neglected. These include the concepts, present also since antiquity, of dialectics – conflict as well as change and alternation between the different but closely related, interactive elements of a phenomenon.

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[1] It is now well known that from both a formal logical or practical standpoint, this formulation of absolute identity is either trivial or false. Identity must be relativized either to some context or particular predicates, or denotations of nouns. What remains as strong as ever is the normative idea of absolute identity as an ideal or preferred state.

Dialectics can be considered neither more, nor less, than the generalization and mental expression of conflicts in nature and civilization, and their resolution, that man has observed from time immemorial. “Beings and things seem to exist and are able to exist only in function of their successive and contradictory conflicts.” (Lupasco 1979) (For Heraclitus, conflict did not mean the splitting or destruction of the unity of reality, but its constitution. The *logos*, the only “abiding thing”, the orderly principle according to which all change takes place is a ‘binding-together’. Conflict (*polemos*) and *logos* are the same.)

I thus propose that there are no less than *three* major roles for logic to play: the first, already referred to, as a the theory of forms or structures of abstract relations between abstract objects, thoughts and concepts: the second, as a theory of forms of still abstract relations holding between real items from which, essentially, properties of change have been eliminated. Set theory, part-whole theory (mereology) and group theory are examples of logic in this sense. In a third, qualitatively different role, logic as a theory of reality in which its dynamic structures of conflict, change, and alternation take center stage. At this point, logic can and should “join forces” with science and metaphysics to give the best possible description of that reality.

The classical dualisms indicated listed are expressions of some of these dynamic structures of conflict, change, and alternation.

Presence – Absence	Actuality – Potentiality
One – Many	Identity – Diversity
Subjective – Objective	Internal – External
Local – Global	Proximity – Distance

These pairs of opposing notions can be considered forms of reality not only because they formally articulate aspects of our experience, but because we actually experience them.[2] Being self-evident, they are thus a further rationale, for the axiomatization of a logic of reality,

The fundamental postulate of LIR, of ‘dynamic opposition’, which depends on these notions, is as follows: all phenomena continually but non-reflexively (that is, without perfect circularity – returning to exactly the same starting point) alternate between degrees of actualization and of potentialization of themselves and their opposites or ‘contradictions’. In the original formulation by Stéphane Lupasco (1987):

> “To every phenomenon or element or logical event whatsoever, and accordingly to the judgment which thinks of it, the proposition which expresses it, to the sign which symbolizes it must always be associated, structurally and functionally, a logical antiphenomenon, or

[2] Roberto Poli (2003) has shown the philosophical importance of dualisms in the relationship or correlation between their role in (standard) logic and current views of ontology.

anti-element or anti-event and therefore a contradictory judgment, proposition or sign in such a fashion that the former can only be potentialized by the actualization of the latter, but not disappear such that either could be self-sufficient in an independent and therefore rigorous non-contradiction – as in all logic, classical or otherwise, that is based on an absoluteness of the principle of non-contradiction."

The point half-way between actualization and potentialization is a point of maximum antagonism or 'contradiction' from which, in the case of complex phenomena, a T-state (T for "*tiers inclus*", included third term) emerges, which is capable of resolving the contradiction (or 'counter-action'), at another, higher level of reality.

As a first step, one may capture these concepts and this postulate by re-writing the three axioms of classical logic as follows:

LIR1: *(Physical) Non-Identity*: There is no A at a given time that is identical to A at another time. This formulation is essentially that of Leibniz.
LIR2: *Conditional Contradiction*: A and non-A both exist at the same time, but only in the sense that when A is primarily actual, non-A is primarily potential, and *vice versa*, to a reciprocal extent.
LIR3: *Included (Emergent) Middle*: An included or additional third element or T-state emerges from the point of maximum contradiction at which A and non-A are equally actualized and potentialized, but at a higher level of reality or complexity, at which the contradiction is resolved.[3]

I then add the further axioms, in part re-expressions of the first three, that are required for the proposed application to real-world elements, rather than only to linguistic terms, propositions or expressions. These are restatements of the fundamental postulate, including the essential concept that no real process goes to the idealized, abstract limits of classical logic.

LIR4: *Logical Elements*: The elements of the logic are all representations of real physical and non-physical entities, none of which can be totally identical to another.

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[3] This axiom has been designated as a 'law of the included middle' and the original Lupasco logic as a 'logic of the included middle', LIM. This term does differentiate it from both the classical logic of the excluded middle and intuitionist logic, in which the law of the excluded middle does not hold for certain aspects of mathematics. However, since a T-state is 'included' only in the sense of being positioned conceptually between opposing elements, I have tended to avoid this locution that carries, incorrectly of course, the idea of two things occupying the same space at the same time.

LIR5: *Functional Association*: Every real logical element **e** – objects, processes, events – always exists in association, structurally and functionally, with its anti-element or contradiction, non-**e**; in physics terms, they are conjugate variables. This Axiom applies to the classical pairs of dualities, *e.g.*, identity and diversity.[4]
LIR6: *Asymptoticity*: No process of actualization or potentialization of any element goes to 100% completeness.

In sequence, these axioms express the *notion* [5] of change; the *mechanism* of change; the *product* of change, that is, emergence of a new entity or phenomenon; the *locus* of change in the elements of reality; the *structure* of reality and a *property* of change.[6] The nature of these real-world elements and the basis of the property will be left open for the time being, but the elements can be assumed to be what are commonly termed 'facts' or extra-linguistic entities or processes. It is more common to talk today about 'process and processes' rather than 'change' or 'becoming', but I wish to emphasize the continuity with older work. I will provide a specific discussion of process in Chapters 3 and 4. Regarding the term 'functional', as used in **LIR5**, I hope to avoid potential misunderstanding by saying now that it is *not* intended as part of a functionalist theory of mind, but simply to imply that one element cannot exist without the other, or, put positively, that one element depends for its existence on the other.

The following corollaries refer to the notions of contradiction or antagonism and, in particular, of truth, in view of the central position of truth values in any discussion of logic:

CLIR1: *Contradiction*: Contradiction can never be considered as absolute, because it never takes place between rigorously actual terms, between absolutely contradictory elements, such as those of classical logic and mathematics. Contradiction never occurs except between antagonistic dynamisms. Alternatively, no element, no logical variable or event is rigorously non-contradictory; it always involves some contradiction such that, no matter how much developed, the non-contradiction is always relative and limited.
CLIR2: *Truth and Falsity*: A truth cannot be absolute, because it can never be rigorously (totally) actualized; a contradictory truth (falsity) can be

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[4] The absence, in LIR, of any notion of absolute identity or diversity of real world elements is a concept that has direct bearing on the current debate about the individuation of quantum particles. In this view, only a *conditional* and reciprocal meaning can be given to these terms. The modified views of scientific and structural realism of both quantum and macroscopic systems I will present are the logical consequences this axiomatic formulation.

[5] This notion of change was in a sense anticipated by the predicate reading of the classical axiom.

[6] The axioms could be considered as a new way of looking at regularity in the immanent connection between the elements involved in change.

potentialized as much as one wants theoretically without ever completely disappearing in reality. The LIR conception of truth will be discussed further in Chapter 2.

To my knowledge, the theory developed here is the only one in which the three major axioms of classical logic are modified at once. Standard logics (classical or non-classical) involve rules of inference for determining the truth of propositions and linguistic formulations of beliefs, etc. My logic involves rules for inferring or determining the state of the real-world elements involved in a phenomenon. In order to better capture the notions of LIR that derive from the non-linguistic character of its elements, some of these initial six axioms will be recast later in this chapter in a way that will show a relation to probabilistic logic.

1.2 THE REAL AND REALITY

Comprehension of Axiom **LIR3** and emergence requires a concept both of reality and of levels of reality that accommodates viewpoints of ontology, metaphysics and physical science, especially, fundamental physics. This first requires a distinction between reality and the real. My vision of the real should be understood as similar to, or rather starting from, that of D'Espagnat (1979), namely, weak objectivity. An independent real exists, despite our inability to define it precisely (the veiled real), or to give it a meaning that is independent of our intuition. This view is related to the so-called weak anthropic principle that states the obvious fact that the fundamental constants of the universe are such that observers such as ourselves can exist. The strong anthropic principle claims that our existence is the explanation of *why* the constants have the values they do, introducing teleology – that it was the purpose of the universe to produce us. Kauffman (1995) appears to suggest this in his poetic book:

> If we are, in ways we do not see, natural expressions of matter and energy coupled together in non-equilibrium systems, if life in its abundance were bound to arise, not as an incalculably improbable accident, but as an *expected* (emphasis mine) fulfillment of the natural order, then we are truly at home in the universe.

However, this statement can also be read as a description of a natural order that is nothing more than the self-evident weak anthropic principle. In any event, the latter is sufficient for my analysis, and the appearance of teleology can be reinterpreted as a phenomenon, not a fundamental principle.

Other theories define *reality* as what is, or what constitutes, our experiences, representations, theories, logics, images and so on. The real is what *is*, but what absolutely resists our attempts to represent it or to see it clearly. The real offers us the possibility, so to speak, of understanding it *via* a concept of levels of reality and the structure and properties of phenomenal reality that we can perceive (non-veiled reality). Rescher (1996) cites Peirce to this effect: "Given that human intelligence is a resource developed over time by creatures that are themselves an evolved part of nature, our capacity to understand the world should not be seen as all that surprising." The most useful approach may be to maintain a description of reality as being both veiled *and* not veiled (D'Espagnat 1979).[7]

What I have called here non-veiled reality is, of course, divided into the perhaps less poetically designated domains of *observables* and *non-observables*. When to say that an entity is a non-observable because not *directly* observable, and that hence its reality and existence independently of the human mind is open to question, is a major issue of scientific realism. The logic of/in reality is relevant to both the philosophy and physics applicable, as I will discuss in later chapters.

The next section discusses the concept of levels of reality from several points of view that will be useful in subsequent applications of LIR to science. However, a book that purports to discuss reality also requires, I feel, some minimum discussion of the metaphysical problem of what it is to be or exist, the nature of being. Without some indication of what constitutes being, what it means for something to exist, and why something exists rather than nothing, any description of the inhabitants of existence, as pointed out by Jacquette (2002), may be inconsequential unless it is in some way independently constructed *without* reference to our experience. I have deferred this topic, however, until Chapter 3 by which time I will have developed some of the logical and ontological tools for its discussion.

1.2.1 Levels of Reality

The idea that reality is divided into levels that are more or less distinct and involve different degrees of complexity has been proposed, in various forms, since antiquity, but it has received more rigorous attention since the advent of quantum mechanics.[8] While there always can and will be arguments about the number of levels and their detailed structure, the approach in this book suggests ontological and physical pictures that postulate the emergence and existence of levels, which follow different detailed laws, as a natural consequence of the fundamental antagonistic properties of energy.

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[7] The objects of the theories of modern physics and cosmology (virtual particles, curved space, ten or eleven fundamental dimensions, etc.) are in the domain of reality, as are the objects and concepts of levels of reality in traditional beliefs. The problem of the reality of non-existent objects is discussed in Chapter 3.

[8] After Heisenberg, the notion of levels of reality as critical for *philosophy* was introduced in an independent way by Nicolescu (1982).

1.2.1.1 The Ontological Approach

Poli (2001) has provided a description of levels of reality and analyzed the complex relations that obtain both *between* and *within* levels of reality. The following methodological steps can summarize his approach:

1. Distinguish three strata, rather than levels, of reality: the material, the psychological and the social (the latter encompassing all phenomena of history, language, science, morals, in fact, the entire body of human knowledge and ideation).
2. Define the hierarchical relations of dependence *between* strata.
3. Define the hierarchical relations *within* strata, organized into levels (or layers). The layers within strata correspond to "levels of organization", different structurings of the same fundamental laws (Nicolescu 2002).

Each stratum has its own principles, laws and ontological categories, and there are clear discontinuities between strata. This approach is also realistic in that this ontology seeks to extract the relevant categories directly from objects. Levels of reality are radically different from levels of organization; the latter do not presuppose a rupture of fundamental concepts. Several levels of organization or hierarchies can belong to one and the same level of reality, that is, sets of different structures governed by the same fundamental laws.

The logic that appears to be adequate for this view of levels of reality is an intuitionist logic, which maintains an unmodified principle of non-contradiction. This logic is adequate for the entities of classical ontologies and their categories, but it does not fully describe the distinctions between levels of reality. In my view, a distinction should be also based on metaphysical considerations, for example, that the tendencies in and between levels toward physical homogeneity or biological heterogeneity are not independent but are related as discussed below.

1.2.1.2 The Physical Science Approach

To a physical scientist like the writer, the description of the world in terms of discontinuous levels of reality seems natural and rigorous. At the human level, one has no direct contact with the world of quanta, or even cells, but one visualizes the 'inside' of a proton, observes the fantastic variety of biological life, and is conscious of the existence of consciousness itself. This picture supports a view of reality as constituted by levels that are in some essential respect separated. That different scientific laws apply to the phenomena at these different levels also seems natural. Most people would also agree that another kind of illogical or a-logical 'rules' apply in the areas of affectivity, love and religious faith.

A concept of levels of reality, however, in *all* of which at least *some* of the same basic principles are instantiated, suggests a possible isomorphism of the underlying laws of nature. For purposes of this analysis, I will take the view that there are six such major levels of reality, as follows:

- Microphysical or quantum mechanical.
- Macrophysical, characterized energetically by global entropy and gradual homogenization of its components.
- Biological, characterized by local negentropy and the emergence of new forms (heterogenization).
- Human mental or psychological.
- Human social.
- Cosmological (universe or multiverse).

Such a division is an idealization, and reality is a coherent whole. Thus, independently of the properties that are proposed as the basis for the location of the cuts between levels, an additional principle seems necessary, namely, to explain the transition from one level to the next. This is, in other words, the problem of emergence, and Axiom **LIR3** suggests a concept of or mechanism[9] for emergence that 'emerges' naturally from logic in reality.

1.2.2 Contradiction, Counteraction or "Countervalence"

There is an endless discussion in the literature of the difference between contrary and contradictory that harks back to the triangle of Carneade, the tree of Porphyry, and the Aristotelian Square of Opposition. These concepts are useful for the analysis of simple terms, but they fail as both a deep analysis of semantics and above all of phenomena involving dynamics, that is, phenomena involving some internal metabolism or energetic change. The LIR approach goes beyond a definition of dynamics in standard logics that refers essentially to binary informational input and output states. Examples of these are belief changes and games involving more or less ideal players (agents) whose goal is to maximize gain. Interaction here takes place only within the rigid framework of the rules of the game.

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[9] Here and subsequently, I use the term 'mechanism' in an informal descriptive sense without implying that computable models exist for all the transitions between levels that I will examine. Indeed, I argue that such models for living organisms *cannot* be constructed.

In my opinion, part of the confusion in this area stems from the use of the word contradiction itself, by Lupasco and countless others, given its root in *dicere*, to speak. It would desirable to replace it with a term that conveys the essentially *non-linguistic* character of the conflicting energy states, physical or non-physical, for example, 'counter-action'.[10] Another possible neologism for contradiction – 'counter-being' – should be avoided due to potential confusion with discussions of being in ontologies from which contradiction and/inconsistency may be excluded. Perhaps the most appropriate word in English to describe the dynamic opposition of two elements or terms in a phenomenon is '*countervailing*'. This has the same meaning as counteraction, but with the additional idea present in its root – *valere* – of value as well as energy (strength). The use of *countervalence* to describe the dynamic equilibrium of the T-state would be consonant with the use of *prevalence* to describe the dominant process in pairs such as actualization/potentialization and identity/diversity. For simplicity, however, the term contradiction will continue to be used with the understanding that it has this additional dimension.

The structure of the included middles (T-states) is highly complex. Phenomena at any level of reality can be characterized by differing actualization of primary trends toward non-contradiction (identity, homogeneity or diversity, heterogeneity) or toward contradiction (emergence of new entities). To distinguish them, I will call the former contradictional and the latter contradictorial. These trends are themselves actualized or potentialized to a different degree, but never completely. In the resulting emergent elements that enter into further contradictorial relations, either homogeneity or heterogeneity is predominant, but the other is also always present.

1.2.3 The Senses of Reduction

This is a book that deals with both science (physics) and philosophy, and in both areas, I will frequently use the terms of 'reduction' and 'reductionist'. These terms, as has been summarized by Kistler (2006), are used in opposite senses by philosophers and physicists. In the philosophers' sense of reduction, the more fundamental theory reduces the less fundamental one: stated in the (to me) more accessible direction, a less fundamental one, say – thermodynamics, reduces to a more fundamental one, statistical mechanics. In the physicists' sense, the more fundamental (or more precise or more general) reduces to the less fundamental one.

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[10] The term "anti-A" can be considered, but it should not be confused with the same term used by Florentin Smarandache in his fuzzy (neutrosophic) logic and by Gabbay (2001): "The job of anti-x is to delete x." The resulting epistemic logic is another coherent (consistent) logic with applications primarily in AI and automated reasoning.

In what follows, I will use exclusively the physicists' sense. Thus, my more fundamental, complex, ternary LIR logic *reduces to* less fundamental standard binary logic. Binary logic is present in LIR in potential form and it is what is actualized for simple phenomena. Is a logic of reality present in standard logic in potential form? I say yes, since we know that classical or standard logic applies to many real entities and/or processes to all intents and purposes.

LIR provides further structure to the bi-univocal epistemological (better logical and epistemological) relation involved in the process of reduction. If all theories are "more or less fundamental", this means that they have both fundamental and non-fundamental aspects, the former being at a higher level of complexity than the latter. The process of reduction, in my view, is also governed by the principle of dynamic opposition, that is, when fundamental aspects are actualized, non-fundamental aspects are potentialized and *vice versa*.[11]

To keep this distinction better in mind, the language of asymptotic reasoning developed by Batterman (2002) is useful. The limits of identity and diversity (primacy of non-contradiction: contradictional) toward which phenomena tend asymptotically are instances of *regularity* at which the tenets of reduction and those of classical logic apply. The 'movement' toward an equal actualization and potentialization of two opposing elements results in a state of maximum contradiction. This limit, at which emergence is possible, is *singular* (contradictorial: T-state). As Batterman suggests, the features of this state (critical point) cannot be understood unless statistical aspects are asymptotically (without detail) sewn onto thermodynamically governed processes. I will return to this in the discussion of the physics of duality in Chapter 4.

1.3 LIR VERSUS STANDARD LOGICS: DEDUCTION

The axioms of LIR and the related notions of interactive contradiction involving real entities imply major innovations and modifications to the form and machinery of standard logic. They suggest a form of logic that is radically different from that of classical and neo-classical propositional and predicate logics. In this chapter and the next, I will claim both that this new concept of logic retains the characteristics of a formal logic, and that throughout standard logic one can find hints that such a logic is conceivable.

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[11] It is possible to say, using the philosophers' definition, that binary, standard logic *reduces to* ternary logic, but the real problem may be that at this point, reduction has lost all intuitive meaning. One could perfectly well say that standard logic complexifies to ternary logic. Further discussion of the necessity of the philosophical sense of reduction is not critical to my thesis, as long as the sense in which I use the term is understood.

A simple definition of a typical classical propositional logic (CL) is a set of statements (syntax) and a relation of semantic consequence showing how those statements are to be used, that is, how arguments are to be constructed and conclusions derived from premises. The calculus or proof theory of this logic consists of a set of axioms, a set of allowable expressions and their grammar, and a set of inference rules for deriving new more complex expressions or 'well-formed formulas'. Rules of inference are syntactic schemes for relating the expressions and assertions. Axioms, which in standard semantic terms are valid, self-evident assertions or truths,[12] are the starting point for the application of rules of inference and generating conclusions. The semantics of a logic, which is part of the grammar, captures the meaning of the assertions and explains those features of the logic that are essential to its arguments, *e.g.*, notions of logical truth, logical constants – a set of sentential operators or connectives, and logical consequence.

The logic of deductive reasoning is the 'most abstract' of standard logics in that it is concerned only with what follows universally from given premises. In deductive logic, an inference is valid if and only if there is no possible situation in which the premises are true and the conclusion false. Such logics are termed 'bivalent' or 'two-valued', that is, the semantics of the language assigns the value of true or false to every sentence in the system. As it is often put, the truth of the conclusion is 'guaranteed' if the premises are true.

1.3.1 Bivalence: Logical Truth, Logical Constants and Logical Consequence

As Béziau (2003) has shown, the principle of bivalence amounts to a definition of the notion of proposition. Objects to which values other than true or false are attributed should not be called propositions. This leads to the first conceptual difference **D** between CL and my proposed logic (LIR):

D1: The statements in the language of LIR are not propositions in the usual sense, but 'formulas' and their 'opposites' or 'contradictions'.

The principle of bivalence implies the second and third axioms of classical logic, expressible as non-contradiction: a proposition and its negation cannot be true together, and the excluded middle: a proposition and its negation cannot be false together. The corresponding modifications LIR introduces are:

[12] The characterization of axioms as self-evident is currently rather discredited, due in part, and not unsurprisingly, from my point of view, to the use of the ambiguous term "self-", cf. my discussion of self-reference in Section 4.8.1.

D2: There exist circumstances under which a 'formula' and its 'contradiction' are both true and false, but not wholly so at the same time.

D3: There exist circumstances under which a 'formula' and its 'contradiction' are not wholly false together, but generate a third term, an '*included* middle', at the same time.

The classical notion of logical truth as governed by the principle of bivalence holds even in many-valued logics, since the set of three or more values is reduced to two sets, one containing what is false and possible and the other what is true.

D4: In LIR, the notion of truth is defined logically by non-contradiction and contradiction. The term 'false' is not applicable to real processes and entities.

Logical constants are expressions in a language that, unlike non-logical expressions, have been assumed never to have a specific *meaning* of their own, but the *function* of determining the logical form or structure of propositions and arguments. They are designators of semantic values, that is, truth-functional in their own right. These include the connectives, the group most commonly composed of signs for negation, conjunction, disjunction, conditionality and, in first-order predicate logic, the quantifiers – 'all' and 'some'.

The definition of constants depends on how one wants to establish the difference between logic and non-logic. One way is to state this is that the former is 'topic-neutral', and topic-neutrality means that necessarily true propositions – *logical truths* – are indifferent to content. However, if logic is universally applicable to reasoning about any subject, because it is intimately connected with the conditions and processes of thought, topic-neutrality means that logic is limited to a very general kind of valid inference (or inferring).

In fact, classical logics have developed to the point that, in certain cases, logical constants *may* have independent significance. If so, they are no longer 'constant' in and thus may contribute to the 'non-logical', variable content of that representation in which they are involved. The vague dichotomy between logical and non-logical expressions is itself a reflection of the principle of bivalence. In my view, one should avoid artificial rules that amount to the same thing, such as inferential rules involving fixation of semantic value, invariance conditions or notions of logical necessity that define this dichotomy.

In some views, making the distinction between logical and non-logical constants is not essential for understanding what logic is about, and it is not the limited number of expressions and argument forms that have been used traditionally for this purpose that define the subject matter of logic. This does not mean that the distinction does not exist, but no principled criterion has been found for it.

Even within the restricted domain of deductive logic, pragmatic demarcations between logical and non-logical constants are much closer in spirit to this present inquiry. They start from a 'job description' for logic and identify the constants as the expressions necessary to that job, namely, to serve as a framework for the systematization of scientific theories. In this conception, what counts as logic could depend on the current state of scientific or mathematical theory, but this relativization of logic is less universally accepted than might be assumed (He and He 2006).

D5: In LIR, the choice of logical constants, in addition to the standard ones, can be made relative to the notion used of logical consequence (next paragraph).

The next broad concept of classical logic that I will address here is that of *logical consequence.* Logical consequence is the notion that in a good logical argument, the conclusions are the consequences of or follow necessarily from the premises. What this means exactly is a crucial question at the heart of logic as a formal philosophical discipline.

Current analyses of the concept of consequence (Beall and Restall 2005) can be summarized as follows: consequence is necessary or formal, and its various aspects are explicated *via* proofs or models. Deductively valid consequence is 'necessary', and the type of necessity can be metaphysical, conceptual or analytical. Formal consequence is distinguished from material consequence; for the latter, content is required for validity determination in addition to the structure or form of the arguments. Finally, the distinction between formal and non-formal rules of logical consequence (schemes) is that the former can be taken to be topic-neutral (see above) or abstract, again, from the semantic content of thoughts or arguments, leaving the rules as the only semantic structure. A somewhat different distinction is to take the formal rules of logic to be constitutive norms for thought, which conjoin and disjoin thoughts to make new ones, independent of content. This means that regardless of the content of thought, a logical vocabulary, and the norms governing it, may be used to structure and regulate any kind of theory.

D6: Logical consequence in LIR is a notion of material consequence, dependent not only on the substance of material claims in propositions (topic-dependent) but also on the *metaphysical necessity* of events or phenomena. The rules of LIR are also general without being either topic-neutral or abstract. These rules are not only constitutive norms of thought, but also constitutive norms of aspects of reality.[13] For logicians accustomed to an

[13] In this respect, they resemble paraconsistent logics, which are not closed under deduction. This is not an innocent modification. It implies a view of logical and biological closure that is incomplete or 'leaky', with consequences for emergence.

absolute distinction between general and topic-dependent rules, this subject will be a further introduction to how far-reaching for logic the implications of LIR may be.

In general, the limitations and separations implied by the principle of bivalence of classical logic, in various forms, underlie arguments in all areas of philosophy. Examples are the discussions of whether geometry or dynamics is more fundamental in the universe, or one or the other of the dualisms mentioned above. Is it reductionism or holism, or their connection by recursive structures, as described by Hofstadter's picture of 'tangled loops' that better describes the world? CL implies an absolute separation of terms that shows up in, for example, discussions of universals and particulars, appearance *vs.* reality and in a requirement of total independence between internal and external processes, and in the choice between opposing concepts in scientific theories. As we will see on several occasions in this book, the fact that certain interpretations in classical logic are explicable using principles of the logic of/in reality suggests a continuity between classical logic and the extension of it that I am proposing.

The last component of standard logic that requires definition of a major conceptual difference are the connectives, mentioned above. The symbols of the object language of a propositional calculus include a series of connectives, of which the most significant are negation $\neg$, conjunction $\wedge$, disjunction $\vee$, the material conditional $\supset$, also called material implication, and material equivalence $\equiv$. The symbols also include standard punctuation marks, parentheses and commas. The connectives are truth functions in the sense that they are also operators that insure preservation of truth between antecedent and consequent propositions. The properties of conditionals for natural-language propositions in this usual sense are by no means straightforward, but the problems that arise do not concern us here.

The essential elements we are dealing with in standard, classical logic are propositional, linguistic variables and strings of symbols that can be generated from them and the connectives which are called formulas, or well-formed formulas. There are many significant consequences of shifting to elements that are non-linguistic defined by the initial set of axioms of LIR. In particular, the dynamic, oppositional relation between two elements will always be expressed by implication, $\supset$. Thus for any element **e**, I write, where **e** actual implies non-**e** potential, $e_A \supset \bar{e}_P$. I use the bar and not $\neg$ to refer to the real element non-**e** rather than the negation of classical logic.[14]

D7: The connectives of implication, conjunction and disjunction all correspond to real operators on the parameters of real elements. Accordingly,

[14] I also do not wish to use the connective ~ that formalizes negations from natural language in inconsistent and paraconsistent propositional logics.

these operators are, also, subject to being actualized, potentialized or in a T-state. They operate not on theoretical states-of-affairs or propositions, considered as the abstract meaning of statements, but events, processes and properties, to the extent that properties also have the character of processes. The formal calculus of LIR, presented in Chapter 2, develops the symbolism further, and the critical concepts of property and process are related in Chapter 3 to the development of LIR as a formal ontology.

1.3.2 Semantics

The semantics of a logic is a complex conceptual construction for understanding the meaning and purport of its symbols and principles. For this reason, the construction is also called an interpretation. Semantics, or interpretations, exist for all logics. The differences refer to specific parts or properties of the logic. For example, a truth-functional semantics refers to the preservation of truth in standard deductive logics. Paraconsistent logics (see below) are considered to have a non-truth functional semantics in the sense that propositions can have aspects of truth and falsity at the same time. The semantics of LIR are non-truth-functional in the different sense that their elements are not propositions at all, and the concept of truth-functionality (defined as valuations based on homomorphisms (mappings) between formulas and an algebra of truth functions defined on a given set of values, 0 or 1 in binary logic, several values in many-valued logics) should not be applied.[15]

In the semantics of LIR, however, sentences do not *look like* those of a classical logic, and its inferential patterns are different. In classical logic, the function of a standard semantics is to insure truth preservation as a basis for the validity of the logical reasoning. However, the meaning or sense of truth can change. Let us then try to formulate the components of a 'dynamic' semantics, that is, one that could refer to aspects of real process phenomena. The conceptual modifications that are required by LIR can thus be illustrated by comparing the elements of a possible semantics for it with those of a classical logic (CL):

1. *Domain of Interpretation*

CL: some set of propositions, constants or language-like entities.
LIR: representations of the empirical world of physical, including mental phenomena. All discussion of such representations is, obviously, in a language, English, which stands in the relationship of a meta-language to the

[15] For a discussion of these issues, including non-truth-functional Kripke semantics, cf. Béziau (2006).

parameters of the real elements that constitute the domain of LIR, the relations between which elements, in the object language, are defined, at this point, by the above Axioms and by the connectives as operators.

Comment: Some readers may object that, at least in the area of deductive logic, a semantics can deal *only* with propositions and their standard truth-values, propositions having the possibility of being combined *via* the standard connectives into more complex propositions. I agree in part, but also feel that the relation between classical logic and "what a proposition is" is much more complex, as I have just shown.[16]

2. *Symbols of the Object Language of the Calculus*

CL: an infinite number of propositional parameters or variables, the connectives, and the punctuation marks.

LIR: a transfinite number of reality parameters corresponding to real-world entities, processes and events (phenomena) and their accompanying actualized and potentialized contradictions, $\mathbf{e}_{0A}$, $\mathbf{e}_{1A}$,…; non-$\mathbf{e}_{0P}$, non-$\mathbf{e}_{1P}$ …, the *LIR* connectives and the punctuation marks, the sequence of real numbers 0, 1, … referring to the first, second and subsequent instances of the pairs of variables or parameters. A and P stand here for the actualization and potentialization respectively of the reality parameters, whereby the other sequence, in which **e** and non-**e** are inverted, is understood.

3. *Formulas*

CL: the (well-formed) formulas of the language comprise all, and only, strings of symbols that can be generated recursively from the propositional parameters by the following rule: if A and B are formulas, so are $\neg A$, $(A \wedge B)$, $(A \vee B)$, $(A \supset B)$, $(A \equiv B)$.

LIR: the formulas of the language comprise the strings of symbols that can be generated from the connectives indicated in **D7**, the signs for actual, potential and T-state, that is, the reality parameters The resulting inference rules are that, where **e** is any real-world element, $\mathbf{e}_A$ (**e** actualized) implies non-$\mathbf{e}_P$ (non-**e** potentialized) and *vice versa*; both imply that contradiction is potentialized and non-contradiction actualized;

the parameter $\mathbf{e}_T$ implies non-$\mathbf{e}_T$ which implies that contradiction is actualized and non-contradiction is potentialized.

[16] In fact, classical logic deals with *logical* relations involving the mutually exclusive and jointly exhaustive values of truth and falsity. This does not mean, however, that propositions when they are interpreted actually instantiate such values (Iacona 2005). The reality of thought-as-process lurks even at the heart of classical logic.

4. *Interpretation of the Language*

CL: a function ν, which assigns to each propositional parameter either 1 (true) or 0 (false).

LIR: a function *Rl* which assigns to each pair of reality parameters A and Pa value that is greater than 0 and less than 1, although the sum of the values is equal to 1. The formulas in the interpretation do not have truth-values other than the values of the reality parameters. These reality values *are* the 'truth' values.

5. *Premises and Conclusion: Consequence*

CL: for any set of formulas (the premises) ***S***, then ***A***, the conclusion is a *semantic* consequence of ***S*** iff (if and only if) there is no interpretation that makes all the members of ***S*** true and ***A*** false, that is every interpretation that makes all the members of ***S*** true makes ***A*** true.

LIR: no set of formulas can be considered as a set of independent premises permitting a conclusion as a semantic consequence (or non-consequence) for two reasons. One is the relation of opposition between **e** and non-**e**. The second is that one is not dealing with linguistic premises and conclusions. Of course, one formula may entail other, but in LIR that *p* implies *q* means that this happens in reality. Further, the *dynamic* material consequence of **e** and non-**e** being equally actualized and potentialized is a T-state (see Axiom **LR3** above), the emergent result of an interpretation that has given each of the reality parameters the value of 1/2.

6. *Logical Truth (Tautology)*

CL: Many (but not all) classical logics make extensive use of tautologies, a tautology being defined as a statement that is always true, cf. Axiom **CL1**. Tautologies are conclusions (statements) for which there are no premises.

LIR: The empty set of premises does not exist in this logic (there are neither premises nor conclusions), and logical truth as tautology is metalogically meaningless. The concept of tautology has meaning only when identity and non-contradiction are absolute Axioms CL1 and 2).

Restating the major aspect of the LIR semantics, I can say that the sense of truth that the semantics gives is the dynamic state of the event, phenomenon, judgment, etc, where the event is 'on the way', more or less, as the case may be, between its actualization and the potentialization of its contradiction. These considerations apart, there are some indications that the Fregean principle that general propositions have fixed truth values and truth conditions is not always valid. Reference can be determined by sense, that is meaning and concept, and context taken together.

There are no proofs in LIR in the semantic sense. The demonstrations are closer to those in science. Although not based on experiment, they purport to describe and explain in coherent manner aspects of processes and changes that are occurring or have occurred, by reference to a model of the elements involved and their interrelationships. LIR will always, therefore, exhibit aspects that are at the same time logical, scientific and metaphysical or ontological.

1.3.3 First-Order Predicate Logic (FOL)

Frege, Russell and Whitehead extended the term (or syllogistic or statement) system of deductive logic outlined above in the late 19th and early 20th century. Their purpose was to represent valid deductive arguments, also in mathematics and science, whose validity depended only on the logical structure of the arguments involved. Predicate logic of the first order has a calculus that consists of, in addition to the notations – symbols, connectives, punctuation marks, etc. of the statement logic – quantifiers and predicate variables and constants. The axioms are the axioms of propositional logic plus quantifiers of variables, of which the most used are: 'for all' $\forall$, and 'at least one' $\exists$. In FOL, there are two types of axioms: one refers to reasoning involving quantified statements, and other describes the subject matter involved such as sets in set theory.[17]

There are two ways of looking any logic, namely, how it is built up, and how it is used. For example, a first-order theory, e.g., in mathematics, is a formal theory for which the first-order predicate calculus suffices as the logical basis. Predicate logics of the second order essentially permit quantification over the quantifications of first order predicate variables. In all such logics, however, the elements are propositional or mathematical variables of some kind, the underlying classical logical concepts of truth and bivalence, remain unchanged. There is no implication that real events can be represented; the expressive power of second-order logic can be tied to computational complexity, not that of phenomena. Higher orders of logic possible by extension are no less abstract.

Standard first-order predicate logic has the curious feature that it validates $(\exists x)x = x$ but not $(\exists x)(\exists y)x \neq y$. This is due to the fact that in FOL, the domain of discourse is required to be non-empty, i.e., have at least one element. This makes it a logical truth that there is at least one thing, but not that there are at least two things. From the LIR standpoint, reality, of course, has the 'feature' of there being at least two things, namely, an element and its contradictory conjugate, and this is, accordingly, a logical truth. In free logics, on the other hand, general terms are allowed to have *no* existential import, that is, no real referent, although a separate existence predicate can be introduced. Free logics have interesting applications in mathematics and computer science, but they will

[17] The subsequent development of basic FOL is enormously complex, for example, the attempts to avoid paradoxes *via* a meta-mathematics and the demonstration of the incompleteness or inconsistency of formal systems by Gödel.

not concern us here. The 'existence' involved is only logical existence in the classical sense (Leblanc 1971). The variables in LIR, the 'reality values', are *not* bound by the FOL existential and universal quantifiers. Accordingly, problems due to the range of values not being the same for the two quantifiers do not arise: this concept of quantification is not applicable.

1.4 NON-CLASSICAL LOGICS

I have proposed above a non-propositional logic of and in reality that exhibits a number of features, including changes in the basic axioms, which make it are quite different from standard binary logics. However, other new logical systems were developed during the 20th century particular in response to the need to handle certain problems arising in the foundations of mathematics and situations involving incomplete or inconsistent data. These logical systems include intuitionist logic, paraconsistent logic, many-valued and fuzzy logics and modal and relevance logics. All of these logics, at least to a limited extent, recognize the existence of aspects of reality that are not captured by classical logic or its FOL extension. These need to be examined to determine to what extent they accomplish the objective I have set out for LIR.

1.4.1 Intuitionist, Paraconsistent and Paracomplete Logics

The major logical developments of the 20th century involved the demonstration, by da Costa and others, that rigorous logics could be constructed by rejecting the universal application of the second and third classical axioms: logics in which the axiom of non-contradiction does not apply but that of the excluded middle does are called paraconsistent; in the opposite case they are paracomplete. It is in this sense that Béziau has described them as 'duals'.

1.4.1.1 Intuitionist Logic and Paracompleteness

The most significant example of a paracomplete logic is intuitionist logic. Brouwer (1951) and Heyting were prompted to develop intuitionist logic as a basis for mathematical reasoning about infinite sets. Brouwer claimed that the law of the excluded middle cannot apply in mathematics, "once it has been recognized to be an autonomous interior constructional activity which, although it can be applied to an exterior world, neither in its origin nor in its methods depends on an exterior world". He thus rejected the application to mathematics of a classical binary logic of 'truth' and 'falsehood', and of the concept of truth as a relationship between language and an extra-linguistic reality. However, there is no indication in this work of a basis (or need) for applying such principles outside mathematics. He did not, apparently, formulate or show the necessity of a law of the *included* middle. His formulations contain idealized distinctions and processes that apply only within mathematics. As the law of non-contradiction is maintained, however, as shown by Priest and others, intuitionist logic remains closely related (congruent) to classical logic.

Another aspect of interest, however, relates to the concept of intuition as such. Brouwer's (Largeault 1993) concept of the non-mathematical aspects of intuitionism, apart from the rejection of the excluded middle, has a philosophical kinship with the idea in this book of a logical status of both intuition and knowledge: "intuitionist logic, despite its mathematical interest, is neither the strongest nor most essential part of intuitionism. A by-product of mathematical constructions (or of impossibilities of construction), it has no value of its own." Paracompleteness implies a fundamental incompleteness in a logical system. Neither of two elements is considered true by itself, and new concepts must be introduced to close the gap between them. I consider this a form of an included middle, as defined earlier, and the applicable logic would seem to be LIR. However, by **LIR2**, LIR is also paraconsistent, but in a new sense.

1.4.1.2 Paraconsistent Logic

The objective for which paraconsistent logic was introduced was to gain control of contradiction. Once it was recognized that both a proposition and its negation can be deduced from a given set of hypotheses, the set must remain non-trivial, that is, not require the deduction of anything. The characteristics of the negation must thus not be too strong, and at the same time they cannot be too weak, so that the contradictions in question are not purely illusory.

Priest has provided the most complete picture to date of a rigorous alternative, paraconsistent logic based on the existence of dialetheias – true contradictions – in semantics and mathematics (set theory), empirical science and social contexts (Priest 1987). A logic in which the inference from A and non-A to any arbitrary conclusion (explosion) is not valid is called paraconsistent (Priest 2000). Priest has said that the end of reverence for the logic of Aristotle could lead to a major revolution in human thought and to important new kinds of theory within science itself. On the other hand, LIR is based on the contradiction between A and non-A giving rise to a specific resolution (at another level of reality). Further, the paraconsistent conception is that A and non-A, or truth and falsity, are both actual at the same time, hence the contradiction. In LIR, if A is (predominantly) actualized, non-A is (predominantly) potentialized, and vice versa, alternately, without either ever disappearing completely. LIR should therefore not be considered paraconsistent in the same way, and I have therefore designated this logic elsewhere (Brenner 2006) as *transconsistent.*

Dialetheism and the Logic of Paradox (LP) proposed by Priest, which involve modification of the second axiom of classical logic as indicated, provide a solid basis for understanding set-theoretic and semantic contradictions (paradoxes), in terms of the truth or falsity of certain sentences or formulas, and a 'nexus' (nodal point of transition) which is both true *and* false, but at a single level of reality. It is thus a correct logic for aspects of language and mathematics in isolation, with single-level or two-dimensional self-reference. Priest has analyzed some real changes in these terms, such as simple motion (to which the Eleatic paradoxes apply) and the apparent passage of time, in which the contradictions that appear are considered to be of this type. However, the concepts of truth and falsity as used by Priest do not differ fundamentally from those used by classical logicians, and he provides no discussion suggesting the possible resolution of energetic 'contradictions' at another level of reality. The principle of dynamic opposition focuses on the dynamics of the *processes* by which changes come about in reality, in terms of their alternating actualization (A), potentialization (P) and the nexus here – the T-state – which is an included third term at another level of reality or complexity.

Other leading paraconsistent logicians, especially da Costa and his students of the Brazilian school, have made extensions of their logical systems to explore aspects of reality that involve key issues in the foundations of science (Béziau and Krause 2007). These include intertheoretic relationships, the individuality of quantum entities and reasoning, among others. However, they share the problem of the restrictions imposed by the concept of logic as a class of mathematical systems and their related formal tools, especially, standard set theory. I will refer to some of these extensions in my discussion of structure and physics in Chapters 5 and 6, and show how the principles of LIR might make extensions to the domain of application of *those* logics.

1.4.2 Many-Valued and Fuzzy Logics

The significance of many-valued and fuzzy logics to this discussion is that they provide for three or more truth-values. Because they recognize some aspects of reality, these logics are certainly better representations of it. Why then should LIR not simply be another many-valued or fuzzy logic? My answer is that such logics are still applicable only to the essentially idealized, abstract entities of propositional systems from which dynamic interactions are (almost completely) absent.[18] The only similarity between many-valued logics and LIR is that both deal with multiple values of 'something'. The following summary gives some examples:

Perhaps the first three-valued logic that contained a value other than 0, false, F and 1, true, T, associated with ½ or an intermediate or unknown value was that of Peirce (Hammer 2002). Similarly, in the three-valued logic of Lukasiewicz, sentences can take on the truth values of 0, ½ and 1. This is supposed to enable the description of the state of uncertainty or vagueness existing in the absence of complete knowledge by avoiding the dichotomy between truth and falsity (Priest 2001). To assign any real meaning to the third term, *i*, has proven, however, very difficult: in the Lukasiewicz logic and the logic of paradox LP of Priest, it is 'both true and false'; in the Kleene system, K_3, *i* means neither true nor false; neither the law of identity nor that of the excluded middle are valid; and there are no logical truths. Finally, in fuzzy logics, sentences can take on any truth-value *i* from and including 0 and 1.

Smarandache (2003) has provided a generalization of intuitionist fuzzy logic that is relevant to this study, despite its maintenance of (neo-) classical definitions of truth[19] and falsity. His "Neutrosophic Logic", NL, provides a very general framework for the description of many, if not all, classical and non-classical logics. It involves a combination of the formalism of non-standard mathematical analysis, the idea of tripartition (truth (T), falsehood (F) and indeterminacy (I)) applied to evidence and belief, and generalizations of fuzzy sets, taking on values of less than 0 to greater than 1. This scheme provides a model of human reasoning that seeks to capture the imprecision of knowledge and linguistic inexactitude; uncertainty due to incomplete knowledge and vagueness, lack of clear contours or boundaries of mental phenomena.

The claim is made for NL that it can also describe true contradictions in the real world (e.g., dialetheias). Opposing elements are labeled A, anti-A, and neut-A, which have the values of T, F and I respectively. Neut-A corresponds to something that is neutral (hence the name, neutrosophic logic) with respect to A and anti-A, but not to any contradiction (or counter-action).

However, the dynamic opposition that is the source of the emergence of the logical included middle (T-state) is not present in this system. Although, as with other logics, modal operators can be applied to the 3-term interval or field, and temporal and deontic neutrosophic logics can be constructed accordingly, NL is a basically static tool to measure the (static) truth values of A, anti-A and neut-A.

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[18] On the other hand, it is impossible to ignore the vast number of practical applications that fuzzy logics have found. In fact, without them, it would be difficult to imagine the management of real uncertainty in global economic and technical decision-making, 'soft computing' and knowledge engineering, as well as other areas in which computer science is essential such as artificial intelligence and neural networks. Books on fuzzy-logic-based programming and fuzzy logic for business, finance and management are bestsellers.

[19] Smarandache makes use of the Leibnizian notions of absolute and relative truth (truth in all worlds and truth in at least one world, respectively).

The existence of truth coming in multiple or continuous degrees, as Priest has pointed out, is not sufficient to resolve Sorites paradoxes (e.g., the point at which a 'child' becomes an 'adult'). In this scheme, there is still a point in the Sorites transition where the truth-value changes from *completely* true to *less than completely* true, and the existence of such a point seems to be intuitively problematic. This suggests that there is something fundamentally wrong, or at the very least not sufficiently general, with the concepts and properties of truth and falsity that continue to be used. The partial truth-values of the *related* propositions in the logics of Lukasiewicz and his followers do not change their basically binary characteristics.

In LIR, the intermediate truth-values are replaced by values corresponding to the degrees of actualization and potentialization of the phenomena themselves ('reality values'). The continuity of such values does not pose a problem, since at the 'point' of maximum contradiction, any emergent discontinuity involves another level of reality.[20]

1.4.3 Modal Logic

Modal logics are methods for formally accounting for the intuitions which accompany the large part of human thought devoted to non-actual situations, represented by the expressions "it is necessary that" and "it is possible that" applied both to physical processes and to the development and revision of beliefs. Modal operators that correspond to these expressions qualify, primarily, the propositions, judgments and other formulas of language. Temporal logic and deontic logic (of obligation) are also included in the group of modal logics. Modal operators can also be applied to propositions in other logics, for example, intuitionist, paraconsistent and quantum logics. In view of the central role of potentiality (non-actuality) as a property of real entities and processes in LIR, it seems reasonable to examine the structure and properties of modal logics to see to what extent they reflect the dynamics of reality.

In moving from non-modal to modal logics, one goes from an interpretation of a sentence *de dicto*, where the modal operator applies generally, to an interpretation of the same sentence *de re*, which picks out a particular individual. This distinction, due to the ambiguities in language, is still the source of much discussion, as it can be looked at from a syntactic, semantic or metaphysical

[20] The term 'orthogonal' for this situation, however, would not be felicitous, as it would imply the absence of a relation between the T-state and its precursors.

standpoint. In all cases, however, what is at issue are the kind of beliefs in the truth of statements or attributions, not the states of the objects of belief themselves.

My conclusion is that standard modal logics are not adequate to do the job of giving a picture of reality. The remarks in the previous section on truth-values hold, with minor modifications in the sense of their having their own systems of calculi, for modal logics. However, the basic notions of interest, *e.g.* of truth, are unchanged in these non- or neo-classical systems.

Non-modal logics characterize the difference between valid and invalid arguments using a formal semantics that provides a definition of validity by characterizing the truth behavior of the sentences of the system using standard truth tables. A semantics for modal logics can be defined through the concept of 'possible worlds', a formal approach to looking at different truth-values of the sentences being considered. Priest (2001) has described the problems involved in trying to assign some *physical or metaphysical* meaning to possible worlds as 'sets of propositions'. It remains unclear whether they are to be looked at as worlds with their own space-time or abstract entities, either existent or non-existent. To avoid a lengthy digression about whether objects in one world may fail to exist in another, I will consider only the world-relative or actualist interpretation[21] and assume that even if the domain of quantification changes from world to world, I need be concerned only with the entities that actually exist in *this* world.

The difficulties associated with possible worlds interpretations of modal logics have already motivated the abandonment of some classical rules in favor of a free logic. The significance of the development of free logics (FL) for LIR is that they take us closer to the real world *via* their modified rules for quantifiers. This is done by adding to the universal and existential quantifier, a predicate '**E**' for 'actually exists'. It should be noted, however, that the quantification remains, as in all of the logics discussed in this section, over formulas of the standard predicate logic. It has been considered an *objection* to FL that **E** appears to be an existence predicate, and the argument is made that existence is not a legitimate property. LIR, as a logic of/in reality, provides a happy home for such an ontological predicate.

The way to retain the value of the modal approach, in my view, is to abandon the underlying classical concept of non-contradiction that applies throughout. Following the basic axiom of Conditional Contradiction, phenomena can be considered neither totally necessary nor totally contingent, but subject to a degree of actualization and potentialization of necessity and contingency that is quantifiable. It is reasonable to consider values of LIR as defined by a 'reality' operator (see Section 1.7 on the 'reality function'). I agree with Frege's statement that notions of possibility and necessity must unavoidably be referred to human knowledge, but disagree that their place is, accordingly, outside logic.

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[21] The alternative, 'possibilist' interpretation assumes a single, fixed domain of quantification that contains all possible objects.

To summarize, LIR supports the notion of an objective modal reality, that is, one which the terms of necessity and probability express real and accordingly scientific aspects of nature, but avoids the associated dilemmas by reinterpreting their dynamics and establishing their interaction. I will discuss later why, in my extension of logic to reality, probability is preferable to possibility as a description of contingency.

1.4.4 Relevance and Natural Logics

There have been two approaches to propositional logic that have involved changes in the *function* of the concept of truth. I call attention to them here not because the concept of truth itself is modified, but because they are responses to perceived inadequacies of classical logic.

1.4.4.1 Relevance (or Relevant) Logics

These logics were developed, simply, following the observation that in classical logic, one can construct inferences in which the conclusion seems to have nothing to do with the premises; they are *irrelevant*. The same problem exists for certain paradoxes of logical implication. Subsequent development led to formal methods of resolving these paradoxes that will not be discussed here. In the process, however, the initial insight, that premises *should* in some way be relevant to conclusions was often lost.

One line of attack is of interest, as it involves a ternary relation, albeit a non-dynamic one in my terminology. It involves the concept of an accessibility relation ***R*** on three possible worlds. The truth condition for implication in this semantics is by Mares (Mares 1998), but it is the interpretations that are of interest here. One is that the world contains informational links such as laws of nature, for example, that two things are material carries the information that they attract each other. A similar view is that what is needed for an implication to be true is that the antecedent carries the information that the consequent obtains. The antecedent must be informationally relevant to the consequent.

In my LIR view, in the complex cause-effect relations in the real world, causal relations are *dynamically* relevant; cause is relevant to effect, but also *vice versa*. It can be shown that not all relevant relations are causal, but the overall form of the relevance approach seems to imply a relation between elements that is something like a principle of dynamic, interactive opposition. It is the existence and functionality of this relation that is explicated in LIR.

1.4.4.2 Natural Logic

Language is frequently considered to have its own logic, but one with its own rules, much more vague and difficult to formalize and axiomatize, despite its character as action. As a discipline, natural logic was an offshoot of the Operative Logic (*logique opératoire*) of Piaget. Its objective was to capture aspects of non-formal human reasoning and is defined most simply (Grize 1996) as a logic used spontaneously[22] for customary reasoning performed by means of everyday language. The point in this theory that relates it to a logic of/in reality involves a schematization of 'logical-discursive' operations in which what is essential is not a text or a discourse as such, but the underlying activity (pretext), the reality of language-in-use. A distinction is made in the domain of application of natural logic – to first person experience – and that of formal logic – to scientific observations.

Natural logic is thus always situated in a social context and is *not* subject or topic neutral. Formal, classical logic and the formal view of reasoning was specifically criticized by Grize as taking place in a closed domain, elaborated at some point from facts, but without further relation to reality. An absolute concept of truth is implicit in that premises are stated as such and their establishment is not required, and the only rule of deduction is *modus ponens.* Natural logic on the other hand is referred to not only as a "logic of subjects", but *also* as a "logic of objects", and care is taken to differentiate natural logic from formal logic also designated as a physics or logic of "any old object". This idea confers the particularity of context to objects and raises their ontological status, so to speak. In the logic of dynamic opposition, subject and object are dialectically and contradictorially related, according to Axioms **LIR2** and **LIR5**. LIR thus provides a framework for natural logic that I feel its practitioners would find acceptable. In particular, the failure of early attempts to relate natural logic to logics of action such as that of von Wright, in my view, was because such logics do not in fact adequately describe action and change.

[22] Note the resistance to assigning a possible dynamic origin to this natural logic, as if it were outside nature, cf. Chapter 5 on failures of explanation.

1.4.5 The Metalogic, Imaginary Logic and Empirical Logic of Vasiliyev

The logic proposed by Vasilyev [23] (Poli 1993) is of interest here because it brings into further relief the unique position of LIR. Vasilyev proposed a "universal", "non-Aristotelian" logical system, universal because it was in part more general than standard classical and neo-classical logics, non-Aristotelian because it rejected in part the axiom of non-contradiction (referred to by Vasiliyev in general as the law of contradiction). Vasiliyev has been variously considered as the forerunner of the multi-valued logics of the Polish school, as well as the paraconsistent logics of Priest, Routley and others. However, he was *not* a forerunner of a logic of the included middle. In fact, he extended the law of the *excluded* middle or third to encompass an excluded first, second and fourth.

Vasilyev's system consisted of a reworking of Aristotelian logic, referring to the real world, plus an imaginary logic, concerning imaginary worlds, worlds mentally created or imagined. What was new in this work was the idea that logical laws may vary in such worlds, anticipating aspects of normal and non-normal modal logics (Priest 2001). Vasilyev's "metalogic" is also of interest, since Vasiliyev claimed that it was at the same time the simplest and most general logic, characterized as "the foundation of our logic", "a logic of perfect cognition, with no negative propositions", "what is common to all logics", "a formal science of logic", and so on. Rather than go over Vasiliyev's presentation in detail, let me list the major characteristics of these logics (Table 1.1)

Table 1.1 The Logics of Vasiliyev

Logic	Propositions	Laws	Essential meaning
Metalogic	Affirmative	Excluded 2nd	Pure theory, no practical meaning; no relation to reality
Empirical logic	Affirmative and negative	Excluded 3rd	Conglomerate of pure logic and natural science; practical meaning; yielded by a process of life and struggle; logic serves cognition, cognition serves life, therefore logic serves life

(Continued)

[23] I am grateful to Professors Roberto Poli and Jean-Yves Béziau for their suggestions of the relevance of Vasilyev to this overview. Very little of Vasiliyev's work has been translated from the Russian, and I am indebted to Professor Poli for access to his brief biographical review and reprint of one of Vasiliyev's key papers.

Imaginary logic	Affirmative, negative and indifferent (both at once)	Excluded 4th	Logic of an imaginary world; negation of the law of contradiction (= excluded 4th); negation of the law of self-contradiction (= law of absolute difference between truth and falsehood)

Vasiliyev's tried to break the stranglehold of classical Aristotelian logic, by introducing contradiction into *something*, albeit in a way that was diametrically opposed to LIR. For Vasiliyev, "the law of (non-) contradiction addresses the world and objects, and asserts that contradiction cannot be realized in them. It forbids external contradiction, contradiction in objects; the law of non-self-contradiction, the law of absolute difference between truth and falsehood forbids internal contradiction, contradiction in a subject." As we have already seen, such distinctions between truth and falsity, subject and object remain the characteristics of standard, classical logics.

Vasiliyev's imaginary logic, however, has several aspects of interest, not because it provides a logic of reality or existence – by definition it does not – but it *refers* indirectly to such a possibility. Here are the suggested links:

- A proposition of contradiction is allowed, e.g., *S* is and is not *A* simultaneously, as in LIR, not as in Hegel and the other dialectical logicians.
- Such propositions, rejected by "earthly logicians", have a factual substantiation, a real substratum (perceptions and ideas).
- The imaginary world is the world of realized notions.
- The law of the excluded fourth correlates imaginary logic with the "earthly" logic of propositions of concepts (no temporal-spatial coordinates). The latter differs from propositions of facts (specific temporal and spatial moment). This point parallels the connection of two levels of reality by the *included middle*.

Despite the references to struggle and life, there are no dynamics in any of these propositional logics. Vasiliyev gives a textbook example of the second-rate ontological status generally allotted to heterogeneity and diversity when he defines "ambiguous" as the opposite of "homogeneous". But he does make one statement, in a footnote, which is worth reporting (emphasis mine):

> "Now it will suffice to say that imaginary logic *without* the law of contradiction is based on the introduction of direct negation, "perception of absence". *Imaginary logic would be real in a world with negative sensations, in a world with two contradictory kinds of being.*"

This is, in almost the same words, my description of the world we actually live in! Vasiliyev closes by saying that all contemporary movements in logic are a rebellion against Aristotle. "This rebellion progresses slowly, step by step, now here, now there. It is difficult to foretell the future." "… future generations will decide whether this contemporary movement in logic was a riot against Aristotle or a scientific revolution." (Poli 1993) I leave it to the reader to position Vasiliyev's work, and LIR, on this scale.

1.5 INDUCTIVE LOGIC AND ABDUCTIVE LOGIC: PROBABILITY

I recall that the major objective of LIR was to address the characteristics of real phenomena as a logic, and that this involved not only a set of three real values of actuality, potentiality and T-state but a explanation of the origin and evolution of their instantiation. The contrast I am making between LIR and other logics is to determine if and/or to what extent any of the latter in fact describe reality.

While the standard deductive logics, as shown in the previous Section do not accomplish this, there are other candidates. Inductive logics, which allow for intermediate, qualitative or quantitative, values of deductive validity, would appear to address aspects of real situations. In the next two Sections, I will call attention to the conceptual differences between inductive logic and LIR, similar to that made above for standard deductive logic. I will demonstrate that the notion of probability underlying quantum logic, which can be captured in LIR, provides a picture of reality that neither inductive logic nor the related abductive logic is capable of.

Classically, deduction was reasoning from the general to the particular, and induction was reasoning from the particular to the general. A simple modern formulation of the relation between deduction and induction is the following: there is just one form of logical argument, namely, a set of propositions, one of which is the conclusion, the rest premises. Deductive logic offers strict guarantees that the conclusion follows from the premises or not. Inductive logic (IL) allows for intermediate, qualitative or quantitative, values of deductive validity. In the formulation of Carnap, a given hypothesis H can be supported by evidence E that only *partially* deductively implies it. Carnap called it a theory of logical probability or degree of confirmation (Carnap 1947).

The first conceptual difference **D** between IL and LIR is the same as before:

D1: The statements in the language of LIR are not propositions in the usual sense, but 'models of reality' and their 'opposites' or 'contradictions'. There are no premises and no conclusions.

The concept of probability, however, is central to modern IL. Probability (Pr) is a function that comes in two forms, unconditional probability that a proposition *p* is true, and conditional probability, that a proposition *p* is true if a proposition *q* is true.[24] The degree of confirmation *C* is the degree of 'inductive strength' of an argument, measuring the degree to which the premises support the conclusion.

D8: The models of LIR have real energetic values. The reference to 'strength' in the previous paragraph is suggestive. Despite the absence of specific reference to the reasoning process as involving energy, there is perhaps an intuition of this underlying the metaphor.

In the axiomatization of Kolmogorov, a probability function is a measure function from a Boolean algebra[25] of propositions (or sentences in some formal language) to the unit interval [0,1] such that for all such elements X and Y in the algebra:

KIL1: $\Pr(X) \geq 0$
KIL2: If X is a logically necessary truth, then $\Pr(X) = 1$
KIL3: If X and Y are mutually exclusive, then $\Pr(X \vee Y) = \Pr(X) + \Pr(Y)$

KIL3 leads to the ratio concept for conditional probability, where Pr (Y) $\neq 0$, $\Pr(X \mid Y) = \Pr(X\&Y)/\Pr(Y)$

[24] The difference between conditional probability and the probability of the material conditional (implication) is not relevant since it applies *only* to propositions, and I am using inductive logic only as a *model* for LIR.

[25] A Boolean algebra is a set *B* of things, with two operations, usually + and –, satisfying axioms to the effect that the operations are commutative and distributive; that there is an identity element 1 for + and 0 for –; and that for every x there is a complementary element x´, such that $x + x' = 1$ and $x - x' = 0$.

I introduce these axioms[26] because of their relation to the concept of probability that is essential for construction of the formal axiomatization of LIR. In fact, that the values of actualization, potentialization and T-state that are the consequences of the initial set of axioms of LIR can be seen as analogous to probability and formalized accordingly.

D9: In LIR, the function is a probability-like 'reality' function, Rl, a measure function over an algebra of the non-propositional formulas of actualization, potentialization and T-state.

The relevant formal axioms for LIR are indicated below, following the discussion of quantum logic. The reason is that the 'reality model' that corresponds to the probability model here is based on a non-Boolean algebra and non-Kolmogorovian probability calculus, closer to those of quantum situations involving non-commuting sentential elements.

At the interface between induction and probability, Jaeger (2005) uses non-standard probability distributions to describe states of knowledge or belief that are either true or false that are called *subjective* probabilities. The objective is to allow both statistical and subjective probability terms to be interpreted over the domain of semantic structures. Although the logic of strict inference used is still based on first-order predicate logic, the presence in this system of two probabilities again reflects, in my view, that it is also related to the dynamic systems modelled in LIR.

The interest of inductive logic, in addition to being a model for LIR, is in some of its epistemological implications. As noted, logical probability, as a degree of potential confirmation, was considered by Carnap to be distinct from statistical probability. He used a definition for the latter as a "limit of relative frequency (s) in an infinite series of proofs", but this can be shown to be compatible with a traditional statistical point of view, that is, one describing the real world. Both frequency and the extension *l* are concurrently involved in the determination of the overall probability, but it is not a great step from here to the idea that they are contradictorially involved. In the discussion of non-classical logics by Dubucs (2000), the choice of an inductive method cannot itself depend on inductive arguments, "*one must resign oneself to seeing in the value of the (Carnap's) extension l an element irreducibly subjective and personal, the measure of the "inductive inertia" of each of us, that is to say the intensity (in both senses!) of our repugnance to*

[26] Other sets of axioms can be written for probabilistic inductive logic that consider probability as a function 'supporting' the conclusion. Combinations of logic and probability (e.g. Horn abduction) have been developed to combine evidential reasoning (abduction) with causal reasoning (prediction) in AI applications.

change our ideas in the light of experience (emphasis mine)." This statement points toward what a dynamic view of inductive logic might comprise, in which reference to human involvement does not automatically have to be excluded.[27]

1.5.1 Inference and Abductive Logic

The term inference was used above without definition, but it is necessary to state what it could mean for real elements, especially as the notion of inference will be essential for the consideration of LIR as a formal logic. Inference is a process limited to human thought and reasoning. Usually, one looks at the structure and properties of mental states and their constituents, and at what the roles of those constituents are *qua* their reference to sentences. However, since I replace the referents of inference to sentences by aspects or models of real phenomena, what are the consequences? Can I still talk legitimately about inference and/or patterns of inference?

I claim that I can. The inferences that I make are from the state of an entity that is primarily actualized to some estimate of its potentiality or forthcoming potentialization. The analysis involves looking at what interactive, antagonistic processes of attraction and repulsion or association and dissociation are involved, as well as the contradictory trends toward homogeneity or heterogeneity. Details of the structures and inferences from them depend on the level of reality under consideration, but the *pattern* of inference will be substantially the one indicated. In this, LIR resembles standard logics that are characterized by a limited number of patterns of inference.

The concept of abduction provides further support for this view. If induction is defined as a process of generation of new hypotheses, in most cases abduction is a process of evaluation, explanation and if possible quantification of hypotheses whose origin may well be induction. I will be inferring knowledge about properties that are not immediately observable, with the objective of explanation rather than prediction. The reason for mentioning abduction here is that the reasoning process used to develop LIR as a theory is primarily abductive. Inductive explanations do not provide any insight as to *why* things are the way they are. Abduction provides explanations only relative to a given theory, but that is all I ask of it. Peirce's original conception of abduction, cited by Flach and Kakas (2000), emphasizes its non-algorithmic character, which is compatible with LIR. In addition,

[27] Carnap felt that both deductive and inductive logics were independent of our subjective beliefs. "Just as deductive logic does not describe the manner in which we actually reason, inductive logic does not have the objective of representing the level of confidence that we attach personally to certain statements on the basis of certain facts."

however, "…abduction is logical inference having a perfectly definite logical form." In my view, while not constituted by propositions, LIR has a definite logical form, defined by the axiomatization above and at the end of this chapter.

Abduction is like induction in that the results of the process, that is, its truth-values, are not guaranteed. As has been suggested by Wang, induction and abduction are dual. In LIR terminology, the two systems resemble, for propositions, what one observes for real processes. They instantiate a 'structure' of alternation of application, and indeed abduction often follows a 'good' induction and *vice versa*, very much as the sequences of the kind implied by the Axiom **LIR2**.

Peirce saw the origin of abduction in intuition, but this should not be viewed negatively. In my LIR theory, intuition is a process of thought related dialectically to knowledge, and has a non-trivial logical and ontological status. A further discussion of inference and explanation is presented with the ontological construction in Chapters 4 and 5.

It has been necessary to make the above comparisons of LIR with various kinds of standard logics – deductive, inductive and abductive – in order to show the points of contact that insure that LIR, as an organized system of thought, not only shares many of the same characteristics, but represents a valid extension of those logics to reality. Further, that the statement that the logic of/in reality reduces to standard binary logic in the case of simple phenomena is not empty. It will be correct in all cases in which the interaction between two entities disappears, as when two individuals refuse a dialogue, or the interaction never existed, as in the terms of classical dilemmas and paradoxes.

1.6 QUANTUM LOGIC

In the theory presented in this book, normal phenomena are essentially considered as being non-classical systems, or having significant non-classical aspects that have not yet been explicated. To establish the logic of/in reality as a formal logic, in view of the differences with classical logic noted, it should first be accepted that a logic can exist for non-classical systems. Quantum logic, the logic of the elements of reality studied by quantum mechanics, provides such a formal model of a non-classical physical system.

There is an on-going debate about whether a realist interpretation of quantum mechanics (QM), one which does not require a primitive notion of measurement, or an operational view that interprets QM as theory of measurement is to be preferred. I claim that the logic of/in reality is a quantum-type logic with the quantum probabilities of the quantum logical structure replaced by the statistically determined and in principle measurable values A and P of the alternating actualization and potentialization of dynamically contradictory states. As in probabilistic logic, the values also do not include the limits 0 and 1, but are reciprocally determined between greater than 1 and less than 0 (limits are only approached, asymptotically).

In 1968, Putnam wrote that quantum mechanics requires a revolution in our understanding of logic *per se.* "Logic is as empirical as geometry. … We live in a world with a non-classical logic." Quantum mechanics (Wilce 2003) can be regarded as a non-classical probability calculus based on a non-classical propositional logic. Among other things, quantum logic focuses on the problem of the inability of measurement of two dependent quantities at the same time. Quantum mechanical states correspond to probability measures defined on an appropriate projection lattice of operators in a complex mathematical space (Hilbert space). This lattice requires a non-classical, non-Boolean logic for its description, which can be extended to other types of lattices, for example, of the properties of the system. In QM every probability-bearing proposition has the form "the value of physical quantity A lies in the range B", and as (Aerts et al. 2003) has shown the mathematical structure that is constituted by these values can represent some of the properties of sufficiently complex physical macroscopic systems.

To show that the concept of a non-distributive projection lattice would be applicable to the LIR approach requires further work. However, it is no problem that a truth-functional semantics cannot be provided for the LIR connectives, given the notion of truth as reality that is developed for LIR as a formal system in the next chapter. In any event, we have seen from the comparison of LIR and other classical and non-classical logics the major changes in the meaning of their components, such as the connectives, that must be made when moving to the extra-linguistic elements that are described by LIR.

On the other hand, it is possible to approach a logic of quantum entities and their behavior from the point of view of propositions about them. The use of paraconsistent logic has been studied most recently by da Costa and Krause, especially in relation to the interpretation of the concept of complementarity between particle and wave properties introduced by Bohr. I will return to the comparison of the LIR system with this epistemological discourse in Chapter 7. At present, I simply will outline the relation to a quantum formalism that I think appropriate to the axiomatization of LIR.

1.6.1 The Quantum Formalism of Aerts

The formalism developed by (Aerts et al. 2000) converts quantum mechanics into a system that can be applied to macroscopic phenomena, including space-time and the emergence of biological form and human cognition. The key point is that situations or entities that are intermediate between pure classical and pure quantum are not only possible, but their combined quantum and classical aspects can be described by different types of generalized mathematical structures. In this relatively quite new form of quantum logic, standard connectives themselves take on new, non-classical meaning, suggesting that, as in LIR, there is a close relationship between logic and quantum physics.

I will discuss the relevance of the Aerts formalism to LIR theories of physics and emergence after the formal aspects of LIR itself have been established. At this point, however, I wish to emphasize that despite the possible applicability of this formalism that I perceive (for there exists no literature as yet) there are fundamental differences between Aerts' program and mine for which the reader should be prepared. First, it makes no ontological commitment regarding the functional characteristics of the underlying particles and fields. His formal models are not directly concerned with *being*, that is the existence of the *substrates* that instantiate entities in real structures and processes. His theory is a theory of 'actions in the world' (Aerts and Aerts 2004). This approach does insist on the importance of the context in which an entity evolves, and the relationship between the entity and the context: it is referred to as context-driven actualization of potential (CAP) (Gabora and Aerts 2005). In the simple macroscopic systems chosen as examples, the Bell inequalities are violated, as they are by quantum particles that demonstrate non-locality. The interactions between system and context can thus be handled readily by the mathematical model. The criteria for analysis that develop from the application of the Bell inequalities allow an investigation of the probabilistic and *logical* structure of the available data. However, in talking about such violations of Bell's inequalities in language, Aerts says that not only are they not linked to contradiction, but "The contradiction *per se* is of no importance" (Aerts et al. 2005). Aerts thus excludes an essential role to what I have defined above as contradiction (or counter-action), that is, *dialectic* interaction. Something like the Aerts formalism for LIR may nevertheless be desirable, despite the difference in the metaphysical positions, and his theory will help to illuminate several aspects of my core thesis.

1.7 THE FORMAL AXIOMATIZATION OF LIR

A major concept of the logic of/in reality, as has also been developed in the analysis of inductive and quantum logic is that its logical values have the characteristics of probability. Accordingly, I will rewrite its axioms *as if* they followed a simple Kolmogorovian framework:

For all X and Y, if X and Y are not mutually exclusive, Rl is the reality function and A, P and T are the measures of actualization, potentialization and T-state of X and Y

LIRF1: $Rl(A_X) > 0$ and < 1

LIRF2: $Rl(P_Y) > 0$ and < 1

LIRF3: $Rl(A_X) + Rl(P_Y) = 1$

LIRF4: $Rl(A_X) = Rl(P_Y) = 1/2 \equiv Rl(T_{X,Y})$

In LIR, since no individual term is an identity, that is, unconnected to other terms, one has the same relation as that between a term and the context that perturbs it. Both the commutative law of standard logic,

$$(a + b) + c = a + (b + c) \tag{1.1}$$

and the distributive law between conjunction and disjunction

$$(a \vee b) \wedge c = (a \wedge c) \vee (b \wedge c) \tag{1.2}$$

do not hold. Any applicable formalism is, accordingly, non-Abelian and non-Boolean respectively, and the resulting probability distributions are non-Kolmogorovian. The detailed mathematics remain to be worked out for the LIR description of reality values as 'probability-like'.[28] However, as I will show in the discussion of quantum physics in Chapter 6, the Aerts' formalism is necessary but not sufficient to completely characterize real processes and relations in which relation between and the reciprocity of the elements "in contradiction" are at least as important as the elements themselves.

These axioms define the *relative* values of A and P. In states of any real system, the degree of actualization and potentialization will be more or less constant or in a process of more or less rapid change, following and preceding a period of relative stability. Description of these dynamic states will require some mathematical system that provides a structural representation of the interactions involved. Narens (2005) has studied a non-classical logic of events that models key properties of verifiability and refutability in science. He applies a Kolmogorovian

[28] These values are like objective probabilities which do not indicate limits of knowledge, but are about the properties that things objectively have.

probability function to a Boolean lattice of propositions in which, however, all of the connectives are those of classical logic. These notions can accordingly not be used for LIR since its logical constants and connectives are non-classical. Accordingly, I propose that the real systems described by LIR could be modeled by a non-Boolean, non-Kolmogorovian framework.

The LIR description of physical systems may follow the rules of quantum logic, as follows: one defines a logic of abstract constructions called test spaces, **B**, and physical systems are represented by probabilistic models, composed of the **B**'s and the set of states identified with the probability weights, Δ. For quantum systems, testable properties form a non-Boolean algebra of sets.

The claim of LIR is that real, macroscopic entities involving an antagonistic interaction at the biological and mental levels cannot be described by classical logic and classical physics. Although quantum mechanical entities are not directly involved in the higher level processes of which they are the ultimate components, a description of their behavior using something like the probability values of quantum systems is required.

The LIR conception of a semantics of reality values is not incompatible with *some* kind of measurement of them. As Dressner (2006) has shown in his discussion of the application of measurement theory to propositions, linguistic expressions that can be structured algebraically express propositional content, but they are at the same time logically and conceptually dependent on language. Although measurement theoretic propositions are abstract entities, they measure it semantically. Like the assignment of a utility value to a commodity *C* that reflects the preferential relation between *C* and others (non-*C*), LIR reflects the moving relations between terms that are relatively and reciprocally actual and potential. Measurement theoretic semantics anchors propositions in a global distribution of inference; decision theory anchors utility in a global distribution of preference; LIR semantics anchors processes in a global distribution of change. I want to include the possibility that reality values of actualization and potentialization can be measured in some macrophysical cases. Examples might be trends in social or political phenomena, the balance of power, or shifts in public opinion, or, at another level, the status of a book manuscript undergoing revision. At present, however, there exist no 'protocols' for making such measurements.

All real physical and non-physical systems involved in change are dissipative, that is they are subject as material systems to the 2nd Law of Thermodynamics according to which they involve a degradation of energy from a higher to lower level. At the same time, in the material systems of interest to LIR, non-linear feedback is present which, as I proposed above, involves a non-Boolean algebra and non-Kolmogorovian probabilities for the dynamic state of its elements. The axiom of the included middle, **LIR3** provides the logical basis for the emergence of new phenomena, whose physical basis is in a principle of differentiation equivalent but opposite to that of thermodynamics, namely, the Pauli Exclusion Principle for electrons and other particles with similar properties (cf. Chapter 4).

The ensemble of the six informal axioms in their non-Kolmogorovian versions will be the basis for the development of LIR as a formal but uninterpreted system in the next chapter.

References

Aerts, Diederik and Sven Aerts. 2004. Towards a General Operational and Realistic Framework for Quantum Mechanics and Relativity Theory. In *Quo Vadis Quantum Mechanics? Possible Developments in Quantum Theory in the 21st Century*, eds. A. C. Elitzur, S. Dolev and N. Kolenda. Berlin: Springer.

Aerts, Diederik, Ellie D'Hondt and Liane Gabora. 2000. Why the Logical Disjunction in Quantum Logic is not Classical. *Foundations of Physics* 30: 1473–1480.

Aerts, Diederik, Jan Broekaert and Liane Gabora. 2003. A Case for Applying an Abstracted Quantum Formalism to Cognition. In *Mind in Interaction*, ed. R. Campbell. Amsterdam: John Benjamins.

Aerts, Diederik, Marek Czachor and Bart D'Hooghe. 2005. Towards a Quantum Evolutionary Scheme Violating Bell's Inequalities in Language. In *Evolutionary Epistemology, Language and Culture*, eds. N. Gontier, J. P. van Bendegem and D. Aerts. Amsterdam: John Benjamins.

Batterman, Robert W. 2002. *The Devil in the Details. Asymptotic Reasoning in Explanation, Reduction and Emergence.* Oxford: Oxford University Press.

Beall, J. C. and Greg Restall. 2005. Logical Consequence. In *The Stanford Encyclopedia of Philosophy (Spring 2005 Edition)*, ed. Edward N. Zalta. http://plato.stanford.edu/archives/spr2005/entries/logical-consequence/

Béziau, Jean-Yves. 2003. Bivalence, Excluded Middle and Non-contradiction. In *The Logical Yearbook 2003*, ed. L. Behounek. Prague: Academy of Sciences.

Béziau, Jean-Yves. 2006. Many-Valued and Kripke Semantics. In *The Age of Alternative Logics.* Dordrecht, The Netherlands: Springer.

Béziau, Jean-Yves and Décio Krause. 2007. New Trends in the Foundations of Science. *SYNTHESE* 154: 345–347.

Brenner, Joseph E. 2006. A Transconsistent Logic for Model-Based Reasoning. In *Proceedings of the 2004 Pavia Conference – Model-Based Reasoning in Science and Engineering*, ed. L. Magnani. London: King's College Publications.

Brouwer, Luitzen E. Jan, 1951. *Cambridge Lectures on Intuitionism*. http://home.mira.net/~gaffcam/phil/brouwer.htm

Carnap, Rudolf. 1947. *Meaning and Necessity*. Chicago, IL/London: The University of Chicago Press.

D'Espagnat, Bernard. 1979. *A la recherché du réel*. Paris: Gaulthier-Villars.

Dressner, Eli. 2006. Measurement Theoretic Propositions. *SYNTHESE* 153: 1–22.

Dubucs, Jacques-Paul. 2000. *Logiques Non-classiques. Encyclopedia Universalis*. Paris: Encyclopædia Universalis.

Flach, Peter A. and Antonis C. Kakas, eds. 2000. On the Relation Between Abduction and Inductive Learning. In *Abductive Reasoning and Learning* Dordrecht, The Netherlands: Kluwer.

Gabbay, Dov. 2001. Anti-formulas, Anti-elements and the Logic of Deletion. *Computational Linguistics Colloquium*: Winter 01. Saarbrücken: Saarland University.

Gabora, Liane and Diederik Aerts. 2005. Evolution as context-driven actualization of potential. *Interdisciplinary Science Reviews* 30: 69–88.

Grize, Jean Blaise. 1996. *Logique naturelle et communications.* Paris: Presses Universitaires de France.

Hammer, Eric. 2002. Peirce's Logic. *Stanford Encyclopedia of Philosophy (Winter 2002 Edition)*, ed. Edward N. Zalta. http://plato.stanford.edu/archives/win2002/entries/peirce-logic/

He, Hua-can and Zhi-tao He. 2006. *Philosophy Significance of Universal Logic*. Xi'an, China: Northwestern Polytechnic University of China Press.

Hofweber, Thomas. 2005. Logic and Ontology. In *The Stanford Encyclopedia of Philosophy (Summer 2005 Edition)*, ed. Edward N. Zalta. http://plato.stanford.edu/archives/ sum2005/ entries/logic-ontology/

Iacona, Andrea. 2005. Rethinking Bivalence. *SYNTHESE* 146: 283–302.

Jacquette, Dale. 2002. *Ontology.* Montreal, Canada: McGill-Queen's University Press.

Jaeger, Manfred. 2005. A Logic for Inductive Probabilistic Reasoning. *SYNTHESE* 144: 171–180.

Kauffman, Stuart. 1995. *At Home in the Universe*. New York/Oxford: Oxford University Press.

Kistler, Max. 2006. Reduction and Emergence in the Physical Sciences: Reply to Rueger. *SYNTHESE* 151: 347–354.

Leblanc, Hugues. 1971. Truth-Value Semantics for a Logic of Existence. *Notre Dame Journal of Formal Logic* XII: 153–168 .

Largeault, Jean. 1993. *La logique. Que sais-je?* Paris: Presses Universitaires de France.

Lupasco, Stéphane. 1979. *L'Univers Psychique.* Paris: Denoël-Gonthier.

Lupasco, Stéphane. 1987. *Le principe d'antagonisme et la logique de l'énergie.* Paris: Editions du Rocher (originally published in Paris: Éditions Hermann, 1951).

Mares, Edwin. 1998. Relevance Logic. In *The Stanford Encyclopedia of Philosophy (Summer 1998 Edition)*, ed. Edward N. Zalta. http://plato.stanford.edu/archives/sum1998/entries/logic-relevance/

Narens, Louis. 2005. A Theory of Belief for Scientific Refutations. *SYNTHESE* 145: 397–423.

Nicolescu, Basarab. 1982. Sociologie et mécanique quantique. *3^{e} Millénaire* 1: March-April. Republished in *Nous, la particule et le monde*. Editions Le Mail: Paris (1985).

Nicolescu, Basarab. 2002. *Manifesto of Transdisciplinarity.* Albany, NY: State University of New York Press.

Poli, Roberto. 1993. Vasil'év, Nicholas A., Logic and Metalogic. Imaginary (non-Aristotelian) Logic. *Axiomathes* 3: 325, 329, 351–353.

Poli, Roberto. 2001. The Basic Problem of Levels of Reality. *Axiomathes* 12: 3–4.

Poli, Roberto. 2003. Descriptive, Formal and Formalized Ontologies. In *Husserl's Logical Investigations Reconsidered*, ed. D. Fisette. Dordrecht, The Netherlands: Kluwer.

Priest, Graham. 1987. *In Contradiction.* Dordrecht, The Netherlands/Boston/Lancaster, U.K. Martinus Nijhoff Publishers.

Priest, Graham. 2000. Paraconsistent Logic. *Handbook of Philosophical Logic*, eds. D. Gabbay and F. Guenthner. Dordrecht, The Netherlands: Kluwer.

Priest, Graham. 2001. *An Introduction to Non-classical Logic.* Cambridge: Cambridge University Press.

Rescher, Nicholas. 1996. *Process Metaphysics.* Albany, NY: State University of New York Press.

Smarandache, Florentin. 2003. http://www.gallup.unm.edu/~smarandache/eBook-neutrosophics2.pdf

Wilce, Alexander. 2003. Quantum Logic and Probability Theory. *The Stanford Encyclopedia of Philosophy (Spring 2003 Edition)*, ed. Edward N. Zalta. http://plato.stanford.edu/ archives/ spr2003/entries/qt-quantlog/

2 LIR AS A FORMAL SYSTEM

Abstract The definition of LIR as a formal system in this chapter is based on a calculus that defines reality values of actualization, potentialization and T-state axiomatically set out in Chapter 1 that are the LIR equivalents of truth values in standard logics. The further essential aspect is a view of logical implication as a dynamic process, that is, a formal structure that is applicable to physical reality. These operational aspects of the LIR calculus relate these values to the real process entities that are the elements of LIR as systems of systems of processes, showing the trends or tendencies of these chains of elements toward contradiction or non-contradiction. Other properties of LIR as a logic are discussed including the LIR definitions of conjunction and disjunction and a classification table for its connectives. A brief comparison is made to calculi of events and relations.

2.1 THE NON-CLASSICAL CALCULUS OF LIR: IMPLICATION

At this point, LIR is formally an uninterpreted system. Later, I will present the categorial components of the theory that will be the basis for its *ontological* interpretation. Nevertheless, as implied above, the modifications made in the standard ideas of a logic have not been made in a classical logical context. They have been made with reference to real, complex processes and events, in particular, those present at quantum, macroscopic biological and cognitive levels of reality. Basic differences between LIR and standard logics, for example, in the meaning of implication and the conditional have been outlined.

However, I have not yet introduced any symbols for the language of LIR, other than **e** (and non-**e**) for an arbitrary element. The notation I will now follow was developed by Lupasco and as far as I know used only by him (Lupasco 1987). Axioms **LIR2** and **LIR3** can be written as follows. Where **e** is any real-world element involved in some process of change; e_A means that **e** is predominantly actual and implies $\bar{e}_P$ meaning that non-**e** is predominantly potential; e_T and $\bar{e}_T$ mean that **e** in a **T-state** implies non-**e** in a **T-state** (where T-state, as indicated, is the included middle element emerging from the point of maximum interaction between **e** and its 'partner' non-**e**); and $\bar{e}_A$ means that non-**e** is predominantly actual implying e_P , that is, that **e** is potential.

$$e_A \supset \bar{e}_P,\ e_T \supset \bar{e}_T,\ \bar{e}_A \supset e_P \tag{2.1}$$

Including the concept of contradiction, I write, using **C** for contradiction

$$\begin{aligned}
(e_A \supset \bar{e}_P) &\supset \bar{C}_A \supset C_P \\
(\bar{e}_A \supset e_P) &\supset \bar{C}_A \supset C_P \\
(\bar{e}_T \supset e_T) &\supset \bar{C}_P \supset C_A
\end{aligned} \tag{2.2}$$

In this notation, **e** actual implies **non-e** potential implies **non-contradiction** actual $\bar{C}_A$ which in turn implies that **contradiction** is potential C_P ; similarly, **non-e** actual implies **e** potential also implies **non-contradiction** actual and **contradiction** potential; and **e-Tstate** implies **non-e-Tstate** implies **non-contradiction** potential, $\bar{C}_P$, implies **contradiction** actual C_A .

The symbol $\supset$ is normally used as a 'truth-function' for the simple English material conditional (or material implication) – 'if → then'. It is, unfortunately, easy to show that the simple definition does not work in many cases, that is, it leads to meaningless or obviously false conclusions. Rather than go into the details of these demonstrations, I simply suggest that implication in the LIR system is *syntactic* since it depends only on the syntax or grammar of the language of LIR. As indicated, this involves 'dynamic' elements of reality to be defined. In contrast, *semantic* implication depends on the (well-formed) formulas of the language being 'true'. A well-formed formula is syntactically valid if and only if there is a deduction of it without premises. LIR as a formal structure has no premises to which standard deductive or inductive rules of inference could be applied. One starts with an assessment of the state of a dynamic system, and implication refers to what one could infer about synchronic or diachronic states. This process is syntactical, which permits a dynamic interpretation of it – 'implying-as-a-process' – in the further discussion of the calculus.

2.2 TRUTH VALUES, CONTRADICTION AND REALITY VALUES

The idea that reality can be considered as composed of some values of actualization, potentialization and T-state, is critical to all further discussion of LIR as a *calculus*, as the application of the fundamental postulate to phenomena results in a radical departure from the standard notions of truth and falsity. This further postulate, as formulated by Lupasco (1987), is that the notion of 'truth' refers to the *status* of the dynamic, contradictory interaction between a real element and its opposite, **e** and **non-e**. In other words, what is 'true' about the two elements is that each is in some state of actualization and potentialization compared to the other. One may look here for an analogy with Aristotle's original intuition of the 'underlying things' that make statements true, as I discuss below in relation to the correspondence theory of truth, but LIR focuses on Aristotle's implication that these 'things' were logically structured. However, Aristotle also defined facts and things as contingent, by opposition with the necessary truth of propositions, thus prejudging an indeterminist view of the real world. As we will see, the relationship of chance and necessity receives another interpretation in my system.

In LIR, there are thus four 'true things' that exist. To avoid confusion with the T-state, I will use the symbol V as a sentential operator meaning the 'truth of ' the term or element **e** and the subscripts refer to its actualization and potentialization: Ve_a, Vnon-e_a, Ve_p, Vnon-e_p. An object, a process, a true proposition or a truth in the above sense, as a predominately actualized phenomenon, is never found in isolation. To every actualization, which is true as a consequence of its actualization, that is, to every truth, always corresponds a potentialization, also true as a consequence, of the contradictory element, giving rise to the contradictory truth of the potentialization. The term truth is to be preferred over validity since the latter implies less of a real existence of the respective states and could be confused with the proof-theoretic notions of validity in standard propositional logic.

What is true is true as a function of the actualizations and potentializations possible in a real process; since each of these is relative (sum to 1 by Axiom **LIRF3**), the four true terms (truths) of the quadruple are also relative, like the partial non-contradictions from which they derive. Thus for every actualization of a thing, proposition, whatever, which is accordingly true – a truth, always corresponds a potentialization, also accordingly true, the contradictory or 'negative' truth of existential potentialization. This means that potentialization must be given equivalent ontological status as actualization. An alternative formulation is that there are two 'trues' which can be in turn actual and potential, the former positive and the second negative: V_a and V_p, non-V_a and non-$V_{p.}$ In this expression, V now stands for the value of this truth as a variable, the 'reality value' of truth, rather than an operator. The concept of a contradictory 'negative' truth does not imply some kind of unbridled cultural relativism. Rather, it is an existential expression of the contingency in any real reasoning process.

Lupasco assigned the term ‘false’ to what is contradictory and that it is contradiction that logically defines a ‘falsity’ in this sense. ‘False’ is accordingly replaced by the **T** – state = 1/2A//1/2P, the state of semi-actualization and semi-potentialization of both elements. This produces an actual (real, ‘true’) contradiction $\text{Fe}_{\mathbf{T}}$, where F means “false” and potentializes the non-contradiction $\text{Fnon-e}_{\mathbf{T}}$. This should be read: “It is false that **e** is not in a **T-state**.”

There are thus two truths, one positive or affirmative or ‘of identity’ and the other negative or ‘of non-identity’, attributed to the logical values (elements) themselves, **e** and **non-e** respectively. Since these have the possibility of being respectively actual, potential or neither, under the conditions indicated above, the notion of falsity as such disappears, as noted: the two truths produce non-contradiction when one of them is actual and the other potential. This non-contradiction can be considered as a true relative non-contradiction or as a truth of relative non-contradiction. The same two truths produce contradiction when they inhibit themselves reciprocally (by Axiom **LIR3** of the Included Middle) and prevent themselves from being able to actualize themselves fully with respect to one another, a contradiction that appears (or emerges) accordingly as a relative (non-absolute) contradiction. What is understood as ‘false’ in classical logic is redefined in this way as the truth of (the existence of) contradiction.

A truth cannot be absolute, because it can never be rigorously (totally) actualized; the contradictory truth can be potentialized as much as one wants without ever completely disappearing in reality. To repeat, what I am doing here is taking the joint consequence of application of the Axioms **LIR2**, **5** and **6** of Conditional Contradiction, Functional Association and Asymptoticity respectively to truths considered as phenomena. The non-contradiction that is present will accordingly never be absolute either and will always include an irreducible amount of contradiction. Similarly, contradiction can never be considered as absolute, because it never takes place between two rigorously actual, absolutely contradictory elements. Contradiction never occurs except between antagonistic dynamisms that mutually and reciprocally instantiate each other. Since they are dynamisms, no matter how far they are from their potential states, they still inhibit one another’s full instantiation and therefore the element predominantly potentialized possesses an irreducible residual margin of actualization. Contradiction is actual, or relatively actualizes itself when it results in **T-states** as we have seen, and as potential, when the relative non-contradiction of the A and P states represses it. One can therefore write, where **C** refers to contradiction as above; **T-s** here refers to the **T-state**, and V refers, again, to positive and negative truth in the above sense, or in a T-state, $V_{\text{T-s}}$. Eliminating the notion of “falsity” as such:

$$({}_{+}V_{A}.\ {}_{-}V_{P}) \supset (\overline{C}_{A}.C_{P})\ ;\ ({}_{-}V_{A}.\ {}_{+}V_{P}) \supset (\overline{C}_{A}.C_{P})\ ;\ ({}_{+}V_{T\text{-}s}.\ {}_{-}V_{T\text{-}s}) \supset (C_{A}.\overline{C}_{P}) \quad (2.3)$$

Alternatively, since the implications are reciprocal:

$$(\overline{C}_{A}.C_{P}) \supset [({}_{+}V_{A}.\ {}_{-}V_{P}) \vee ({}_{-}V_{A}.\ {}_{+}V_{P})]\ ;\ (C_{A}.\overline{C}_{P}) \supset ({}_{+}V_{T\text{-}s}.\ {}_{-}V_{T\text{-}s}) \quad (2.4)$$

This can be said as follows: if there is non-contradiction, more precisely actual non-contradiction and potential contradiction, then there are two contradictory truths of which one actualizes itself at the expense of the other, which is potentialized as a consequence. If there is a contradiction, then there are two contradictory truths that repress each other reciprocally and mutually prevent that state of affairs, namely, that one is completely actual and the other completely potential. This formulation of the properties of contradiction constitutes the fundamental rule of contradictorial methodology, as we will see throughout this book.

Let us now look at a further formalism that follows from the replacement of the values of True and False in standard logical truth tables by values measuring the degree of actualization, potentialization and T-state. Starting with (2.6), the symbol **T** refers *exclusively* to the **T-state**, the logical included middle defined by Axiom **LR3**.

$\underline{e}$	$\underline{\overline{e}}$		$\underline{e}$	$\underline{\overline{e}}$	
True	False		A	P	
False	True		T	T	(2.5)
			P	A	

The following table combines the above with the concept of contradiction: when there is actualization and potentialization of logical elements, their non-contradiction is always partial, incomplete, and when two contradictory elements are neither actual nor potential, non-contradiction is potentialized, as in (2.6).

$$\begin{array}{cccc} \underline{e} & \underline{\bar{e}} & \underline{\bar{C}} & \underline{C} \\ A & P & A & P \\ T & T & P & A \\ P & A & A & P \end{array} \tag{2.6}$$

Such contradiction, however, cannot take place between two classical terms that are rigorously or totally actualized or absolute, that is, where the axiom of non-contradiction holds absolutely.

The consequence is that no element, no logical variable or event can be rigorously non-contradictory; it always contains an irreducible quantity of contradiction. However, contradiction also, no matter how much developed, is always is relative and non-absolute, due to the fact that this logic is a direct logic of elements in dynamic opposition, and not a logic of language, that is, a linguistic-ontological theory of truth.

2.2.1 Other Theories of Truth

There is, of course, a vast literature on the subject of truth. In view of the drastic modification made in the notion of truth in the last sections, it is important to see if any part of it exists in any other of the various theories of truth, I will thus contrast some of their salient elements with truth in LIR.

1. The above concept of truth in relation to actualization and potentialization is clearly not *deflationary*. The deflationary theory of truth considers it a semantic notion, limited exclusively to propositions, and the source of no logical or metaphysical questions. LIR, however, does find useful meaning for the concept of truth outside propositions. One could therefore consider it an *inflationary* theory, one in which something is *added* to a simple notion of truth (although this would place it a collection of concepts from binary logic that are totally unrelated.)

2. Truth in LIR does have the properties of a *correspondence theory* of truth, that is, one in which the truth conditions of propositions, sentences, judgments, etc. – 'truth-bearers' – are given by a relevant relation (cf. the discussion of relevance above) – correspondence, agreement, accordance – with some portion of reality – facts, states of affairs, objects, etc. – 'truth-makers'. However, in LIR, the emphasis is reversed: it focuses primarily on

the dynamic phenomena and their evolution and secondarily on sentences that describe the activity.

In a key paper, Mulligan et al. (1984) derive a notion of the entities that make sentences true from the Husserlian version of 'moments'. They propose events and/or objects-plus-tropes[1] rather than facts as the corresponding portions of reality, as they regard facts as too sentence-like, with which I concur. However, their approach to a theory of truth relies ultimately on neo-classical notions of essential parts and wholes and their total separation. Simons' program is well summarized in the following citation (Simons 2000, 139): "That this or that individual is an essential part of something is so of analytical necessity and not because of natural, metaphysical or logical necessity.[2]"

The theory of truth-makers has now been criticized along lines that are similar to the rejection in LIR of unnecessary entities in other domains, and for other deficiencies, including inability to handle negative truths. (Negative operations and concepts are, in LIR, given the same ontological status as positive ones. A negative statement is true not because something exists that necessitates its truth, but because the property was absent) For a truth to be grounded is not for a binary relation to obtain between a proposition and a truth-maker, A grounding relation consists in the existence of sub-sentential thought/world relations and the fact that the object instantiates the property in question (Dodd 2007).

2.2.2 Verificationism

Verificationism and verificationist doctrines are of interest at this juncture because they are areas of reasoning in which concepts of truth intersect concepts of reality, and standard logics have had an important role in their understanding and evaluation. There are three examples I will cite in increasing order of relevance to LIR and to the concept of realism that should be associated with it. This brief

[1] LIR sees both objects and relations as processes, and these in turn as concatenations of systems of systems and/or classes of classes. Defining properties and relations in terms of "tropes", i.e., instances or bits of a property or relation, and existence as bundles or complexes of tropes, adds little to a description of the underlying reality and seems to retain some of the idealism of concepts of individuals and universals that tropes were purported to obviate (cf. article "Tropes" in the *Stanford Encyclopedia of Philosophy*).

[2] The quotation defines an interesting domain of philosophical inquiry, but I will not comment on it here except to say that it demonstrates an example of the possibility of dynamic opposition between theories, cf. Chapter 5.

survey should be seen as another of the several attempts I have made and will make to delineate the specific characteristics and domains of application of LIR.

1. One version of verificationism states that what is true can be known – all truths are knowable. However, this anti-realist position leads to the logical conclusion that all truths are known. According to Marton (2006), some anti-realists claim that if classical logic proves that verificationism is untenable, then classical logic must be wrong. The verificationist counter is to invoke intuitionist logic and the concept of something being true that is completely different from being a realist fact. These facts are not truths, but are somehow involved in their definition. This view, however, has additional problems with it. Simply, my conclusion is the same as that of Marton: this kind of verificationism should be limited to theoretical areas where no contingent facts (that is, no areas of reality of the kind with which LIR is concerned) are considered.

2. Verificationism, for Dummett (1993), is a theory of meaning of sentences that replaces a truth-conditional meaning theory in which truth is the central notion. This leads rapidly to circularity. Verificationism defines a variety of alternative methods that establish a sentence as true, such as observation or argument. Verification is to say that "that in which an understanding of the sentence consists in an ability to recognize, whenever presented with it, whatever we take to count as establishing its truth" (the 'criterion'). The resulting notion of truth, significantly for this study, is not subject to the principle of bivalence, since it is the observation that sentences exist in the language that can neither be verified nor falsified is one reason for rejecting the truth-conditional theory of meaning. This stance remains an anti-realist one (see Chapter 6), since it claims that if our statements and thoughts are not all determinately true or false, reality itself is (fundamentally) indeterminate. However, in an anticipation of some of the positions in this book, Dummett suggests that the verificationist who is not satisfied with this result "will adopt a semantic theory yielding a non-classical logic – quantum logic or, more probably, intuitionist logic". LIR is, of course, my preferred candidate for this job.

3. Ladyman and Ross (2007) state that their naturalist metaphysics, a "dialectical combination of realism and empiricism", is equivalent to adopting a verificationist attitude to both science and metaphysics. These authors' verificationism, however, is verificationism about epistemic value derived from empirical science and the empirically measured boundaries of the real, not about meaning. Verificationists, on this view, restrict acceptability in metaphysics to entities defined by a *physical*, as opposed to a logical or mathematical perspective. "No empirical science is responsible for counter examples

drawn from just anywhere in the possibility space allowed by *currently accepted logic* (emphasis mine) and mathematics."

The key question is, then, whether LIR has a capability that 'currently accepted logic' does not. To what extent can one say that logic in reality, in contrast to mathematics and first-order predicate logic, has empirical characteristics that would enable its 'patterns' to be verifiable? I will return to this question in Chapter 6, where I will compare the realism of Ladyman and Ross with that of LIR.

2.3 IMPLICATION BETWEEN THE LIMITS

The fundamental postulate and its formalism can also be applied to logical operations, answering a potential objection that the operations themselves would imply or lead to rigorous non-contradiction. Thus: **e** (actual or potential) implies **e** (actual or potential) is impossible rigorously because **e** also implies **non-e**, or else, because **e** implies **e** implies at the same time that **e** excludes **e**. Inversely, **e** excludes **e** is impossible rigorously since **e** implies, at the same time, **e**. I thus write, in place of $e_A \supset \bar{e}_P$, the actualization of **e** implies the potentialization of **non-e**, the symbol $\overline{\supset}$ for exclusion or non-implication, or, preferably, negative implication, such that:

$$(e \supset e)_A \supset (e \mathbin{\overline{\supset}} e)_P \text{ or } (e \supset_A e) \supset (e \mathbin{\overline{\supset}}_P e)\text{. Similarly,}$$

$$(e \mathbin{\overline{\supset}} e)_A \supset (e \supset \bar{e})_P \text{ or } (e \mathbin{\overline{\supset}}_A e) \supset (e \supset_P e)\text{, and for the T-state}$$

$$(e \supset e)_T \supset (e \mathbin{\overline{\supset}} e)_T \text{ or } (e \supset_T e) \supset (e \mathbin{\overline{\supset}}_T e) \tag{2.7}$$

Since actualization and potentialization thus apply to the operation of implication, **e** can be neglected, since it is any element, and the reciprocal contradictional implications can be written as follows:

$$(\supset_A) \supset (\overline{\supset}_P)\,;\ (\overline{\supset}_A) \supset (\supset_P)\,;\ (\supset_T) \supset (\overline{\supset}_T) \tag{2.8}$$

This should be read: if an implication is actualized, an exclusion or negative implication is potentialized; if a negative implication is actualized, an affirmative or positive implication is potentialized, and if a positive implication can be neither actualized or potentialized, a negative implication cannot be potentialized or actualized.

One can therefore proceed, as previously for elements, to construct a table of values for contradiction and non-contradiction:

$$\begin{array}{cccc} \supseteq & \overline{\supseteq} & \overline{\subseteq} & \subseteq \\ \mathrm{A} & \mathrm{P} & \mathrm{A} & \mathrm{P} \\ \mathrm{T} & \mathrm{T} & \mathrm{P} & \mathrm{A} \\ \mathrm{P} & \mathrm{A} & \mathrm{A} & \mathrm{P} \end{array} \tag{2.9}$$

Written for implication, the contradictional conjunctions and disjunctions are, therefore:

$$\begin{gathered} \supset_{\mathrm{A}} . \overline{\supset}_{\mathrm{P}} ; \overline{\supset}_{\mathrm{A}} . \supset_{\mathrm{P}} ; \supset_{\mathrm{T}} . \overline{\supset}_{\mathrm{T}} ; \text{and} \\ (\supset_{\mathrm{A}} \overline{\supset}_{\mathrm{P}}) \vee (\overline{\supset}_{\mathrm{A}} \supset_{\mathrm{P}}) \vee (\supset_{\mathrm{T}} \overline{\supset}_{\mathrm{T}}) \end{gathered} \tag{2.10}$$

2.3.1 The Transfinite

At this point, I need to introduce a term that describes the behavior of real processes and systems. The LIR concept of real processes is that they are constituted by series of series of series, etc., of alternating actualizations and potentializations. However, these series are not finite, for by the Axiom **LIR6** of Asymptoticity they never stop totally. However, in reality, processes *do* stop, and they are thus not infinite. Following Lupasco, I will use the term transfinite for these series or chains, which are called ortho- or para-dialectics.

The term infinite refers to a set of elements, such as the integers, which has no upper bound or limit, or set of process steps that can be repeated indefinitely (iterated) without any basis for stopping. The term applies also to the oscillations of the mind between two equally likely but opposite statements, as in paradoxes of self-reference. The difference between finite and infinite has also now received formal treatment in the concept of programs of idealized computers (Turing machines) that do and do not stop respectively.

The term transfinite goes back to Cantor, who tried to resolve what he called the paradoxes of absolute infinity by introducing an 'increasable actual-infinite' and an "undetermined quantity which is capable of innumerably many determinations", as opposed to the a Hegelian conception of a true infinite, a completely generated infinity. The LIR transfinite looks very much like what Priest quotes Hegel as saying is the false or potential infinite, which is:

> … the problem of attaining the infinite, not the actual reaching of it; it is the perpetual generation of the infinite, but it does not get beyond quantum (a real value), nor does the infinite become positively present.

Priest thinks that a potential infinity, for which no precise definition has been given, at any stage of its existence, is, after all, never more than finite. Hence it is not truly infinite. I agree with the latter phrase, but not the previous one. The LIR transfinite seems well described by the Hegel statement, although the latter has no dynamic basis. It is clear that the 'truly' infinite does not exist in reality. There can only be "perpetual generation" that does arrive at some real value.[3]

The terms in (2.11) thus develop into a transfinite series of disjunctions of implications:

$$\left(\supset_A \bar{\supset}_P \vee \bar{\supset}_A \supset_P\right) \vee \left(\supset_A \bar{\supset}_P \vee \supset_T \bar{\supset}_T\right) \vee \left(\bar{\supset}_A \supset_P \vee \supset_T \bar{\supset}_T\right)$$

etc.... , etc....

(2.11)

However, every implication implies a contradictory negative implication, such that the actualization of one entails the potentialization of the other and that the non-actualization non-potentialization of the one entails the non-potentialization non-actualization of the other. This leads to the tree-like development of chains of implications, of which one example is indicated in the following diagram:

[3] This is my interpretation of what Lupasco meant by his lapidary statement, unfortunately never elaborated: "It is evident, also, that the notions of infinite and transfinite as used by Cantor need to be revised" (Lupasco 1987).

$$(\supset_A) \supset (\bar{\supset}_P) \begin{cases} [(\supset_A) \supset_A (\bar{\supset}_P)] \supset [(\supset_A) \bar{\supset}_P (\bar{\supset}_P)] \begin{cases} \text{etc.} \\ \ldots. \\ \ldots. \end{cases} \\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \end{cases} \tag{2.12}$$

This development in chains of chains of implications must be finite but unending, that is, transfinite, since it is easy to show that if the actualization of implication were infinite, one arrives at classical identity (tautology): $(e \supset e)$. Any phenomenon, insofar as it is empirical or diversity or negation, that is, not attached, no matter how little, to an identifying implication of some kind, $(\bar{e} \supset e)$ suppresses itself. One can use this logical symbolism to show this by reducing the implication $(\bar{\supset}_A) \supset (\supset_P)$ to: $\bar{e}_A \supset e_P$. One then sees that if *both* A and P are infinite and, accordingly, P disappears, there is nothing left but $\bar{e}_{A\infty}$, that is, an absolute and definitive negation, nothing. It is a theorem of LIR that both identity and diversity must be present in existence, to the extent that they are opposing dynamic aspects of phenomena and consequently subject to its Axioms.

2.3.2 Ortho-deductions

The first of the three sets of chains illustrated by (2.12) shows progressive actualization of positive implication and potentialization of negative implication, the second the inverse progressive actualization of negative implication and potentialization of positive implication and the third a progressive semi-actualization semi-potentialization of the two contradictory implications. Lupasco called these the ortho-deductions, and all are models of different aspects of reality, as we will see.

- Positive Ortho-Deduction

The first is oriented toward the limit of infinite or absolute actualization of positive implication, which is approached asymptotically, in other words, that of classically positive and tautological deduction. It is a model for the structure of physical causality and classical physical theory, and, by extension, of classical mathematical deduction. This process of deduction of classical science should be seen as an activity, as a real 'process' and not as the activity of a mind exterior to the phenomena. In LIR, positive deduction is relative and contradictional, and this is what makes it a real deduction, captured formally by the indicated sequence of symbols.

- Negative Ortho-Deduction

The first, as noted, is familiar, since it approaches classic deduction. The second is a dynamic, transfinite set of implications of contradictional implications that is oriented toward the other limit of infinite or absolute negative implication, which is also approached asymptotically. This negative relative deduction is new to logic. One should imagine a chain of exclusions, negative implications, non-links and ruptures developing in a non-arbitrary fashion, independently of human psychology. Lupasco considered this a considerable discovery. It corresponds to a negative causality of diversity, grounded in the structure of logic, a logic of the irrational. What are usually designated as irrationalities, things or ideas without connection, indeterminate, new, heterogeneous, incoherent, have their *logical* negative causes and are tied to a negative deduction that controls and develops them. Far from being illusions, errors or absences, due to the limitations of intellect, illogical or a-logical phenomena, they are the links in the chain of a negative deductive network. "This negative deduction is relative and contradictional, that is, progressively potentializes positive deduction; it is an activity, a negative dynamism. Due to it, diversities and irrationalities exist and are not nothing."

- Contradictorial Ortho-Deduction

The third ortho-deduction is that of the third chain of implications of implications, according to which the T-state, opposed to the two contradictory implications (positive and negative) that give rise to it, also develops transfinitely. The deduction corresponding to this set of antagonistic implications, inhibiting each other equally, is the deduction of contradictions, or of *doubt*. This ortho-deduction is called contradictorial, involving a T-state, and is to be distinguished from the two others, which were termed contradictional.

2.3.3 Para-Deductions

The development of the three, 'normal' chains of implication going asymptotically toward three absolute, unreachable limits, two of non-contradiction and one of contradiction has been indicated. There are, however, six other 'abnormal' chains of implications, each of which also sub-divides into three further ones, which develop transfinitely without any particular orientation. Lupasco identified these with the multiple combinations of linkages and ruptures (negative links) that build up the scaffolding of the various complex deductive configurations of experience and “weave the tapestry of a large number of existential forms.”

The para-deductive chains are thus an integral part of logic. As can be derived from the Table of Deductions, a *disjunctive* dialectical oscillation is required between the first three implications of implications, and between the three implications of implications of implications controlled by the former, and so on, of which the following is the first sequence:

$$\left[(\supset \mathrm{A}) \supset (\bar{\supset}\, \mathrm{P})\right] \vee \left[(\bar{\supset}\, \mathrm{A}) \supset (\supset \mathrm{P})\right] \vee \left[(\supset \mathrm{T}) \supset (\bar{\supset}\, \mathrm{T})\right] \tag{2.13}$$

One sees here the real meaning of disjunction: it is the mechanics of dialectics: no dialectic without disjunction and *vice versa*. It is disjunction that is implied by the fundamental postulate that permits the dialectic, and the dialectic implied by the same postulate, as principle of antagonism that permits and requires the disjunction, the connective ‘or’.

But disjunction itself, as discussed in the next section, also cannot be absolute and rigorous. Para-deductions, will always accompany, to some extent, ortho-deductions and *vice versa*. As long as the logical world exists, there will always by chains of deductions and causalities that have a sense, an orientation, and those that will have, rather, a non-sense, a negative sense of divergence. One can assign, in fact, greater existentiality to some para-deductions in that they do *not* go in the direction of an abstract absolute limit.

2.3.4 Operational Aspects of the LIR Calculus: Logical Necessity

The above series of series of symbols are at the heart of the LIR representation of reality, since they relate both: (1) levels of reality and the processes that are predominant at those levels of reality; and (2) the trends that I have described in Section 1.2.2 toward non-contradiction (identity, homogeneity or diversity, heterogeneity) or toward contradiction (emergence of new entities). Thus the first, positive ortho-deduction represents the formal dynamic aspects of macrophysical, inorganic matter, tending primarily toward a *non-contradiction of identity* according to the 2nd Law of Thermodynamics. It provides a rational for the existence of (relatively) stable physical objects. Note in this view, an identity, a stable “object” is not necessarily a singular individual. It may consist of a number of essentially identical entities like grains of sand, the result of degradation of a rock, that bear no dynamic relation to one another.

Negative ortho-deduction describes the tendency toward a *non-contradiction of diversity* which is characteristic of the biological level of reality and provides for the emergence of new forms and entities, ultimately based on the Pauli Exclusion Principle for electrons. Further details of the physics involved will be provided in Chapter 4.

The third ortho-deduction describes a contradictorial dialectics, the movement toward *contradiction*, and the emergence of T-states involving highly organized states of matter/energy/information at the microphysical level, and at higher cognitive and social levels, especially, those of science and art; and, perhaps, at cosmological levels of reality.

The picture of reality that is conveyed by the transfinite aspects of the above calculus is that all of the process movements described are in progress at the same time, to a greater or lesser extent, interacting with one another. What this means is that any process must be looked at as the resultant of a highly complex set of microprocesses, which nevertheless share the same structure, reflecting the basic principle of dynamic opposition and the axioms of LIR at different scales, in a fractal manner. The existence of these series of microprocesses, involving several co-existing trends, will be the basis in subsequent chapters for the discussion of the various applications of LIR.

The calculus of standard logics has its major role in the construction of proofs of theorems. There are no proofs of a propositional kind in LIR, but as pointed out by Kauffman, proofs are not primarily a matter of true and false, but of coherent indication, and this concept is compatible with the arguments of LIR. The above formulation of processes as deductions serves as a reminder that the complex transitions of reality can be modeled by a relatively limited number of logical generalizations that reveal their inner workings. The approach of Jacquette, outlined in Chapter 3, looks at the combinatorial possibilities of the objects and properties of a pure classical logic, but makes no commitment as to forces at work in individual exemplars. In contrast, the ‘combination’ in LIR of real logical elements, the reality values referred to above, is not the result of random conjunction or adjunction of terms, as in category theory, but of a form of necessity that is both physical (causal) and logical in my extended sense.

In other words, if the elements of the sets (or classes, see Appendix 1) of processes of processes follow ortho-deduction as indicated, and if ortho-deduction is a consequence of the operation of the principle of energetic antagonism in reality, then the concatenation of symbols developing in a transfinite manner according to their own internal dynamics represents *deductive necessity.* This is the metaphysical basis of logical necessity in *all* logics, both classical and LIR. This is another statement of my view that logic does not found metaphysics, as Kripke has been quoted as saying, but that metaphysics founds logic.

2.4 CONJUNCTION AND DISJUNCTION

The rigorous classical logic of non-contradiction requires an absolute choice of one of two terms, e.g., identity or diversity, as fundamental. The actualization of one term implies a total disjunction of exclusion between them. In LIR, reality is described by the dialectic alternation of a contradictional conjunction and a contradictional disjunction of exclusion. If we designate the former by $\wedge$ and the latter by $\vee$, the fundamental postulate can be written for an element **e** and its contradiction (or an identity ***i*** and a diversity ***d***). The situations to be formalized are where contradiction is potential and non-contradiction actual:

$$(e \vee \bar{e})_A \wedge (e \wedge \bar{e})_P \tag{2.14}$$

and where contradiction is actual and non-contradiction potential:

$$(e \vee \bar{e})_P \wedge (e \wedge \bar{e})_A \tag{2.15}$$

This means that the classical disjunction $e \vee \bar{e}$ can only be actual or potential, because it is linked contradictorially to the contradictional conjunction $e \wedge \bar{e}$. One can then write alternatively,

$$(e \vee_A \bar{e}) \wedge (e \wedge_P \bar{e}) \tag{2.16}$$

By eliminating the element **e**, one arrives at the same table for conjunction and disjunction as for implication, always based on the existence of a point T, the T-state of semi-actualization and semi-potentialization in the passage from **A** to **P** and from **P** to **A**, that is $(\vee_T) \wedge (\wedge_T)$ and $\wedge_T \supset \vee_T; \vee_T \supset \wedge_T$.

$$\begin{array}{cc} \underline{\Lambda} & \underline{V} \\ A & P \\ T & T \\ P & A \end{array} \tag{2.17}$$

The T-state, in this development, corresponds to the co-existence, the conjunction of a contradictional conjunction, or, more generally, of a contradiction and a disjunction of exclusion, or, a non-contradiction. Since no conjunction, such as the latter, can be fully actual or potential (or neither), we have the same form of transfinite sequence that we saw above for implication.

$$(V_A)\ \Lambda\ (\Lambda_P) \begin{cases} \left[(V_A)\ \Lambda_A\ (\Lambda_P)\right]\ \Lambda\ \left[(V_A)\ V_P\ (\Lambda_P)\right] \begin{cases} \ldots \\ \ldots \\ \ldots \end{cases} \\ \left[(V_A)\ \Lambda_P\ (\Lambda_P)\right]\ \Lambda\ \left[(V_A)\ V_A\ (\Lambda_P)\right] \begin{cases} \ldots \\ \ldots \\ \ldots \end{cases} \\ \left[(V_A)\ \Lambda_T\ (\Lambda_P)\right]\ \Lambda\ \left[(V_A)\ V_T\ (\Lambda_P)\right] \begin{cases} \ldots \\ \ldots \\ \ldots \end{cases} \end{cases} \tag{2.18}$$

Etc.... Etc.... Etc....

The values of **A**, **P** or **T** of any two elements or sets that are linked by the operations Λ or V can be entered into these basic formulas and developed transfinitely. It is easy to show, as previously, that if any operation goes to infinity, one recovers the disjunction of classical logic.

$$\Lambda_{A\infty} \supset V_{P\infty} \equiv \Lambda \equiv \overline{e\bar{e}};\ V_{A\infty} \supset \Lambda_{A\infty} \equiv V \equiv e\, V\, \bar{e} \quad (2.19)$$

The conjunction and the disjunction of exclusion of classical logic are particular limiting cases, impossible and ideal, of the dynamic logic of reality.[4]

The reader will have noticed that, up to this point, I have discussed only elements that stand in the relation of opposites or contradictories – **e** and non-**e**. I defined this relation as one of Conditional Contradiction (Axiom **LIR2**). But the relation between two arbitrary elements, events or processes, **e** and **u**, can be defined as implication, in the sense that either **e** implies **u** or it does not.[5] Since **LIR2** applies to the operation of implication, I can say that they are linked by positive or negative implication, inclusion or exclusion. However, any such linkage is also, never absolute, the (partial, greater or lesser) actualization of a positive link potentializes the exclusion and *vice versa*, as usual. Since these links exist throughout nature, this approach is equivalent to saying that everything is connected to everything else, more or less, transfinitely. In fact, the notion of implication is also present in the original formulation of a logical element that is defined and exists in relation to its contradiction. The negative implication or exclusion discussed here which characterizes two apparently independent elements, and which is the contradiction of positive implication, should not be confused with the exclusion relation between two elements one of which is the antagonist of the other. This latter exclusion is the relation of contradiction itself.

2.4.1 A Classification Table for Connectives

One can further characterize LIR as a formal logic by classifying the values of actualization, potentialization and T-state (A, P and T) for **e** and **u** for the standard connectives, as indicated in Table 2.1.

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[4] According to de Morgan duality in classical logic, conjunction and disjunction are not *independent*, in the sense that a complementation operator takes any proposition to a similar one with the negative and operation inversed. This duality, however, still refers to abstract entities.

[5] A and B may also be semantic elements provided there is some dynamic interaction between them. Jakobson distinguishes between *privative* oppositions of the type presence/absence (A/non-A) and qualitative oppositions of the type A/B in relation to phonemes: "(1) every distinctive trait (in a phoneme) is defined by opposition to another trait; and (2) the presence of a trait excludes its opposite (principle at the same time of exclusion and participation, of disjunction and conjunction)."

Table 2.1 Classification Table for Connectives

e	U	$e \wedge u$	$e \vee u$	$e \supset u$	$e \,\overline{\supset}\, u$
A	A	P	A	P	A
T	A	Nil	Nil	Nil	Nil
P	A	P	A	A	P
A	T	Nil	Nil	Nil	Nil
T	T	T	T	A	P
P	T	Nil	Nil	Nil	Nil
A	P	P	A	A	P
T	P	Nil	Nil	Nil	Nil
P	P	P	A	P	A

$$\supset A \quad \supset \quad \overline{\supset}\, P$$

A = predominantly actual
P = predominantly potential
T= T-state (‘included middle’)

Positive implication actualized implies negative implication potentialized, etc.

These entries should be understood as meaning, for example, that when **e** is (predominantly) actual and **u** is also, their conjunction is potential by Axiom **LIR2** if they are linked by positive or negative implication. Conversely, the table shows that if both **e** and **u** are actual, in fact that positive implication is potential. Further, it is not possible, by definition, for one element or the other to be actual or potential and the other in a T-state. However, the fact that both elements are in a T-state means their conjunction and disjunction are in T-states, positive implication is actual and negative implication is potential. This analysis demonstrates the consistency of the notation.

This terminates my presentation of LIR as a non-classical calculus, i.e., as an uninterpreted formal system. The structures of this calculus, that is, the strings of symbols, the chains of implications and the ‘reality value’ tables are not modified as such in the analysis of any individual process phenomenon (they are placeholders).

An important formal application of the calculus of LIR is in the analysis of classes and sets, outlined in Appendix 1. The essential idea is that sets and their elements are not totally independent entities, but share some of one another's characteristics. These are alternately actualized and potentialized like the opposing elements in other domains. I have also used this notation in the construction of a theory of systems (Appendix 2) that is compared with General Systems Theory.

2.4.2 The Calculus of Events and Relations

There have been other formal attempts to capture the existence and characteristics of change. Russell developed a logic of events in order to reason coherently about time and to make logical constructions of instants of time in a finite and closed world, as summarized by Lin (2003). The Russell event structure consists of a non-empty set E of events together with five binary relations: 'before', 'overlap', 'meets', 'begins-before' and 'ends-before'. Subsequent work has refined certain technical aspects of this logic, to which the many publications on the topic of temporal logics can attest.

However, the Russell logic remains fundamentally a binary logic, based on and supporting a completely classical, idealized concept of time. There is, as far as I can tell, no indication of any dynamic relationship *here* between the terms of the relations. The later Russell, however, discussed relations, in particular those between propositions and meaning, which are directly relevant to my brief discussion of the philosophy of mind in Chapter 6.

The calculus of LIR is in a sense about nothing but relations, but it has little to do with the calculus of relations first proposed by Peirce (Hammer 2002), in which symbolic concepts of Boolean algebra are applied to (very simple) relations. Further development by Tarski (Hintikka 2004) went in the direction of abstract algebraic structures that transcend propositional logic. In my view, following this tack would take us farther away from, rather than closer to reality. Application of Tarski's ideas to the notion of truth in the real world is possible, but not, as far as I can see, to real phenomena.

Shanahan (1999) has elaborated an event calculus, a logical mechanism with which one can infer what is true when given what happens when and what actions accomplish. It allegedly provides a logical foundation for deductive, inductive and abductive reasoning, with applications in some kinds of diagnosis, planning and theory formation. It is based on first-order predicate calculus, and is able to represent a variety of phenomena including compound actions (actions that cause other actions) and continuous change.

In Shanahan's system, events are objects that can be quantified over and can appear as arguments in predicates. Events are initiated, terminated and negated (non-occurrence or non-effect modeled) *axiomatically*. For example, a function symbol & is introduced to express an axiom covering the cumulative effects of concurrent actions.

The interest of Shanahan's system is its explicit use of actions as predicates, that is, elements capable of entering into logical relations. However, the kinds of relations involved are limited to abstract formal ones, with little further similarity to LIR. Symptomatically, the event calculus formulae do not apply straightforwardly to compound actions involving recursion, that is, actions or events that are involve something like the feedback dynamics of real systems. In the LIR calculus, *all* elements are compound ones, and if a new state appears (T-state) it can enter a new process system recursively as an element without the requirement of additional assumptions.

References

Dodd, Julian. 2007. Negative Truths and Truth-Maker Principles. *SYNTHESE* 156: 383–401.

Dummett, Michael. 1993. *The Logical Basis of Metaphysics.* Cambridge, MA.: Harvard University Press, 314–319.

Hammer, Eric. 2002. Peirce's Logic. *Stanford Encyclopedia of Philosophy (Winter 2002 Edition)*, ed. Edward N. Zalta. http://plato.stanford.edu/archives/win2002/entries/peirce-logic/.

Hintikka, Jaakko. 2004. On Tarski's Assumptions. *SYNTHESE* 142: 353–369.

Ladyman, James and Don Ross. 2007. Every Thing Must Go. Metaphysics Naturalized. Oxford: Oxford University Press.

Lin, Francis Y. 2003. Events and Time in a Finite and Closed World. http://www.hf.uio.no/filosofi/njpl/vol5no1/eventcl.pdf

Lupasco, Stéphane. 1987. *Le principe d'antagonisme et la logique de l'énergie.* Paris: Editions du Rocher (originally published in Paris: Éditions Hermann, 1951).

Marton, Peter. 2006. Verificationists Versus Realists. The Battle over Knowability. *SYNTHESE* 151: 81–98.

Mulligan, Kevin, Peter Simons and Barry Smith. 1984. Truth-Makers. *Philosophy and Phenomenological Research* 44: 298–321.

Shanahan, Murray. 1999. The Event Calculus Explained. http://www-ics.ee.ac.uk/mpsha/ECExplained.ps.Z

Simons, Peter. 2000. Are All Essential Parts Analytically Essential? In *Méréologie et Modalités, Actes du colloque*, D. Miéville, ed. October 20–21. Neuchâtel, Switzerland: Centre de Recherches Sémiologiques.

3 LIR AS A FORMAL ONTOLOGY

Abstract The components of LIR that will constitute it as a formal ontology, an interpreted formal system, from which the categories of LIR will be constructed, are completed in this chapter. The three components are: (1) its axioms; (2) the 'language' of LIR and its rather unusual semantics; and (3) the ontological constants and predicates which correspond to interpretations of the language. Additional sections address three concepts that are critical for the development of the LIR categories – dynamisms, processes and properties. A new definition of intrinsic and extrinsic properties is suggested. Comparison with classical logic is made in a section that reviews the metalogical properties of classical logics with those of LIR. The problem of the logical foundation of reality – being and existence – is discussed in relation to the fundamental LIR principle of dynamic opposition, and the position defended that metaphysics grounds logic and not the contrary. A brief discussion of abstract or non-spatio-temporal objects concludes the chapter.

3.1 REALISM AND FORMAL ONTOLOGIES

Before proceeding with the main development of my theory, a few comments are in order about the nature and role of a formal ontology and some associated logical and philosophical concepts, in particular, logical realism and natural realism. These ideas will be the basis for a later discussion of the particular LIR 'brand' of realism. Formal ontologies are generally divided into three kinds: representtational – a framework to represent information in as formal a mathematical manner as possible; descriptive – with the objective of correctly describing a certain domain of entities; and systematic – theories of what there is. Since LIR is a theory that is intended not only as description of the entities of reality but how they are related, I shall consider it a systematic ontology that is ontologically committed to those entities. In other words, in LIR, they are real and LIR is a realist system.

A potential problem arises here, however, since the term *formal* ontology is also understood as being a theory of logical *form* as well as a metaphysical theory about the ontological structure of the world. As such, it is subject to division into another three kinds, based on three classical kinds of predication of universals: nominalism, which refers only to the use of universal terms in language; and conceptualism and realism, in which the universals provide the semantic grounds for determining whether a statement (predicate expression) is true or false of real things. Concepts do not exist independently of the capacity humans have for thought and language. The universals of realism underlie predication in reality – real states of affairs in natural realism, but also the propositions that constitute the objective truths and falsehoods of the world, the latter, as well as the former, are assumed to exist independently of the human capacity for thought and language. Logical realism, in this view, is a modern form of Platonism and its universals are assumed to exist independently of the causal structure of the world as well (Cocchiarella 1996).

The combination of logic and reality in the one phrase I have used to characterize my logical system might accordingly lead to a possible misunderstanding which it would be well to dispose of promptly. I have said that, LIR, the logic of and in reality, is a logic of real entities, and the latter implies that I am talking about a realist metaphysics. On the other hand, the term logical realism as indicated is usually taken to mean that the terms of *standard classical or neo-classical logics* are endowed with real characteristics. On this view, logical forms can provide a basis for logical necessities, and their connections could amount to logical 'facts'. This would yield a kind of logical realism as these 'facts' would be the ontological grounds for logical truth and inference.

Such a doctrine of logical realism (doctrine and not logic), that there could be any facts or matters of *logic* that obtain independently of our holding them to be true has been criticized by Resnik (1999). His argument is that logical (and mathematical) truths are obtained through deductive proofs and are insulated from experience, even although not immune to empirical revision.

The simplest thing to say is that logic in reality has nothing to do with logical realism, despite or better due to the fact that the PDO, the fundamental postulate of LIR is physical — as well as metaphysical. *It* is independent of human psychology, etc. in the same way in which other objects of our theories, but on other ontological grounds, since the logic that is referred to in logical realism is classical ideal and abstract logic.

If LIR then, can be clearly differentiated from logical realism, what about natural realism, as in Cocchiarella's conceptual natural realism? Natural realism, despite its name, is simply another system of predication about natural properties and relations with a mode of being that is analogous to that of predicable concepts: they are part of human cognitive capacities to identify, characterize and refer to real world objects. LIR supports this view: the fact that these capacities and concepts do not exist independently of human thought or language does not mean they are not "objective" as assumed in logical realism. On the contrary, I consider these entities to be *more* realist and hence more objective in the usual sense of the term.

In conceptualism, being and concrete/actual existence are formal, 'logical' concepts and not properties, or attributes, which things might or might not have. (The scare quotes around logical are the author's.) The being of natural properties or relations, that which is the subject of this study, on the other hand, does not consist in its being a characteristic of some object at some time or other, but rather the causal possibility of its being *in re* – that is, having a mode of being as such within the causal structure of the world. This is in other terms what the following categorial development of LIR will show.

3.2 THE LIR ONTOLOGICAL PREDICATES: DUALITY

Cocchiarella's view of formal ontology is "the systematic, formal, axiomatic development of all forms and modes of being". However, to repeat, it is difficult to assign anything more than formal existence to the entities of this ontology, much less any interactive or processual aspects (Cocchiarella 1991). LIR, on the other hand, is a theory about change. Change, or becoming, is thus *the* primary ontological predicate or categorial feature with which this theory is concerned as a formal ontology. The most significant ontological predicates of LIR that I will use are fundamental dualities that correspond to some fairly well defined commonsense notions, founded in what Seibt has called 'agentive' experience and intuition (Seibt 2001). The predicates implicitly defined by the initial axiomatization are the following, together with the notions to which they correspond:

• Actuality – potentiality	Present – absent
• Homogeneity – heterogeneity (diversity)	One(identity)–many

I have included as predicates actuality and potentiality that, since Aristotle, have been often considered categories rather than categorial features. I will leave them in this 'category' of predicates for the time being, since the emphasis, in Axiom **LR2** of Conditional Contradiction, is on the processes that 'are' potential or actual, as the case may be. I will return to *this* point after the ontology of LIR has been constructed.

Poli (2003) has shown the importance in philosophy of dual phenomena not only in ontology, but also in the relationship or correlation between their role in (classical) logic and ontology. Some additional pairs, which have been the subject of much philosophical discussion, are matter and form, one and many, and, especially, part and whole. Internal and external play an essential role in any discussion of biology.

The additional key ontological predicates that will receive an interpretation in LIR based on its axioms are the following:

• Intensity – extensity	Internal – external
• Local – global	Neighborhood–distance+xtensity part-whole

Other predicates that are also self-explanatory are

- Alternating
- Reciprocal

If the axioms indeed apply to these predicates, then one must accept, at this stage of the discussion, that they will display not only Conditional Contradiction, but also the relationships of Functional Association and Asymptoticity. Internal aspects of a phenomenon cannot be totally independent of its external aspects; similarly parts and wholes are not independent of one another.

It should be clear that at this point no characterization of these ontological predicates has been given, except that intuitively all predicates shown refer in some manner to dynamic aspects of reality. What this manner is and what relationships are involved will emerge from the further construction of the categories of LIR in Chapter 4.

3.3 THE DOMAIN OF ENTITIES: LEVELS OF REALITY

The domain of entities that is described by the axioms, language, constants and predicates of LIR is all of reality. This concept can be made more understandable by reference to the axioms, according to which entities and their opposites may be in states that approach classical limits of non-contradiction, in which case bivalent logic holds ‘to all intents and purposes’, or in states which instantiate contradiction or opposition between the two elements, eventually leading, in some cases, to the emergence of a new entity (T-state). The entities of LIR include all real physical and non-physical phenomena, including those in the former group. From a formal ontological standpoint, the sentences of LIR are thus interpreted over the domain of all reality, the extant domain.

3.3.1 Complexity Versus Levels of Reality

The notion of levels of reality outlined in Chapter 1 is useful in an additional connection, namely, to differentiate in a general way the domain of phenomena that are sufficiently complex or, in the Lupasco terminology, have an 'adequately' contradictorial relationship to require the use of LIR and those that are not. The key point is that complexity is not a smooth function of levels of reality. It goes from large values at the quantum level, through a minimum at the macrophysical level, increasing again at the biological level and reaching the largest values at the conscious human mental and social level.[1] Complexity is thus a function of the relative degree to which heterogeneity, diversity and contradiction (or opposition, antagonism) are the prevailing 'biological' tendencies as opposed to the 'macrophysical' tendencies toward homogeneity and identity. Domains exist throughout reality that are the consequence of what I might call emergent simplicity, and it is no more than commonsense to say that binary logic applies to them.

Energetic exchanges are a necessary but not sufficient condition for complexity. In a game of billiards, the cue stick and balls exchange energy, but the location of the complex processes of interest are in the mind of the player (intentionality, frustration, etc.). It is macroscopic systems that embody some form of coded internal representation of the processes being actualized that require a logic of the included middle.

3.4 LIR AS AN INTERPRETED FORMAL SYSTEM

A preliminary description of the logic of/in reality as an interpreted formal system can now be made: it is a formal system 'of a third kind' that is neither totally classical nor totally non-classical. This interpreted formal system can be designated as a formal ontology that is intended to structure all physical and non-physical reality, the *extant domain*. As such, it incorporates the elements of reality of both classical mechanics, described by classical logic, and quantum mechanics, which requires quantum logic, as well as 'everything else' at all levels of reality.

I do not wish, however, to conflate the notion of LIR as a formal, that is, categorial, ontology and LIR as metaphysics, since a more productive relation can be found between them. Smith (2004), for example defines ontology as the science or theory of being, of what is and how it is, but he makes no distinction between ontology and metaphysics. I do suggest, in addition, metaphysics specifically involves speculation about being, even about what may be beyond the range of human abilities to perceive or know. All knowledge is speculative to a certain

[1] My view of quantum systems should not be taken as implying some form of pan-consciousness.

extent. I rather prefer to see ontology on a par with metaphysics,[2] but that the latter be also concerned with aspects of reality that are to a certain extent non-rationalizable and have been consequently inaccessible to the formal (or orderly) procedures of logic. A new correlation between ontology, metaphysics and logic is thus possible, as will become clearer in the discussion of being in Section 3.7.

3.5 THREE CRITICAL CONCEPTS

The theory described in this book includes a number of unfamiliar perspectives. It will therefore be useful at this point to provide working definitions and discussion of three critical terms to be used, namely, dynamisms, processes and properties. The analysis of the current debate on the nature of properties provides a first illustration, at this early stage, of the operation of the LIR PDO in a philosophical context.

3.5.1 Dynamisms

I first propose that the term 'dynamism', used to designate intensity and extensity means, combining the dictionary definitions, that they are not only processes or mechanisms of the operation of energy, responsible for its development and motion, but also theoretical constructs that describe the universe in terms of energy. This definition of intensity and extensity, by this hypothesis, converges to that of dynamics, since they are themselves forces that together, in an antagonistic or contradictorial relation (conjunction), cause motion, activity and change.

If this is accepted, then what are the definitions and characteristics of actuality and potentiality and homogeneity and heterogeneity? These would appear to be intensive properties of real elements or entities to which could be assigned complex values as observables. At the same time, however, I have described change as involving actualization and potentialization, and the operation of homogenizing or heterogenizing forces, which as dynamisms would appear to have the character of processes. One now has the problem of the relation between actuality and actualization (or actualizing, homogenizing and so on). My preferred answer to this point is itself an illustration of LIR: the two terms, the noun and verb forms cannot be considered as totally separate and independent and one is not

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2 Lowe (2006) has developed an alternate formal ontology as a basis of metaphysics. This approach retains, however, standard notions of categories and their underlying predicate logic that limit its applicability to real phenomena.

more basic than the other. There is always some degree of process to actuality and of property to actualization. One should be able to 'feel' an actuality-in-its-repressing of something antagonistic to it that would, if it could, cause it to change, rust, shatter, degrade, or disappear, on an appropriate time scale that is defined for each case.

This now leaves us with the two terms of process and property that require further explication and differentiation.

3.5.2 Processes

Process, like level, is one of those terms that are commonly used without sufficient attention to its implications. Processes can be defined simplistically as phenomena involving orderly change, a series of actions or operations taken to reach an end. However, if processes constitute the world of experience – from nature to social reality to perception and cognition itself – they should not be represented in a reductive fashion – in terms of their results, input-output pairs, or by static computational or discontinuous, step-wise interpretations involving static identities, in which the underlying dynamics has been occulted.

In my view there are two, related analytical jobs to be done. The first is to give processes their proper conceptual role in theoretical descriptions of nature *via* a proper ontological classification of types of dynamic entities, in other words, statements about types of dynamics. Here, as in any ontological category, the processes under discussion are theoretical entities and the dynamics involved are non-developmental. The second task is to describe real dynamisms or dynamics in terms of the fundamental properties of whatever it is that causes the change, which in my view can only be energy, subject to a needed revision of the concept of cause. Such a description has been started above. Complex processes, the consequence of the interactions of processes and processes of processes (systems of systems, illustrated by the series of series of ortho-deductions of Chapter 2) are defined as the result of the operation on energetic elements of logical operators that are themselves dynamisms (e.g., implication, conjunction, disjunction) involveing changes in energy, that is, considered as real, constructive actions.

To complete the description, however, we are still left with the need for a better understanding of the meaning of property and of the relation between property and process.

3.5.3 Properties

The concept of properties is a very old and complex one in philosophy (Swoyer 2000), but the point of introducing it here is that it plays a central role in discussions of reality and description of reality in terms of laws of nature. In addition, since I discuss aspects of a wide variety of entities that are supposed to have something in common, the processes or dynamisms according to which they evolve in time, properties may provide a general way of explanation in the direction of some pattern or unification.

Properties can be: (1) *defined*; (2) their *nature established*; and then (3) *used* to explain phenomena in all the disciplines mentioned, including metaphysics, natural science or 'naturalistic ontology', the philosophy of mathematics and the semantics of natural language. I have designated several aspects of the elements of my system as 'properties', and it seems correct to say that they fit a general theory of properties. An acceptable minimum theory could include the following, recognizing that each of these points itself has given rise to debates, some of which I will address later:

- Properties include relations, as well as attributes, qualities and features of phenomena. Processes are instantiated or exemplified and the 'things' – processes, objects, relations, etc. – that exemplify a property are instances of it.

LIR: Being actual or potential, or being actualized or potentialized are thus properties.

- Properties can be cited to explain or account for change, as well as other phenomena of philosophical interest, provided adequate reference is made to additional background assumptions or underlying mechanisms rather than only state observations (pale skin yesterday, red skin today, but red due to staying in the sun too long, rather than just because paleness and redness were exemplified at different times). Properties are intensional entities that describe the *intensional* aspects of phenomena, and in this sense provide a picture of reality that is not 'abstract'.

LIR: My explanation of energy in Chapter 4 in terms of extensity and intensity as properties is metaphysical, since such properties are clearly not observables, for example, in the case of some electromagnetic radiation, but also physical since they are postulated by the best available physical theories. I will show later that LIR supports a specific kind of scientific realism. No properties or elements are invoked in LIR's account of properties that are outside the laws of physics, but the existence of dynamic opposition provides an additional element of structure.

- Properties can explain sentences in terms of a concept of logical linguistic form, and compound properties can be built up from simpler ones by logical operations equivalent to conjunction, negation, etc.

LIR: Properties can explain phenomena in terms of a concept of logical dynamic form. Complex properties can be built up from simpler ones by logical operations seen as dynamisms.

One area of controversy is that of the instantiation of properties. *Instantiation* has been viewed as a relation but not a normal one: as a link of an entity to a property, it would seem to result in a need for a relation of relations and consequently an infinite regress. In LIR, a relation of dynamic opposition can be postulated between entity and property such that they mutually instantiate each other as dynamic, real systems. It is these systems that are the *objects-in-reality* that are the equivalent, in my theory, to the logical objects of standard logic. One does not need concepts such as 'non-relational tie', metaphysical glue, or metaphors like links in a chain. It explains the idea that 'instantiation just relates', or is metaphysically self-adhesive. Further, iteration, in this case of *real* relations, stops after two or three stages because no new information is added by subsequent stages. An interesting example is the proposal of storing information in quantum systems, not in the relationship among quantum objects, but in the relationship among the relationships. I do not share the general view that such moves are further abstractions, since according to the principles of LIR they fit the category of dynamic opposition, and the consequent epistemology provides the necessary basis for stopping the potential infinite regress.[3]

As a corollary of the above, it is not necessary to call properties of phenolmena concrete as opposed to non-spatiotemporal entities like meanings or concepts. A stark dichotomy between the terms abstract and concrete in relation to properties can be avoided by seeing them, also, as the elements of a dynamic contradictorial conjunction (entity and its dual). Thus the properties or qualities 'of ' a phenomenon, or associated with one, are abstracted from it, not in the sense of being non-real, but for the purposes of analysis.

Finally, LIR solves the problem of *negative properties*, since no real properties are absolutely positive or negative, and a property *F* is a more or less actual or potential part of the negative property *being a non-F*. The absolute contradiction is removed by the interactive alternation of actualization and potentialization.

There are thus conclusions to be drawn regarding the relation between properties and processes. Seen dynamically, a property, redness, is a becoming, the result of a series of processes and processes of processes in different systems culminating, say, in the pigment in the skin of the tomato and my being positioned in front of the tomato, which then appears red to me. Processes can also be seen

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3 Basically, the LIR idea is that the elements of knowledge and the knowledge of that knowledge are in a contradictorial relationship that exhausts the available mental configuration space. They are self-sufficient, and no new information is generated by additional iterations. It is possible to *imagine* the infinite regress as a process that does not stop, but in reality one stops it, or it stops itself.

not only as properties, but also as the consequence of sequences of properties as processes. But processes and properties do not have to be considered totally the same or different. They reciprocally define each other according to whether one focuses attention on the (relatively) static or (relatively) dynamic aspects of the phenomenon.[4] The definition is not circular since in reality, neither process not property return to the exact point of departure. Compound processes and properties are thus both the consequence of the exemplification of series of properties, the ones 'at the bottom' being those, as we will see, of energy itself.

The logics proposed to date as applicable to theories of properties have been standard, consistent, bivalent logics from which any principle of contradiction, conditional or otherwise, is absent. Much effort has been expended to define identity conditions in such classical logical approaches to properties, as well as other things. These are replaced in my LIR system by conditions of identity to-all-intents-and-purposes, without the absoluteness of identity as an *a priori* meta-physical or logical principle. If a logic contains the former notion of identity conditions, it will inevitably be an idealization, at least to this extent. The property of being a property is itself a property, but the LIR approach avoids the problem that the self-instantiation or self-exemplification of a property leads to paradox in binary systems: a property *does* exemplify itself, but in reality, not quite identically so.

3.5.3.1 Intrinsic Versus Extrinsic Properties: Relations

All properties are instantiated by things that exist in space and time or, if properties can themselves instantiate properties, each property is part of a descending chain of instantiations that may or may not bottom out in individuals. The *location* of exemplified properties refers to where they are instantiated in space-time. The principle of instantiation implies that properties are located in their instances, but they can be of two kinds, intrinsic or extrinsic. Intrinsic properties are normally defined as being those which an object may possess independently of everything else that exists. Typical properties are the mass and charge of particles in classical physics or the size and shape of an individual human being. All other properties are extrinsic or relational: weight, which depends on the presence of a gravitational field, relational properties such as being the brother of, and spatio-temporal location. In quantum systems, intrinsic properties are those that do not depend on the state of the system and extrinsic properties do.

The fundamental axioms of LIR imply a major change in the definition of intrinsic and extrinsic properties. No property of a system that is involved in some form of dynamic interaction, that is, at the quantum level and the biological and

[4] Similar considerations apply, I believe, to category and category feature, particularly in the case of actuality and potentiality (actual and potential). Since there are advantages to both uses, and no obvious disadvantages except to theory, I am inclined to take a pragmatic position on this issue.

mental levels can be, according to Conditional Contradiction, separated from its opposite or negation. All properties are partly intrinsic and extrinsic, their internal and external aspects alternately actualized and potentialized. Only at the level of macroscopic objects *qua* that level is it justified to one speak of a, for example, a spatio-temporal property as extrinsic to-all-intents-and-purposes. This will have important consequences for the ontology of LIR, that is, the entities by which it considers that reality is constituted, and for the LIR view of scientific and structural realism.

Following Esfeld (2003) I do not distinguish relations from relational properties. As noted, relations are also properties in that they are predicated of things, but for entities in an interactive relation, relations *are* the relational properties. The LIR approach to properties will find further application in the discussion of the metaphysics of relations, e.g., whether they require underlying properties upon which the relations supervene.

Implicit in the above discussion is the problem of the differentiation, in LIR, between an uninterpreted and an interpreted system, and how goes from one to the other. In the usual definition, the former applies only to the elements in the domain of theories and the latter to the theories *per se*. In LIR, this strict separation, which is, again, a reflection of the principle of bivalence, cannot be maintained.

3.6 SOME METALOGICAL CONSIDERATIONS

It should be clear by now that what I have proposed is a new way of ‘doing logic’ that is much more radical than a change in the established object-process-property terminology. This is a metalogical consideration, since it discusses the logic of a logical system and the major components of that system, its rules and relations.

The metalogical properties of a logic as a system of reasoning about propositions, capable of formalization in a symbolic language, are usually considered to be their completeness, compactness, soundness, among others. (Whether or not consistency is still an accepted metalogical principle has become, however, a matter of predilection with the advent of paraconsistent logics.) Metalogical properties are usually couched in a meta-language, which can be ordinary mathematical English, augmented by some metalinguistic symbols, in which accounts of the validity of inferences made in the formal language of the logic, the object language, are given. The two common notions of validity are semantic, or truth-preserving and proof-theoretic, for which the symbols are $\vdash$ and $\models$ respectively.

Consistency, completeness and soundness proofs in standard logical metatheory can be found in any standard text and will not be reproduced here.[5]

In comparing, for example, the foundations of two-valued logic with unrestricted acceptance of the principle of bivalence with the three-valued logic of Lukasiewicz, the number of values is a metalogical principle. In LIR, it is not only the *number* of values that is metalogical, but also their properties as properties of real processes.

The metalogical properties of LIR are thus of an entirely different kind, since it is based on a view of nature that does not consider fundamental either the abstract entities of pure classical propositional or mathematical logic or the anthropomorphic ontological concepts of phenomenology. The most fundamental metalogical principle of LIR is that of opposition or antagonism, without which, in this view, nothing could exist (see the next section). This is, therefore, at the same time the most fundamental metaphysical principle of LIR. Nothing exists independently of something else in the formal ontology of LIR.

A key metalogical question is, if there are several logics that are candidates for a particular application, how is one to choose between them? As put by Dummett (1991), if one has a metaphysical doctrine yielding consequences for logic, how can one decide (logically) for or against the metaphysical premises involved? The above metalogical concepts suggest the answer to this question about the logicality of the choice of logic. If one has a choice of logics, one may indeed have to look for non-logical criteria in order to decide between them. Thus, a choice between two logics *is* non-logical in classical terms, and one could be said not to be making a genuine (logical) choice. On the contrary, if the choice of logic is logical, can one be said to be choosing it?[6] This problem disappears in the metalogic of LIR, since in LIR no pairs of entities, including the dialectical processes of choice, are absolutely separate. An interactive connection involving their alternate (predominately, not absolute or complete) actualization and potentiallization is present at the level of their meaning and of the physical existence of their referents. Any choice one makes is both logical (in the sense of forced, in the direction of an identity) and non-logical (in the sense of being partly arbitrary, which is a notion of diversity), and this is a *logical* state-of-affairs in LIR. *I* may always choose LIR as my preferred logic, but the potential for my choosing classical logic is always present, and indeed I will actualize this choice in applicable cases.

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[5] Metalogic was extensively used by Lesniewski as a way of checking that contradictions were *absent* from a sequence of reasoning (Simons 2002). Curiously, in Lesniewski's early work, he seemed concerned that mathematics should be able to "capture the heterogeneous reality of the world" and that logical systems should retain a dimension of attachment to the real (Peeters 2006).

[6] The question of what logic to use to choose a logic for scientific rationality and criticism has been discussed by Bueno and da Costa (2007), who come to the obvious conclusion in favor of logical pluralism.

3.7 THE LOGIC OF BEING

This is a book about reality and its logic, but what is the reality that I am presenting a logic about? Some readers may feel that the description of reality and the real in Chapter 1 is too cursory. It does not give an adequate definition of what it means for something to be or exist, that is, an answer to the question of being, and to the related question of why anything exists at all. When I say that the limits of classical logic, among other things, do not exist in reality, I am making a statement that stamps me as someone capable of discerning what does and does not exist, but my position has not been justified.

Well-known attempts to provide answers to the questions of being are those of Heidegger and Sartre. Heidegger located a concept of being in the irreducible presence of the human mind in the world – *Da-Sein*. Sartre (1943) developed an ontology consisting of two distinct, irreducible and mutually exclusive categories of being-in-itself (*en-soi*), essentially unconscious, and being-for-itself (*pour-soi*) which is a characteristic of consciousness. The two are combined or mixed in human beings. The in-itself corresponds to physical matter considered as passive and inert and self-identical, while for-itself is dynamic and non-self-identical. It is a no-thing, the *néant*, an internal negation or nihilation of the in-itself. Both of these existential views are phenomenological, requiring a human a human observer, and are open to the critique that being, or most of it, seems to be independent of human observation.[7]

In his monograph on formal ontology, Jacquette (2002) criticizes such ontological approaches as circular, using aspects of about ourselves as human beings to define being. He challenges metaphysicians to answer the pure philosophical ontological question of existence before defining its various possible categories *via* an appropriate applied scientific ontology. I have accepted this challenge, that is, to carefully define, as far as possible, a concept of being as a matter of philosophical (metaphysical) ontology before developing an applied ontology of the kinds of things in the world that will be consistent with it.

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[7] There are many deep intuitions in Sartre of duality and alternating potentiality and actuality as fundamental, e.g., when he says that the both other and I are co-responsible for the existence of the other *via* two negations, such that I cannot experience one without its immediately masking the other (Sartre 1943). He is unable, however, to avoid the consequence of his total separation of the *en-soi* and *pour-soi* and the resulting contradiction in the appearance of consciousness in the *pour-soi*. LIR can be seen as an explanation of his phrase "everything happens as if the *en-soi*, in a project for founding itself, gave itself the modification of the *pour-soi*". The LIR metaphysics in fact provides a hypothesis for how this "absolute event arrived that crowned the individual adventure which is the existence of being." The *en-soi* had the potential for the *pour-soi* in the first place. Among other things, my approach avoids the need for trying to decide whether *être* or *néant* has ontological priority.

Jacquette's work is especially relevant to LIR because he bases his own response to the question of being on *logic*. Jacquette proposes that pure[8] classical logic can be used in a combinatorial fashion with reference to logical objects and their logical properties, combined into all possible logical states-of-affairs. The set of all such combinations is sure to include one maximally consistent (consistent and complete) combination that represents the actual world in its logical contingency. It should be pointed out, however, that Jacquette's position is that the questions of pure philosophical ontology for which classical logic offers insight are *conceptual*, asking what it *means* for something to exist, rather than an attempt to characterize what actually exists.

The problem with this picture is the major assumption implied by the statement that (classical) logic is entitled to speak in an ontically neutral and noncommittal way of objects and properties. "What could possibly be more basic than something's having or not having a property?" (Jacquette 2002) In my view, the assumption in the question about "something's having a property" *already* implies that (1) 'something', referred to without qualification, exists in some fully separate fashion; and (2) 'something' can only either have or not have a property. This raises the specter that the real world may not correspond to the above maximally consistent combination, if the assumption is incorrect. The logical objects and (properties) relations are those of pure classical binary logic, adapted from *its* use of linguistic forms. If these do not exist, then no combination of them, however, exhaustive, would include the real world and generate a meaningful description about the nature of existence.

Jacquette is aware that his view of the logical possibilities and logical properties of the world as existing constitutes an ontological commitment but believes it is minimal: it is logic that is ontologically committed to these logical possibilities, and only secondarily the combinatorial analysis that makes use of them. In fact Jacquette's argument as to why there is something rather than nothing is simply a restatement of this minor (?) ontological commitment: "…for there to be something is for a particular type of object-property combination to be logically possible. The actual world with no phenomenological baggage exists as the direct implication of pure logic involving a maximum consistent logically possible state-of-affairs or object-property combination". The alternative is dire: since logic is needed as a theory of logical possibilities and of the possession of properties by objects, if one does without logical possibilities, "then we will have to do without logic" (Jacquette 2002).

My conclusion is less pessimistic. Based on combinatorial analysis *only*, if the actual world is logically possible, it is logically necessary. In this conception its modal status is logically contingent, a matter of pure chance, a position ascribed to Hawking, Heisenberg, Einstein and Dirac, among others. In the alternative

[8] Jacquette also talks of pure philosophical ontology, but I must confess to an aversion to the term 'pure', used frequently by philosophers of the caliber of Husserl and Sartre. In my view, as a term of absolute exclusion, it fails in its objective of strengthening an argument or explanation, insuring only that its terms remain in a domain of abstractions.

realist logic I propose, a new definition of logical necessity and a contradictorial relation can be found between necessity and contingency, and the concepts of LIR and the insights of Jacquette partly converge. It thus may not be possible, with a pure philosophical ontology, in which concept and ontological commitment are kept separate, to say something meaningful about the world, and the question of why there is something rather than nothing may be badly posed. Ontology indeed demands a correct philosophical metalogic, but the principles of such a metalogic cannot be totally separated from the physics of the world, i.e., a scientific ontology.

My own first *logical* response to the question of being, that may meet the criterion of no prior commitment to *what* that being is, is to say that it is different from non-being. Being exists by virtue of this difference from, and in the LIR approach opposition to, non-being. To understand being means to me not only understanding non-being, but to understand the relation between them.

Rather than referring to standard 'pure' logical objects to further characterize being, in the metaphysics of LIR, it is assumed that at least one real system exists, composed of at least two process entities, plus the antagonistic relation that enables them to exist as that system (cf. Appendix 2 for further de-tails). Thus I claim that being as something fundamental in the universe cannot be delivered by bivalent logic, but it can by LIR. LIR is perhaps less purely *a priori* than Jacquette's system, but it is in my view the most that can still capture the real world. In other words, no logic, not even the logic of/in reality, can ground metaphysics; metaphysics grounds logic.

The reason is the following: without, as correctly emphasized by Jacquette, yet making any ontological specification of what any of the things in the universe are, I note the existence of duality, two-ness, even in bivalence. Another way of saying this is that 'as soon as' there is duality in the universe, being and non-being, one has *negation*, one thing *not* being the other, that is, at least *that* relation between them. I noted in Chapter 1 that classical logic expresses formally the requirement that one thing must exist but not that two must exist. This aspect of standard logic should not be taken as a 'proof' of anything; I call attention to it simply to compare with what I believe is a more realistic starting point for a discussion of being. I have discussed my view of properties above. Although most people would say that the difference between the properties of existence and non-existence is about as great as it can be, I feel the two entities and their relation also exist as a logical consequence of the fundamental postulate of LIR. In LIR, however, this does *not* require that to exist is to be predicationally maximally consistent.

The philosophical problem thus focuses on the nature of the relation between the minimum of two things in the universe: the 'two things' can be considered either an unconnected duality or a connected duality. Standard logics – bivalent, multivalent, intuitionist, paraconsistent, etc. are neither more nor less than expressions of the former position. LIR is the expression of the latter, and neither more nor less logical than the first.

The most significant statement made by Jacquette is that "it would make logic too important if we were to interpret the facts of the world, beginning with the descriptive facts and laws of natural science, as a matter of metalogical necessity", as this would, in his view, require that we give up the logical or even physical contingency of the actual world. He feels that this would collapse all presumably (sic) distinct logically possible worlds into the one and only actual world *vs.* the ordinary assumption that it is minimally logically possible for particular facts of the actual world to be other than they are. In my view, however, this argument tells us nothing about the real world. It is a category error (see Chapter 4), since possible worlds are totally separated from the actual world. The argument is simply a restatement of the logic assumed. The relation of necessity and contingency that I propose hopefully will reduce the fear that contingency will disappear below the phenomenological horizon.

3.7.1 Abstract, Non-real, Non-existent and Non-spatio-temporal Objects

I have already differentiated on several occasions between abstract or ideal objects, limits or relations and real or concrete ones. Since I now have a preliminary concept of being, these intuitive notions can and should be made more precise, since the different kinds of what are also called fictional or imaginary objects have been subjects of intensive debate since antiquity and still are.

Jacquette in summary says that non-spatio-temporal objects have only abstract being, a category separate from physical being or existence in applied scientific ontology. Jacquette develops a conception of the being of abstract entities using the same strategic combinatorial criterion: if an entity satisfies the requirement of maximum consistency, predicational consistency and completeness, then it exists in its domain. In this case, from the LIR standpoint, the argument works. We know what it means for abstract entities to exist, have being, because by definition they are self-consistent and complete. They meet the criterion because they do not involve energy nor undergo change, and the principles of classical logic obtain.

Priest (2005) makes a strong case for non-existent objects being a part of our real world, using a concept ('noneism'), and a classification that is consistent with an energetic mental process of the creation of such objects, as described by LIR for all such processes. Some of these non-existent objects are consistent, others are inconsistent, as one might expect in view of the generality of the application, in this domain, of the Gödel theorems.

The key point about non-existent objects is that they are real, that is, they are part of our real world, and, as originally indicated by Meinong, they can have properties. One has a long list of candidates for non-existent status – abstract objects, properties, relations, propositions and above all mathematical objects and fictional objects. I first point out that all of these are the result of human mental processes, but they differ from the LIR point of view in their ability to undergo change. This is similar to Priest's useful counterfactual criterion that defines an abstract non-existent object as one such that if it did exist, it would still not causally interact with us. A concrete non-existent object is one such that if it did exist, it would (or could) casually interact with us. Examples of the former category are numbers, triangles and so on and of the second fictional characters, but the division is not absolute, and problem cases will not concern us here.

An example of greater interest is an 'object' such as a scientific theory. The abstract object 3 or a proposition of classical logic do not change, but a theory, which is non-existent according to the concept above, would seem to undergo changes that are different from simple iteration, adding 1 to 3 to get 4 and eventually all the integers.[9] Priest's concept is that a theory containing facts about non-existent objects can tell us about existent objects because a correlation exists, the properties of both have the same structure, and bridge laws or principles, which express this isomorphism, allow us to move back and forth between mathematical objects and physical states. What, however, might these bridge principles be that would be general enough to insure that one has the right properties in the right place?

My interim conclusion is that at least in some cases, it is not possible to maintain an absolute separation between the apparently non-existent and the existent, specifically, a theory and the data of that theory.[10] It is the interaction between the two, expressed by the LIR principle of dynamic opposition that insures the correlation and the co-evolution of the objects in the 'two worlds'. Theories then, like ideas and concepts, while not spatio-temporal in the usual sense, as models or informational structures share some of the dynamic properties of physically existent objects.

The conclusion of this discussion is that both of the above approaches contain valid insights into the complexity of what is designated as being and non-being, with a logical basis in either standard classical or paraconsistent propositional logics. LIR allows *axiomatically* a degree of incompleteness and inconsistency that is the justification for its acceptance as a theory of reality, and the principles outlined in this chapter will facilitate the LIR framework for the discussion of conceptual levels and relations in Chapter 5.

With this in mind, I will now construct the categories that will constitute the formal ontology of LIR. Before proceeding with this construction, some further general remarks are in order about ontology and categories, with which I will begin the next chapter.

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9 The nature of theory change is an important sub-topic of scientific realism for which an LIR interpretation will be given in Chapter 6, see also Boyd (2002).

10 In Section 3.1, I discussed Cocchiarella's view of formal ontology as "the systematic, formal, axiomatic development of all forms and modes of being". As we saw, it is difficult to assign anything more than formal existence to the entities of this ontology, much less any interactive or processual aspects (Cocchiarella 1991).

References

Boyd, Richard. 2002. Scientific Realism. In *The Stanford Encyclopedia of Philosophy (Summer2002 Edition)*, ed. Edward N. Zalta. http://plato.stanford.edu/archives/spr2002/entries/scientific-realism/.

Bueno, Otávio and Newton C. A. da Costa. 2007. Quasi-Truth, Paraconsistency, and the Foundations of Science. *SYNTHESE* 154: 383–399.

Cocchiarella, Nino. 1991. Ontology, Formal. In *Handbook of Metaphysics and Ontology*, eds. Barry Smith and Hans Burkhardt. Munich: Philosophia Verlag.

Cocchiarella, Nino. 1996. Conceptual Realism as a Formal Ontology. In *Formal Ontology*, eds. R. Poli and P. Simon. Dordrecht, The Netherlands: Kluwer.

Dummett, Michael. 1991. *The Logical Basis of Metaphysics.* Cambridge, MA: Harvard University Press.

Esfeld, Michael. 2003. Do Relations Require Underlying Intrinsic Properties? A Physical Argument for a Metaphysics of Relations. *Metaphysica* 4: 5–25.

Esfeld, Michael and Vincent Lam. Holism and Structural Realism. In *Worldviews, Science and Us: Studies of Analytical Metaphysics. A Selection of Topics from a Methodological Perspective*, eds. R. Vanderbeeken and E. Weber. Dordrecht, The Netherlands: Springer (in press).

Jacquette, Dale. 2002. *Ontology.* Montreal and Kingston, Canada: McGill-Queens University Press.

Lowe, E. Jonathan. 2006. *The Four-Category Ontology: A Metaphysical Foundation for Natural Science*. Oxford: Oxford University Press.

Peeters, Marc. 2006. L'oeuvre de jeunesse. In *Introduction à l'oeuvre de S. Lesniewski. Vol. IV, CdRS*. Neuchâtel, Switzerland: University of Neuchâtel.

Poli, Roberto. 2003. Descriptive, Formal and Formalized Ontologies. In *Husserl's Logical Investigations Reconsidered*, ed. D. Fisette. Dordrecht, The Netherlands: Kluwer.

Priest, Graham. 2005. *Towards Non-being*. Oxford: Clarendon.

Resnik, Michael D. 1999. Against Logical Realism. In *History and Philosophy of Logic* 20: 181–194.

Sartre, Jean-Paul. 1943. *L'être et le néant*. Paris: Gallimard (Paris: *tel*Gallimard 1998).

Seibt, Johanna. 2001. Ontological Categories: The Explanation of Categorial Inference. In *Wahrheit-System-Struktur: Auseinandersetzungen mit Metaphysik*. Stuttgart, Germany: Olms Verlag.

Simons, Peter. 2002. Reasoning on a Tight Budget: Lesniewski's Nominalistic Metalogic. *Erkenntnis* 56: 99–122.

Smith, David Woodruff. 2004. *Mind World*. Cambridge: Cambridge University Press.

Swoyer, Chris. 2000. Properties. In *The Stanford Encyclopedia of Philosophy (Winter 2000 Edition)*, ed. Edward N. Zalta. http://plato.stanford.edu/archives/win2000/entries/properties/

4 THE CATEGORIES OF LIR

Abstract Chapter 4 develops LIR as an applied categorial ontology, based a view of the fundamental dualities of energy, and hence of reality, as inherent in the effective quantum field description of quantum phenomena. The categories of a New Energy Ontology (NEO) are established, including the essential categories of Dynamic Opposition, Process and T-state (emergent included middle) and Subject-Object that are both formal and physically meaningful. The categories are shown to fit the LIR axioms and the need suggested to view most important, inter-active physical, biological and cognitive phenomena as instantiating the category of Non-Separability, related but not identical to the existence of non-separability at the quantum level of reality. An initial discussion of LIR as an interpreted system is given that looks ahead to the core thesis of LIR.

4.1 THE DEFINITION AND FUNCTION OF ONTOLOGY

Ontology can be defined as the study of what exists, what entities compose reality and also what the most general features and relations of these entities are. It therefore overlaps the concept of metaphysics, as suggested in the Introduction. The notion of ontology as a general theory in relation to LIR is complicated by the fact that LIR also purports to say much the same things about reality. Prior comments about the relation of classical propositional or first-order predicate logics to ontology are not much help, since these logics were restricted to the study of the non-spatiotemporal forms of thought and judgment. Classical logic has a similarity to the apparent object-property structure of reality, and classical ontology reflects this structure. As Rescher has said, however, the logic of object and predicate does not prevail in nature.

Ontology describes *what* things there are and *how* they are. Metaphysics asks (among many other things) *why* they are, and makes some assumptions and produces concepts and theories about the basic entities of existence. Ontology converts these assumptions, concepts and theories, which are of course expressed in some language, either a natural or a scientific one, into a coherent and general body of knowledge, *via* a system of categories. One speaks, therefore, of ontological theories and ontological schemes of, or which contain, basic entities divided into categories of various kinds. As far as categories themselves are concerned, let us note that categories have descriptors, which are defined, and features, more or less abstract properties. Features may apply to more than one category, but, in classical ontology, no two different categories may have the same set of features.

I look upon an ontology as an orderly structure of descriptions of entities looking in two directions: the first is 'upstream' toward language, as a theory of reasoning and patterns of inference. In doing this I follow the suggestions of Seibt (2001) when she says that ontology goes far beyond clarifying and stipulating relationships between linguistic expressions in a language, natural or scientific: ontology describes 'what there is' in the sense of providing a description of truth-makers of the language.[1] Truth-makers are entities that are extra-linguistic but neutral, between real and constructed. An ontology according to Seibt's definition is a theory about the entities we can take ourselves to be referring to when we speak a language, entities that justify the inferences we draw in that language.

The second direction in which ontology is directed is 'downstream' toward the domain of all entities – reality, in which an ontology is defined by of the real extra-linguistic items described by some theory of such entities.

The task of ontology has thus been defined in many different ways, as it denotes both general concepts of reality and the basic entities or ways of being or aspects of being. For example, Poli (2003) defines dynamic ontology as a comprehensive categorical system capable of adequate theoretical coordination and explication of the achievements of contemporary science. My conception of onto-logy accommodates both types of categories, those whose 'source' is in reality and those whose 'source' is in our conceptualizations of reality. One may say in both cases that ontological categories are the basic entities in some domain M as described by a theory of that domain $\mathbf{T_M}$ or they are the basic terms of the domain theory of $\mathbf{T_M}$. It is not necessary to decide for either the 'entitative' or 'conceptual' reading of the term 'category'. In both of these readings, ontological categories are always theoretical items and it may indeed be misleading to speak of 'categories' of a natural or scientific language.

4.1.1 Formal and Material Categories

The additional general notion that needs to be developed is the distinction, starting with Aristotle, between formal and material categories. I endorse a concept of ontology as one that concerns itself, as a *material* ontology, with the constituents (individual, properties, and relations) in a particular domain or region of the world, and as a *formal* ontology (Schneider 2002), with the axiomatization of the most general pervading categories that partition and shape reality as a whole.

D. W. Smith's proposal (Smith 1999), which he calls *Unionism*, is that there is one world, ordered and unified as 'nature', whose diverse categories can

[1] See however my discussion of truth-makers in Chapter 2.

be defined. The world includes all objects and phenomena, including artistic creations, conscious experiences and so on, in the material categories of Body, Mind and Culture. These are ordered by diverse formal categories such as Individual, Quality, State-of-Affairs, and, most significantly, Relation. "The world enjoys categorical complexity without substance dualism. From quarks to quasars, from consciousness to volition to cultural institutions, there is ontological complexity, but all within this one world."

The key formal categories, which differ somewhat from those proposed by Husserl, are Intentionality and Dependence. (Husserl's formal categories included Individual, Species and State-of-Affairs; his three material categories were Nature, Culture and Consciousness.) Intentionality is defined by Husserl as a being-conscious-of-something *that is not separated from a* being-an-"I" It is not a category but rather a formal feature of entities in the categories of Nature and Consciousness. Dependence is suggested as a category that may govern material causal relations defined in terms of physical force. In Smith's ontology, the physical nature of things is structured by the *interaction* of formal and material categories. "On such an ontology, the world has a systematic unity that consists in the way entities under material categories are governed by formal categories that *weave together in an ordered way* (emphasis mine)." The major physical or material categories are Body, Wave, Mass, Force, Space-Time, Gravitation, Electromagnetism, Quantum Field and Wave-Particle.[2] We will see in a moment why I have chosen this list for discussion among many others possible.

No list of formal and material categories has ever been generally accepted as providing the most adequate picture of reality.[3] Nevertheless, the *methodological* approach of construction of a categorial structure for a theory, such as LIR, is of value in facilitating discussion. Accordingly, let us see which pieces of this puzzle are available, based on my first three chapters:

- A domain M that is the actual, empirical world of all physical and non-physical (mental) entities and phenomena, referred to as noted as the *extant* domain.
- A theory, LIR, of the domain, which I have called a logic, based on its informal and formal axiomatizations.
- A listing of key ontological predicates (cf. Section 3.2). The logical constants in Section 1.2 can now be understood as formal-ontological constants insofar as their meaning can be characterized in terms of standard operations and transition rules of the LIR calculus, applied to 'probability-like' values.

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[2] The material categories of Mind and Culture show up in the group (category?) of 'everyday' material categories.

[3] One can also speak of categories in a material mode as being semantical and categories in a formal mode as syntactical (cf. Section 1.5).

The formal ontology that I propose is a theory that provides *non*-mathematical formulations of the properties and relations of certain categories of phenomena at different levels of reality or complexity. It is intended to be systematic in the sense of stating formally at least some aspects of what all entities are, as well as relating all entities of a certain kind to one another.

Among other things, the formal ontological approach is a way of seeing what is *excluded* from LIR. For example, LIR does not apply to the tautologies of classical logic, together with other abstract entities such as numbers and sets. However, LIR *is* very much concerned with the dynamic process of their creation by the logician or mathematician! The same point was made by Hall (1949) in defending the claim that even standard logic does have an ontology and, by regulating inquiry, says something directly empirical about the world, namely about higher psychological processes.

As suggested by Seibt (2004), an adequate ontological theory should explain (by giving suitable structural descriptions) all of the inferential patterns licensed by all of the most general nouns of the, here, natural language. For LIR, these nouns include, in addition to reality and phenomenon, property, process, change, contradiction and opposition, all of which are well within the domain of common experience. In applying this concept to my theory, however, one must take into account that the inferences being made are not from premises to conclusions, but about changes in real physical or conceptual states. A theory implies a ‘contradictory’ theory not only *in abstracto*, but the conscious and unconscious processes involved in more or less rejecting it or retaining it for consideration.

4.2 THE ESTABLISHMENT AND CONSTRUCTION OF CATEGORIES

Both metaphysical and physical considerations inform the selection, construction and description of any set of preferred ontological categories. The construction of a set of categories is, in general, carried out with the eventual fit with a set of axioms in mind, including the metalogical principles they embody, which in this study is the PDO. This is not an exact science, so in order to better show the role of these categories in relation to my logic of/in reality, I distinguish three steps in their construction:

1. Definition of a general philosophical worldview including the – for me – unavoidable features of inconsistency, incompleteness and contradiction in the dynamic sense I have given.
2. Outline of a physical, obviously today, a quantum mechanical picture of the world.
3. An intuitive, that is, non-axiomatic introduction of categories based on 1 and 2.

The approach I have taken is that of Hartmann (1953) who developed the categories of *his* new ontology "step-by-step from an observation of existing realities". The fundamental assertions of an ontology are about being, as discussed in the previous chapter, and have the character of universal constitutive principles. These are the categories of an ontology. In my analysis, the realities I observe are the manifold dualities of physics, biological science and the dialectics of human thought and behavior.

This formulation raises the question as to how the two terms 'constitutive' and 'principle' are to be understood. At this point, I define a constitutive principle as one that establishes the relation to an object of experience, while at the same time incorporating the even more fundamental principle of dynamic opposition in the universe. Accordingly, in Chapter 6, I will look more closely into the character of the LIR PDO as a scientific principle or natural law.

Like Hartmann, I have also started with an examination of the relationship between possibility and actuality. However, based on the view of being in Chapter 3, rather than make assumptions about pre-existing ideal essences or dispositions for development or becoming (which I feel are nothing more than spontaneity in other terms), I try to focus on potentiality as *real possibilities*, Hartmann's *Realmöglichkeiten* and actual reality, *Realwirklichkeit*. As we have seen, such an actual reality is the complex result of the interaction of systems of systems, and the categorial analysis of reality can be, as Hartmann also suggested before the development of modal logic, as a kind of modal analysis. My theory, however, requires additional considerations of modality, as discussed in Section 1.4.3. Hartmann's possibilities resemble the kinds of probabilities I designate as 'reality values' (cf. the essential differences in LIR between possibility and probability, discussed in Section 6.2.6.)

4.3 THE PHYSICS OF REALITY: THE FUNDAMENTAL DUALITIES

Because the entire axiomatic structure of logic of/in reality depends on energy, it is necessary to establish a consensus about the properties or characteristics of energy in order to construct the ontological categories of the formal system. The physics of reality, and the logic of physics, must therefore be described first. My program is therefore quite different from an attempt to develop an ontology based on a framework of *standard*, generally classical logic. The thesis in this book is thus an implied critique of the fundamentality of consistent, propositional logics, preferred by thinkers such as Jacquette as the basis for their ontology because of concerns about the completeness and hence the validity of pictures of reality based on logics of inconsistency. An even more radical view is that of Froger and Lutz (2007) who found the properties of all quantum entities on a combination of a ternary and a quaternary logic. In my view, these remain in the group of many-valued logics whose basic terms are abstract linguistic entities despite additional forms of negation. Ultimately, Froger and Lutz attempt to ground *their* terms as "dynamic manifestations of a universal *ur-structure* (sic) that presides over every act of differentiation." No explanation is proffered, however, of why such an '*ur-structure*' should exist or in what in consists.

In Section 3.1, I listed Smith's material categories: Body, Wave, Mass, Force, Space-Time, Gravitation, Electromagnetism, Quantum Field and Wave-Particle. To these should be added Information, but all these categories can be seen as physical energy in various forms and aspects. Elementary particles exist that can be more or less well characterized; flows of such particles can take place, as in an electric current or the photons of a light beam; and particles and macroscopic objects composed of them generate fields, electrical, gravitational, magnetic and nuclear that exert forces on one another. I am concerned with grounding the principles and categories of my theory at the most fundamental level of the universe, and the list provided refers to several different levels. The structure of reality, prescribed by LIR, was defined axiomatically above by the existence of a principle of dynamic opposition, a fundamental logical duality at the heart of energy. Energy might be considered as the most fundamental material category, and it clearly instantiates some dualities such as intensity and extensity (see below). However, the quantum field appears to be not only more fundamental, but provide a much clearer concept of the origin of duality, opposition and an included middle, since although there is no full agreement among quantum physicists as what the field is, there are many hints from different approaches that (1) such a dualism exists, and (2) one can discuss it as if further, more complete evidence were in hand.

What we have in hand is thus a mixture of data, theories and insights and intuitions that represent the best that one can do at the present time. A good example is the statement of Roger Penrose (1991) that one cannot "at all draw a clear dividing line between what we call 'matter' or 'substance' and what we call 'empty space' or the vacuum… Matter and space are not totally separate types of entity". But they are equally clearly not the *same* entity.

At the level of experimental physics, the dynamic relationship or interaction (or opposition; the terms are equivalent in the absence of further knowledge) between energy and the vacuum is *expressed* by the fundamental physical constants: the speed of light in the vacuum – c; the gravitational constant – G; and the Planck constant – h, the quantum of action. This defines (Alfredo Gontijo de Oliveira, 2005, private communication) a view of real processes as sets of trajectories of their elements in a multi-dimensional configuration space, or better, configuration space-time. The structure of their causal relations will in general be described by *two* systems of mathematics: the trajectories themselves by a combination of differential and integral equations of second-order cybernetics, and their underlying dynamics by a theory of topological structure, which provides a basis for the emergence of form.

This proposal immediately raises the issue of the detailed structure of such a space (coarse graining – the units of which it is composed). This question cannot be answered definitively, but intuitively it could be along the lines of the description by Penrose of entropy in terms of boxes or sub-regions whose volume is related to the Boltzmann constant. As it turns out, however, it makes little diff-errence where the 'boundaries' between boxes are drawn, provided the coarse graining reasonably reflects the intuitive ideas of when systems are considered to be macroscopically distinguishable. Nature does not seem to require of us that we establish an 'absolute' notion of entropy, nor, I would argue, of the phase space of LIR (Penrose 2005). The model of trajectories as 'structures' can apply to two billiard balls before, during and after collision and those of processes such as change of belief. The difference of is one of complexity and degrees of interaction rather than kind, as the subsequent categorial analysis will make clear.

The evolution of systems, and the emergence of new ones, that instantiate these interactions can be seen as processes of symmetry-breaking governed by a fourth constant, the Boltzmann constant – B. The Boltzmann equation describes how systems *probabilistically* evolve with time and entropic asymmetry (the 'arrow' of time), but does not clarify the deep metaphysical nature of 'time itself '. In the work of Lupasco and some current views of physics to which I will refer in Chapter 7, time is a by-product of the object systems themselves and their causal relations. No background space-time needs to be postulated for existence as such, although the problem remains of describing properly our subjective or epistemic time.

This picture has immediate consequences for the way in which quantum logic should be viewed in relation to bivalent logic. Something like a quantum logic, with its non-commutative connectives, might be seen as the true 'logic of the world' rather than the distributive logic that describes the relations among propositions. Sklar (1992) comments that this view is open to criticism, and that such a new logic should not replace standard logic since the latter also plays a role in the former. LIR offers a way out of this difficulty; it includes the option of reduction to standard logic. This is the logic that is applicable to the binary aspects of the experiments designed to reconstruct the quantum description of the world.

4.4 THE CATEGORY OF ENERGY

I am now in a position to introduce non-axiomatically the categories that I consider capable of capturing the most cogent aspects of the physics of reality suggested above. First, it is reasonable to look at the LIR system as defining Energy as the most significant material category, recognizing that I am using 'Energy' as shorthand for the dynamics of the quantum field defined by some form of effective quantum field theory.[4]

In order to be sure that my system embodies a minimum coherence, I must first show (1) that energy is dual, that is, it instantiates the ontological pre-dicates I have introduced; (2) that this duality is oppositional or antagonistic; and

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[4] The Effective (Quantum) Field Theory description establishes the quantum mechanical basis for the operation of laws of nature at high energies that do not necessarily imply the same ones for lower energies (Cao 1997).

(3) that duality and antagonism translate into oppositional relationships throughout reality, including into contradiction at the linguistic level. At this metaphysical or scientific-ontological stage of my inquiry, it is necessary to insure that the dualities I am analyzing are real and not somehow artifacts of prior approaches. Only if this is done can we look at the question of whether, given an explanation of a scientific theory with the logic of/in reality, it is superior to one without it in some way.

4.4.1 The Duality of Energy

The basic *physical* characteristics of energy – the laws of thermodynamics, the equivalence of matter and energy and the concept of information as a form of energy are thus a consequence of the physics of reality discussed above. At this level of analysis, it is fair to talk about laws of nature and laws of energy being equivalent.[5] Further, the many of the existing dualities of energy are very familiar:

- Electrical charges are only positive or negative. In an atom, the positive charge of the protons is balanced by the negative charge of orbital electrons. The positron, the ‘anti-particle’ of the electron, has a positive charge, and in semi-conductors, the negative charge of electrons is offset by defects or holes with positive charge. Like charges repel one another; unlike charges attract.
- Magnets have two poles, called by convention North and South. As do charges, two like magnetic poles repel one another, unlike poles attract, a physical instantiation of duality of ‘forces’.
- Finally, depending on the energy level, there are always and only two types of quarks bound within a quantum particle, given more or less picturesque names (top and bottom; charmed and strange, etc.). The forces between two quarks are mediated by a third particle, a gluon, and the overall dynamics can be considered as instantiating a T-state. In this case, the gluon is the energy state emerging from the interaction between quarks at another level of reality or complexity.

The effective quantum field can be seen as a self-sufficient, self-included middle that does not require a further underlying substrate. Indeed, it has been referred to as instantiating ‘self-duality’ (Gomez 1995), but it is not easy to see

[5] LIR brings some additional insights to the debate on the necessity and character of laws of nature. For a discussion see Section 6.8.

what this means physically. One proposal defines that self-duality as the structure of the effective field, and it would appear to involve fundamental dualities between, for example, electricity and magnetism. Its dualities can be related to those of string theories (T-duality), developed in the 'second super-string revolution' by Witten in 1995. This involved the introduction of new symmetry operations and sets of dualities, e.g., the strong-weak duality, where strong and weak refer to the strong and weak forces operating between heavy (nuclear) and light particles respecttively. It is still impossible to say today what the physical status of string theory is, but from a mathematical standpoint, the dualities seem to be extremely deep and indicate types of structure that point towards the dynamic opposition of LIR.

Another view of fields is as structures or spatial arrangements of properties of intensive density and an extensive scalar metric. Botta Cantcheff (2002), in view of the self-duality of quantum fields further supports a meta-physical concept of the fundamental duality in energy. The argument is highly technical, but the conclusion is intriguing in the LIR context: "Every duality at the level of classical action comes from some manifest duality between the fields involved in those actions." The author points out that the role of duality in physical systems is well-appreciated, but a well-defined notion of self-duality offers additional explanatory options that have an analogy in LIR. The discovery of a deep unifying concept has come from the recognition of an internal two-dimensional structure hidden in the space of *potentials* (emphasis mine). At the level of *theory*, two dual models representing the same physics 'combine' to yield a self-duality. Self-duality may also relate scalar and vector fields at the cosmo-logical level. In modern theoretical physical terms, these are the features of extensity and intensity attributed to energy in the fundamental postulate of LIR in Chapter 1.

My intention here was to show that LIR provides a picture of reality 'in action' at the most fundamental level that approaches it more closely than the classical and neo-classical logics that purport to model some of its aspects. The metaphysical reality that LIR is directed at describing is similar to that of the quantum field in the sense that the field consists of operators associated with an ensemble of probabilities. These operators represent, however, not the values of physical quantities but those quantities themselves. This is the 'directness of representation' that I see in all instances of strong interaction (contradiction) leading to emergence (Axiom **LIR3**): there is no need for intermediary structures, especially in the areas of causation (and mental phenomena).

I cannot discuss in detail the attempts being made to develop a unified theory of physics that would effect the critical union of quantum theory with a theory of gravitation. I can, however, point to recent cosmological theories that ascribe a self-duality to the *gravitational field* as well as of the quantum field. The duality of the two domains thus in itself suggests a possible relationship with LIR and the PDO at this and higher levels. The 'pure' mathematical physics used (Majid 2007) would define self-duality at the lowest levels, of which the duality of PDO would be the expression at higher, non-quantum levels of reality. I will return to the issue of self-duality in the section on cosmology in Chapter 7.

For my subsequent development of LIR as an interpreted formal as well as metaphysical system, eight dual but *metaphysical* aspects of energy must also be taken into account, and the most fundamental of these are intensity and extensity.

4.4.1.1 Intensity and Extensity

It was recognized early that different forms of energy had properties that were in some way primarily either external or internal: a volume of a quantity of gas *vs.* its pressure; for a quantity of electrical energy the total charge *vs.* the electrical potential; for gravitational energy the mass *vs.* the gravitational potential; for thermal energy its capacity for doing work (negentropy) *vs.* temperature. These properties were described as extensities or intensities respectively.

The terms intensity and extensity refer to the *quality* of having intension and extension respectively, in a different sense from their use in classical logic (Chalmers 2002).[6] In common speech, extension is already dynamic, involving a notion of physical movement, a tendency to further development of an identity, expansion toward an outside. This tendency or dynamism operates on something heterogeneous and changing of a different, contrary or contradictory type. Intensity and the adjective intensive refer to this 'something' which is interior and implies succession, movement or change from outside to inside. The term intensive contains the notion of power, power-for-itself, hence subjective (cf. the *pour-soi* of Sartre). The dynamic aspects of both terms suggest that they refer to processes and not static states. This description also applies to the field properties mentioned in the previous paragraph.

The German electrochemist Ostwald[7] looked in detail at these extensive and intensive properties of various forms of energy. The 'measures' of intensive energies are vectors or tensors, whereas extensity always implies a certain measurement in terms of a number of identical, scalar units. Volume in liters; mass in grams; and electric charge in coulombs are extensive. Temperature is always defined by difference and gravitational and electric potential by complex field parameters. Ostwald pointed out that an intensity and an extensity could be both actual and potential, *but not at the same time* (see next section). He thus provided the philosophical basis for both the alternation of actualization and potentialization and the relation in energy itself of intensity and extensity.

I quote the original formulation of these ideas by Lupasco:

> In fact, energy, the underlying entity, is nothing other than extensity. Everything that is attributed to it – unicity, permanence, homogeneity, conservation, etc., characterize extensity and nothing else. In postulating the fundamental unicity of energy, with all its properties, one postulates the primordiality, the substantiality, the monism of extensity

[6] Carnap divided the meaning of an expression into independent components of extension or denotation and of intension or connotation. The former corresponds to its understanding or comprehension and the latter is determined by empirical investigation.

[7] 1853–1932; Nobel Prize, 1909.

> under the epiphenomenal or accidental aspect of intensity, and, therefore, accordingly, of a contradictory duality. It is therefore incorrect to say, according to us, that energy possesses two contrary factors. But one can say that energy is the conflict of two contradictory energetic orders, or a logical antagonistic duality of intensity or extensity, and decide later which of the two is the foundation, the essence, and which the appearance of things. One could try to eliminate the other more and more, but then one has to explain how one arose and how and where it could disappear. (Lupasco 1973)

This is the basic statement of the fundamental principle of antagonism, of contradiction or being *contradictory and opposing* rather than just opposite or contrary. Lupasco's view was that people mistakenly tried to apply, to the sources of intensity (force, gravitation, and electrical potential), the characteristics of extensity, simply because extensity is more accessible. The philosophical significance of these sources was not grasped, and this failure to see an opposed duality of forces in other areas of human thought has been repeated. Ostwald had defined a "succession of values" in intensity that implies the suppression, the disappearance and the reappearance of new values through and by the succession and the intensive process themselves. I claim that this succession or alternation has a *logical* character: one can see affirmation in extensity, in its obvious existentiality or presence, and negation in intensity, in its instantiation of non-identity and self-referential change.

The smallest unit of energy, the Planck energy, is the product of a frequency and a constant, called the Planck constant. The Planck energy thus instantiates duality as it has aspects that are both continuous, since frequencies can take any value, and discontinuous (a constant). The photon has aspects of both a particle (discontinuity) and wave (continuity). According to the Heisenberg uncertainty principle, the energy (momentum) and position of a particle are both localized and non-localized in the sense that to the extent that one is actualized more precisely by some measurement, the value of the other becomes more imprecise.

The essential concept here is that energy is inherently dual and antagonistic, and the implication is that this duality will be present in all higher (more organized) forms of energy, although it will not necessarily always be the *same* duality. My view is that the ability of fundamental microphysical elements to carry information to more complex levels resides in their irreducible, constitutive antagonistic dualism. The wave-particle duality has been observed with molecules containing sixty carbon atoms (the fullerenes). There is no reason why the *basis* for such dualism should disappear as one goes to still larger more complex systems. As one does, however, the dualism is no longer analyzable in terms of fundamental physics. The form of the duality of the microsystems has been replaced by the form of the duality of the macro-system – the antagonisms of living and cognating systems which are certainly as recognizable and potentially measurable, if not more so. The LIR view implies a type of *dialectics* at all levels of reality between the two terms of whatever duality is being considered.

4.4.1.2 Identity and Diversity: Homogeneity and Heterogeneity

The second most fundamental aspect of energy is expressed by the dialectic between its entropic and negentropic properties. Energy moves from diverse, heterogeneous high-level forms toward a single, homogeneous low-level form (heat), governed by the 2nd Law of Thermodynamics. Let us designate such a tendency toward a single undifferentiated state of affairs as exemplifying identity or, simply, identifying or 'homogenizing', an 'identification'. At the same time, energy, as apparently indistinguishable electrons, shows a fundamental duality governed by the Pauli Principle of Exclusion. Electrons are located in shells around the nucleus of an atom, but two electrons in the same shell cannot have the same quantum numbers for their properties, such as spin. Build-up of a multiplicity of shells is possible, for atoms heavier than helium, in which the electrons will all have, as a consequence of their distance from the nucleus and the degree of completion of the shells, a different capacity (potential) for reacting with other atoms to form different molecules enabling the existence of, ultimately, life and human beings. (A similar phenomenon, due to Pauli exclusion at the nuclear level, results in the existence of nuclear spin isomers (Hougen and Oka 2005). The diversity is real and leads to differences in some physical properties as in, for example, molecular *ortho*- and *para*-hydrogen, which have been separated and characterized. However, the effect on chemical properties is negligible).

Energy and accordingly all existence thus also show a tendency toward or instantiate an opposing process of heterogeneity, or non-identity or diversity, a 'heterogenizing' process, a diversification. Combining this idea with the one in the previous paragraph, I suggest that homogeneity, exteriority and objectivity characterize the process of extensity, and heterogeneity, interiority and subjectivity that of intensity.

In any phenomenon, one should always look at the respective tendencies toward homogeneity and heterogeneity in it, its identifying and diversifying aspects, in order to understand its structure, orientation and the laws applicable to it, since all of these depend the level of reality at which these processes are taking place. Further, the 'coefficients' of homogenization and heterogenization define a relation of contradiction or opposition since they imply the coexistence, in the energetic constituents of the phenomenon, of identity and non-identity. A cell (an identity) that has lost its capacity (potential of non-identity) for maintaining its differentiation from other cells is either dead or cancerous, and my thesis is that these can and should be considered *logical* identity and non-identity.

The terms identity or identifying are to be understood as subsuming the notions of rationality, reality in a limited, classical sense, invariance and classical logic and tautology. The opposite process of diversity or diversification refers to notions of irrationality, variance, *non-sequiturs* and negation in general. The essential point is not only that these two groups of processes are connected physically and dialectically, but also that they have equivalent ontological status. The exclusions, negative implications, etc., the 'non-rationalizable' elements of reality that instantiate diversity constitute an integral part of the total logical structure of reality, independently of anything arbitrary or subjective.[8] When the two processes are of equal strength, in a symmetric dynamic equilibrium, one is in the presence of a 'contradictorial'[9] process, expressed most clearly in human mental and social phenomena. The formal structure of these processes has the form of chains of chains of implications, the ortho-deductions, indicated by the calculus of Chapter 2.

4.4.1.3 Actuality and Potentiality

The concept of a pendulum is familiar: energy goes from potential when the pendulum is momentarily at rest at the top of its arc to actual, kinetic when it moves most rapidly at the bottom. Now, the concept of potentiality is central to my thesis. While the term is applied routinely in many scientific fields – oxidation/reduction potential in chemistry; activation potential in neurophysiology – the absence of a general framework has made it difficult to understand its origin as well as the modalities of its operation at specific levels of reality.

The first point is that for energy to manifest itself in change, with regard to an observer or not, it must go from a certain state of potentiality to a certain state of actuality. If everything were completely actualized or realized, for any reason, everything would be definitively static; no event or change could take place. However, for any energy to be in that state of potentiality, something, some brake or obstacle, which in an energetic universe can only be another quantity of energy, must be what maintains the former energy as such, through the latter's own actualization. And this latter potentializes itself or is potentialized, in its turn, to enable the former to become actual. The movement from one state predominating to the other takes place within the global energy gradient of the universe present since the Big Bang or prevailing in an alternative cyclic picture. In other words, since, according to the 2nd Law of Thermodynamics, some energy is degraded to heat in all real processes, one never comes back exactly to the same actualized state. Absolute circularity does not exist.[10] The origins of all the processes of change discussed in this theory are statistical and probabilistic,[11] without the need for any other causal principle.

The juxtaposition of the terms energy, actuality and potentiality goes back to Aristotle. The condition of an entity whose essence is fully realized is an entelechy, a condition of actuality as distinguished from potentiality. As René Thom, the originator of catastrophe theory (cf. Chapter 5), has pointed out (Thom

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[8] "Methinks there is some method in his madness".

[9] Cf. Section 1.2.2 for the definition of contradictorial and contradictional.

[10] In some quantum systems, the operators of total energy, kinetic energy and potential energy do not commute. This is consistent with the non-Boolean aspect of the LIR reality values I see at higher levels of reality suggested in Chapter 1 (Rohrlich et al. 1995).

[11] As noted in Chapter 1, there are open issues regarding statistical probability in physics that I cannot go into here.

1988), Aristotle sometimes seems to have not distinguished between *energeia* and *entelecheia*. However, *energeia* is derived from a verb, *energein*, and implies duration in the operation of the driving force of the process, whereas *entelecheia* refers to its two crucial instants, namely, the start of the movement or conception of a project and its achievement (*telos*). An agent is an *energeia*, a subject, a nominative actant; a patient is, from the point of view of the act, an *entelecheia*, the accusative object.

Gill (2003) has re-analyzed Aristotle's views of actuality and potentiality, and I can agree with her formulation that change is not a 'product' but a process that yields a product as the joint actuality of agent and patient. Change is a process in which a patient (potentiality) comes to be other than it was and is assimilated to the positive state of the agent (actuality). Gill supports Aristotle's distinction between *change* as non-uniform process of going from one state to another and *activity* as a uniform (or continuous) process, the dynamic expression of a state that a subject is already in. In my view, this introduction of a distinction between process and state is justified from the NEO categorial standpoint: some physical objects are macrophysically more stable than others, and the 'perdurationist' view recognizes this. But one can also say that things in potentiality and things in actuality (patients and agents) are not somehow *one*, in a joint actuality, as Gill suggests, but they and their opposites alternate between, or instantiate alternately, actuality and potentiality, and, at the same time, continuity and discontinuity.

Aristotle considered that potentiality and actuality were categories, of a kind. However, nothing equivalent to the concept of a dynamic reciprocity of actualization and potentialization has been ascribed to Aristotle. The significant contribution of Lupasco was to see the link between the actuality and potentiality of Aristotle and the other classical dualities; the actual and potential energy defined by the early 20th century energetists; and the new (in 1925) Heisenberg uncertainty principle. The principle of dynamic opposition, Lupasco thought, required redefinition of the logical underpinnings of all aspects of philosophy, metaphysics and ontology.[12]

Other authors, including Russell and Schrödinger, saw the necessity of supplementing actual appearances by potential ones to achieve a satisfactory definition of real objects. However, the emphasis in categorizing 'sensibilia'[13] has been as possible profiles of the object achieved or inferred by different perspectives. Such perspectives, while not visible to me for the moment, are nonetheless, in my view, an aspect of the object's current state, actual to another observer. The problem is thus the radical lack of ontological commitment as to the role of

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[12] Heisenberg considered that the probability wave of quantum mechanics was a *potentia*, a new kind of physical reality "halfway between the massive reality of matter and the intellectual reality of the idea", and the reduction of the probability wave during measurement was a movement from potential to actual. This view is now of historical interest, but the intuition that the choice of the term *potentia* implies is intriguing, as is the 'halfway' that reminds me of the T-state.

[13] Russell's term for objects "which have the same metaphysical and physical status as sense-data, without necessarily being data to any mind" (Bitbol 1991).

potentiality, going back to Russell's statement that logical constructions (in the standard sense) are to be substituted for inferred entities.

This has led to the 'point-of-view' conception of quantum mechanics involving a definition of 'functional dualism'. What I wish to underline here, however, is that no reference that I have uncovered suggests that non-localized potentialities not only have real existence, as existence has been defined earlier in this chapter, as fitting the *logical* foundations of LIR, but also are *functionally* related to actualities, in the sense of Axiom **LIR5**. If one follows the line taken in this book, one arrives at what amounts to potentiality as an inferred physical entity that is, *eo ipso*, also a logical construction in the sense of the logic of/in reality.

Aerts (2001) stated, supporting the LIR picture, that "*Change is described by potential properties becoming actual and actual properties becoming potential* (emphasis mine)." More recent work has concentrated on the aspect of the actualization of potential driven by context, downplaying the reciprocity of the interaction between actual and potential. In LIR, what drives the change or 'becoming' is the overall energy gradient of the universe, but what relates the two is the dynamic opposition inherent in energy and all of its manifestations.

4.4.1.4 Locality and Globality

In addition to the above pairs of dualities, LIR challenges the total separation of locality and globality. In the usual picture,

$$\text{Global } \Phi\text{:}\ \ \Phi\left[(\underline{\mathrm{x}}, \mathrm{t})\right] \quad \text{Local } \Psi : \Psi\left[\rho(\underline{\mathrm{x}}, \mathrm{t})\right] \tag{4.1}$$

where $\mathbf{x}$ is the usual 3D space, $\mathbf{t}$ is time and $\boldsymbol{\rho}$ is a quantity invariable under some transformation. However, what if the standard definitions of space and time above are incomplete? The standard answer is that these definitions come from the equations of motion, but are we sure that the standard equations of motion describe *all* the relevant process phenomena of the real world? My (non-standard) answer is probably not, in view of the questions around the foundations of differential calculus, which will be discussed in the section on paracontinuity.

This approach should not be taken to imply that the equations of motion are wrong; they work, permit predictions, etc. However, the principles that govern the structure of reality may only be partly reflected in this picture of motion and its consequences. I therefore postulate that local and global aspects of phenomena are, like the previous dualities, variables that are conjugate or otherwise mutually dependent in the sense of the formal Axiom **LIRF3**.

Section 7.6 looks in more detail at current views of cosmology, including the concept of invariance that is considered fundamental to the Einsteinian model.[14]

[14] Lupasco (1973) suggested an epistemological and psychological explanation for the drive of scientific thought to extract invariants from the diversity of the external world. Invariants, as

It is impossible to review here all the developments in physics that led to these views, but there is one that I feel most closely corresponds to the picture of physical reality, namely, the Aharonov-Bohm effect. As described by Cao (1997), this effect revealed the physical reality of the gauge potential and the non-local character of electromagnetism. Like the Lupascian intensity of energy, it is the relative change in the phase of a wave function of the electrons produced by the potential that is physically observable. The change is not produced by any local interaction of any specific potential with the electrons, but is dictated by a certain global property of the potential. In terms of its ontological foundations, the gauge potential can be unique and non-arbitrary. This is the picture I have of potentiality in LIR of elements related by dynamic opposition: potential is a real component of a system, but does not have to be localized to have causal properties.

4.4.1.5 Energy Is Dual and Antagonistic

I describe again the principle of antagonism in energy as follows: whatever it is that prevents a quantity of energy A from moving in one direction or another can only be an opposing quantity of energy, which I will now call non-A or anti-A, such that the actualization of non-A implies the potentialization of A, and *vice versa*. For a chemical reaction to take place, for example, a certain quantity of energy must pass from a state of potentiality in a reactant to a state of actuality. At some point, for all phenomena, there will be a point of equilibrium between the two tendencies, 'on the way from one to the other', which can be considered as the third element existing simultaneously with the other two (T-state, from *tiers inclus* or included 'third' element, cf. Section 1.2.3). In the simple example of a chemical reaction, it can be thought of as the transition state.[15] The significance of the T-state for more complex processes will become apparent in the next section. Examples and further aspects of the T-state as a category are provided below.

Further, as I have shown in the discussion of the calculus of implication, conjunction and disjunction, a relation is not only one of inclusion or identification, but also of exclusion, non-linkage, or rupture, governed by the same logical principles. A relation contains the notion of additional dualities or contradictory categories of things, variant and invariant, real and apparent, internal and external. However, our conscious minds are in general so dominated by an extensive aspect

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extensities, are easier and more normally grasped, whereas variance appears as unreal or irrational.

[15] The transition state in a chemical reaction is the point at which the 'activation energy', the energetic *barrier* to a reaction taking place, has been overcome by an input of energy – heat, light, etc. – from the environment, and the thermodynamically favored products of the reaction can form. One also sees, however, consistent with the principles of LIR, that thermodynamically *less* favored products can also be formed, but to a much smaller extent, unless further energy is made available in some form, for example, by the use of a catalyst with a unique molecular or surface structure.

of reality, the perceived psychological advantages of identity, we generally tend to reject the idea that an appearance of reality subsumed under a relation, that is, intensive, is equally real.[16]

Another objection has been made against antagonism as a logical as well as a physical principle. Even if there are two factors or aspects present in energy, their relation is not one of opposition. Consequently, antagonism and its equivalents are not general properties of phenomena. Lupasco suggested that energy is not a substance having an existence independent of its forms and transformations. Energy is not one thing and the energetic factors, or categorial features, of extensity and intensity another; in its self-duality, energy exemplifies or instantiates the two opposing dynamisms.[17] This can be taken to imply, and as I claim, *does* imply, the existence of real contradiction in the sense of counter-action. Energy is extension in the sense of unity and indestructibility and intension in the sense of being observable only through *changes* in level. Similarly, the notion of relation requires that of interaction and a concomitant contradictorial duality implied by the 'otherness' of the elements related.

What is available today to argue in favor of these intuitions is the field approach to the structure of reality presented above. From now on, it would appear that the burden of proof would be on theories that would *exclude*, or fail to take into account, dualism, the reality of both actuality and potentiality as a fundamental principle, provided that it can also be shown that the properties of energy and the effective quantum field 'percolate' up throughout higher levels of reality. This question is addressed later in connection with the general problems of distinguishability and emergence.

4.4.2 The Fundamental Principle of LIR

The fundamental principle of LIR is thus that the dialectical characteristics of energy discussed – actual and potential, continuous and discontinuous; entropic and negentropic, identifying or homogenizing and diversifying or heterogenizing – can be further formalized as a structural logical PDO, the antagonistic duality inherent in the nature of energy and accordingly applicable to all interactive phenomena, physical and mental, including information, propositions and judgments.

I quote here another key concept of Lupasco (1987):

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[16] The opposing position, that *only* the appearance, as constituted by our conscious minds, is real is the basis for the transcendental phenomenology of Husserl that will be criticized later.

[17] Efforts have been and are still being made to avoid save the principle of non-contradiction. Lupasco saw the entire history of philosophy expressed as a psychological bias toward selection of one or another monism as the basis of reality, a psychological tendency to avoid having to accept conflict and antagonism as fundamental.

> Energy must possess a logic that is not a classic logic nor any other based on a principle of pure non-contradiction, since energy implies a contradictory duality in its own nature, structure and function. The contradictory logic of energy is a real logic, that is, a science of logical facts and operations, and not a psychology, phenomenology or epistemology.

Contradictions or dynamic oppositions thus exist in things being continuous and discontinuous, unified and diversified, wave and particle, local and global, in some way at the same time, but not completely so, only in the alternating sense of Axiom **LIR2**. An Aristotelian logic, in which one tries to eliminate or avoid contradiction of any kind, is not adequate to describe real systems, all of which are derived from energy. Current paraconsistent logics, that permit true contradictions, but retain idealized, abstract concepts of truth and falsity, fail to give an adequate picture of the emergence of complex, real-world phenomena. These points apply to all phenomena: ideas, theories, propositions, as well as physical systems. Further, contradictions, in the physical sense of real opposing processes, entities or properties can never disappear completely, since this would imply, ultimately, going below the standard quantum limit, defined by the Planck quantum of action. All phenomena thus continually but non-reflexively (that is, without 'perfect' circularity) alternate between degrees of actualization and of potentialization of themselves and their opposites or contradictions. This is a restatement of Axiom **LIR6** of Asymptoticity.

As purely mental phenomena, judgment and belief provide good examples of the operation of the fundamental principle. For example, LIR provides a concept of judgment that emphasizes the existence, for any judgment, for the opposite or contradictory judgment, the movement between the two elements, and the possibility of emergence of a third, new judgment that would still embody aspects of the other two. Any autonomous judgment would be one rigorously, that is, completely actualized, absolutely non-contradictory, an Aristotelian, categorical judgment. It would imply absolute logical processes, disconnected from reality. It would no longer be a judgment, that is, a dynamic event. A judgment in this view is constituted or essentially composed of two inverse, contradictory judgments: one of them is the operative, actualized judgment while the other is potentialized, remaining in the conscious mind as a general feeling that one could have made the opposite judgment. Logics of standard patterns of inference or judgments have metalogical deficiencies since they fail to recognize the contradictory processes involved. This criticism applies to the large number of logics that have been proposed to deal with changes of judgment or belief. While these defeasible or 'correctable' logics do handle the addition or subtraction of evidence or premises, they do so without direct reference to the actual processes taking place in the mind. It is the latter, in the approach here, that give a picture of the real pathways and 'jumps' from one judgment to another.

Thus my logic of reality is consistent with a view of a phenomenon as instantiating both appearance, the original meaning of the word, and an underlying reality. An appearance is something relational, what something is for something else. It is a being *for itself* (*pour-soi*) by opposition to a being *in itself* (*en-soi*) independently of its apprehension by another entity, as in the conception of Sartre mentioned in Chapter 3. However, Sartre does not suggest any interaction between the two terms, which in my view is critical and is the central feature of the logic in reality described in this book.

As an interim conclusion of this part of the discussion, I can say that every phenomenon is characterized both by coefficients of the properties of identity and diversity on the one hand *and* of actuality and potentiality on the other. The T-state can be considered as a separate category of entity since is characterized as a state in which two opposite properties, say rationality and irrationality, are *always* equal, both are half-actualized and half-potentialized.

4.5 THE CATEGORY AND SUB-CATEGORIES OF DYNAMIC OPPOSITION

As I proceed with the categorization of reality, I propose Dynamic Opposition, or Antagonism, is the most important formal category.

I have said that the dualities that are the ontological predicates of LIR proposed in Chapter 3 all characterize or are inherent in energy, in all its forms. From the point of view of formal ontology, I have suggested that the sole material category is energy. The difficulty, or, as we will see, opportunity that results from the LIR approach, is that from a *metaphysical* standpoint, for real systems or phenomena or processes in which these dualities are instantiated, their terms are *not* separated or separable! In the theory I propose, real complex phenomena display an adequately contradictional relation to or interaction between themselves and their opposites or contradictions. On the other hand, there are many phenomena in which such interactions are not present, and they, and the simple changes in which they are involved, can be described by classical, binary logic or its modern versions.

This argument, however, suggests that the most useful categorial division that can be made is exactly this: phenomena that show non-separability of the terms of the dualities as an essential aspect of their existence, NSC, at their level of reality and those that instantiate separability, SC. Together with the other categories, I propose that they define the 'New Energy Ontology', NEO referred to above as the formal ontology of LIR (cf. also Section 4.7).

One may ask at this point to what extent these sub-categories, SC and NSC, are simply restatements of the logical operators of disjunction and conjunction respectively, as they are understood in standard logic. This would be valid, however, only for the classical view of conjunction and disjunction as non-spatio-temporal, quasi-abstract concepts, whereas in my theory they also are considered to be dynamic process entities, instantiated in phenomena and subject to the predicates of actuality and potentiality in transfinite sequences, related as shown in Section 2.4.

Dynamic Opposition and its sub-categories of Separability and Non-Separability is thus the formal category of LIR corresponding to the material category Energy. It underlies the other metaphysical and phenomenal dualities of reality, such as, in particular, determinism and indeterminism, subject and object, continuity and discontinuity, and so on. This is a 'vital' concept to which I will return: to consider process elements that are contradictorially linked as separable is a form of category error.

I thus claim that non-separability at the macroscopic level, like that being explored at the quantum level, provides a principle of organization or structure in macroscopic phenomena that has been neglected. The functional non-separability of process systems, for example, both the afferent system of perception and the efferent system of action, is based on the non-separability of properties of lower-level systems, membranes, ions and neurotransmitters, down to the level of fundamental particles. Moving in the other direction, this view has consequences for the relation between the neurophysiological level and the higher level, non-reducible, supervenient phenomena of intentionality and qualia.

4.5.1 Non-separability

Non-separability as a physical principle functioning at not only quantum but also at biological and cognitive levels would require a chapter in itself to do it justice. I will state just a few of the variants currently discussed in quantum physics and show that non-separability in my New Energy Ontology does not correspond exactly to any of them.

Non-separability is related to holism: holism is the thesis that the whole is more than the sum of the parts, and non-separability can be defined by the statement that the state of the whole is not fully constituted by the states, properties and relations of the parts. These do not provide the complete basis for the whole, and one says in this case that the whole – an object or process with its own set of properties and relations – does not supervene on its parts. Since I am talking about states of systems, I will use the corresponding principle as laid out by Healey (2004):

> *State Separability*: The state assigned to a compound physical system at any time is supervenient on the states then assigned to its component subsystems (the latter are the basis for the former).

Since the logical values of LIR that define its states are probabilistic (Chapter 1), this formulation and its negation should apply to them. A further ascription of non-separability to classical processes such as phase change and the propagation of gravitational energy is possible. Healey then makes the following statement: "Non-separability would be a trivial notion if no qualitative intrinsic physical properties were ever assigned at space-time points or in their neighborhoods. *But this would require a thorough-going relationism that took not only geometric but all local features to be irreducibly relational* (emphasis mine). This is exactly the 'relationalist' thesis of LIR, the local features being the energetic states of actualization and potentialization.

Quantum entanglement, which has now been demonstrated over macroscopic distances for pairs of photons, is the paradigm example of non-separability. The failure of the Bell inequalities that would imply no correlation between the results of measurement of properties of separated particles is now accepted as the evidence for their non-separability, although questions remain. This can be considered as a form of holism in that, as in relational quantum mechanics (see Chapter 7), sub-systems function as quantum systems only by virtue of their relations to other sub-systems that compose the whole. As noted above, Aerts has shown that the Bell inequalities are also violated in certain macroscopic systems in which a lack of knowledge about the system results in what I might call "epistemological" non-separability. I prefer to see the non-separability as onto-logical and real, that is, independent of our knowledge or a putative measurement process.

The LIR conception of categorial non-separability, although it is related to the above, is thus significantly different for the following reasons:

- The duality of the fundamental properties of energy – intensity and extensity – also implies they are non-separable. Note that in string theory, charge, mass and spin arise as non-separable features of the world at this deepest level. The principle that LIR adds is that these features are in opposition in the sense of being alternately actual and potential, and the persistence of these features permit non-separability at higher levels.
- LIR rejects the original definition of part and whole as separable which depends on the classical notion of individual and individuation of events. This is consistent with the view of Ladyman of Ontic Structural Realism. By the Axiom of Functional Association, no part and no whole is absolutely such, but each shares properties of the other. Accordingly, any given system (whole) *qua* that system is completely described by its sub-systems (parts, relata) given their necessary relation. Any *additional* property of the whole would be an *emergent* property or structure, resulting from the PDO. This is a form of non-separability but not of holism, since the relata and their spatio-temporal relations do determine the emergent entity (the entity and its relations do supervene on the relata).

To summarize, it is the failure of individuation that is the basis of non-separability, not that there are physical entities that are not wholly composed of existent basic physical parts, following a principle of physical closure (cf. Chapter 6). The ideas in the literature and LIR can now be directly compared: (1) it is not claimed in theories of physics, or in LIR, that any physical entity has *non*-physical parts; (2) the former state that some physical entities that we take to be composed of a particular set of basic physical parts are in fact not so composed; and (3) LIR states that the *basic constituting physical parts include some that are not fully actual at any moment, and their actuality and potentiality are non-separable properties*.

4.5.2 Is There a Mathematical Physics of LIR?

In this first overview of the concept of a logic in and of reality *per se*, I can only confirm that a mathematical characterization of LIR would be desirable but none has been made. In Chapter 1, I suggested that the appropriate formalization of the variables of LIR could be as a form of non-Kolmogorovian probabilities. On the other hand, I have claimed that my dualities are fundamental, and there are other mathematical ways of looking at aggregates of two (or more, of course) objects, namely, set theory and group theory itself.[18]

In quantum mechanics, the elements of the algebras, their 'structure' – constants which can be constructed using group theory – frequently have direct interpretations as physical quantities, such as angular momentum (Penrose 2004). Properties such as spin states of quantum particles, which are 'simple' two-state systems, can also be described by this theory. It should be possible in principle to develop a mathematical language for the description of the physical states that I consider the reality values of LIR to represent. To recall from Chapter 2, these were defined as the relative degrees of actualization and potentialization, in particular, of the tendencies towards identity and diversity.

As pointed out by Krause (2007), while physics has moved its paradigm from classical physics to quantum and relativistic physics, logic and (standard) mathematics still use languages which refer to individuals and collections of distinguishable objects, that is, sets, describable by set theory. Macroscopic object are modeled as individuals, primitive entities that are established as such by a (binary) counting process. These are identifiable as kinds or sorts, whence the term sortal logic. Since individuality and distinguishability of quantum entities is highly problematic, the direction that Krause has taken is to defend a concept of quasi-sets that provides for the partial similarity of their elements. A concept of "relative identity" is introduced to convey the notion that classical identity cannot

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[18] Krause has suggested (private communication) that the appropriate mathematical concepts to describe LIR are the "uniform structures" of Günther Ludwig. These concepts, lie somewhere between topological and metrical structures. The theory has the intriguing characteristic that the structures of the infinitely large and small have no physical meaning, but are tools to approximate finite physical reality, which can be related to the LIR view of the transfinite in Section 2.3.1 (Schmidt 2003).

apply. Quasi-sets, as discussed further in Chapter 5, are collections of elements that have cardinality (some "size") but not ordinality in the sense of having a definitive number of such elements. One defines quantum sortal predicates as providing for quantum entities instantiating both separability *and* non-individuality or *in*distinguishability. A quantum entity is and is not an individual; it is and is not the same as another one (Krause 2005).

The two, related questions that this otherwise very promising approach does not yet answer are the following: what does it mean at the quantum level for an entity to be the same and not the same, and how far up the ladder of complexity does such a property of indistinguishability extend? As noted, molecules with as many as sixty carbon atoms have been shown to exhibit wave-like properties in diffraction experiments, but people do not.

I propose dynamic opposition as the meta-theoretical principle that establishes the antagonistic structure of real process entities, including quantum ones. My 'aggregates' are systems of two entities in a relationship of dynamic opposition, of which at least the following can be said: *the system (aggregate) does not originate in a counting process*. In fact, there must be, as I show in my systems approach (Appendix 2), for any real system, the combination of a principle of aggregation (attraction) and a principle of repulsion (exclusion) otherwise the two-element aggregate collapses into an undifferentiated identity.

Recall that LIR included axiomatically, and now includes categorially, the concept of something being the same and different, individual and non-individual, either synchronically, as would be the case for quantum particles, or diachronically, when the overall structure becomes too complex, at point that remains to be defined. Since these properties are maintained as potentialities in higher-level structures, there is a degree of indistinguishability that can be assigned to all entities, including human beings. We are all, to some extent, ourselves and not ourselves, ourselves and partly others, more or less one or the other at different times.

These properties of human beings are not *quantum* properties, but they are isomorphic to quantum properties in this structural sense. The LIR picture of the physics of reality given so far, however, fails to account for the difference between what appears to be the fundamental space-time structure of the universe as described by general relativity and as we experience it. If the principle of dynamic opposition is as fundamental as I claim, there ought to be some mathematical physics that more specifically describes *its* operation and relates the two domains. These considerations, which play a key role in the *logical* approach to reality I propose will be discussed in the next three chapters under the headings of structure, structural realism and the physics and metaphysics of reality, in that order.

4.6 THE CATEGORY OF PROCESS: CHANGE

The further material categories of Process, the structure of change, Subject, Object and Subject/Object and T-state will emphasize the essential relationships involved in the ontology.

Seibt has described some common heuristic strategies for the selection of 'candidates' for category-hood and the construction of categories. Citing Sellars, she shows how a schema of recategorization of certain inferential patterns leads from a substance-based to a process-based ontology. A new category is introduced "whose model is no longer a portion of physical stuff but a process." Like other standard categorial entities, however, the absolute processes in this formal ontology are theoretical entities.

From the LIR standpoint, I introduce the new *material* category of 'Process' coming from the other side, so to speak. I consider change, suggested as an ontological predicate or category feature of LIR in Chapter 3, as something in common agentive experience whose properties can be captured by 'Process' as describing and *explaining* the structure of change.

4.6.1 Three Current Views of Process

Three current views of process inform the definition of process as a category, one ontological and two metaphysical:

1. The General Process Theory of Seibt (Seibt 2003) (formerly Free Process Theory, FPT) makes a strong case for a central role for process in ontology. FPT is a process-ontological framework that avoids substance-ontological and logical presuppositions that have hobbled analysis of dynamic categories. FPT, as developed over the last 10–15 years, is of interest as a non-Whiteheadian framework that supports my view of the limitations of the Whiteheadian concept of process, namely, its partial reliance on idealized, abstract objects of reality. Free processes are defined by Seibt as general individuals that are both dynamic and concrete and constitute a new ontological category. They are not changes in things or even dynamic modifications of a medium but ways of going-on, activities considered from a qualitative standpoint. They are similar to the LIR concept of 'tendencies', phenomena in movement from actuality and potentiality (and *vice versa*), incorporating the notions of dynamism *and* its inhibition, the stopping of the dynamism or process, but it should be repeated that the free processes discussed are also theoretical entities with only axiomatic characterization.

I have suggested that the exclusion of contradiction from logic has overly constrained its applicability. Similarly, Seibt has shown how characteristic Aristotelian presuppositions have constrained ontology to a substance paradigm. From her framework, Seibt sees a trend in ontological theories that leads from traditional substance-ontological schemes operating with concrete, particular, static and 'causally separate' entities (including abstract and general entities) to schemes whose basic entities are concrete but non-particular, dynamic and 'causally interlaced' or 'overlapping'. My category of dynamic opposition gives a basis for moving from the first group of entities to the second and suggests a physical meaning to 'interlaced or overlapping' that founds this approach for reality, that is, metaphysically, and accordingly for ontology.

2. The foundational work of Rescher on process metaphysics and process semantics is well known, and I have summarized my views of it elsewhere (Brenner 2005). Rescher's mission for process philosophy is "enabling us to characterize, describe, clarify and explain the most general features of the real." Further, he relates his view of the processual structure of reality to energy, the entities of quantum mechanics entering into more and more complex arrangements. Rescher saw the development of a process semantics, as opposed to logic, as the conceptually most versatile and philosophically most fundamental tool for understanding reality. It is at the basis of his ideas of process philosophy and process metaphysics. What he called the mainstream logical theory of the West, which takes an approach to truth that is committed to its static fixity, was and is unable to meet this challenge. I suggest to the extent that LIR describes change in terms of dynamic opposition, it captures the features of process described by Rescher and can be seen as the preferred logic of, in and for process.

3. Lowe (2002) views processes, which he calls events, and persisting objects as entities belonging to quite different categories. This is compatible with my division of entities instantiating separability or non-separability. However, Lowe further maintains a dichotomy between an event-ontological and field-ontological quantum physics. His interpretation of a quantum field, however, requires a further substrate, namely, neo-classical space-time. LIR provides a sim-pler picture in two ways: it denies that there is anything metaphysically funda-mental about persisting objects (rocks) by seeing them also as process phenomena on a long time-scale; LIR could thus be considered a form of eliminativist ontology, in which talk of events and processes replaces talk of persisting objects. But there is no reason to give up, *completely*, the commonsense notion of per-sisting objects; what is potentially misleading it the implied absolutely static nature of the phenomenon as a fundamental property, and all objects may be sub-sumed under the category of Process.

At the basic level of physics, LIR allows for dialectic interactions between entities, eliminating the need for a field substrate. Quantum particles and fields are contradictorially related, in the LIR interpretation. A metaphysical question remains, however, even within my system, as to whether entities at the quantum level *themselves* participate in change and can therefore be included in the category of Process. This would imply a logical distinction between a proton, that theoretically can decay, and an electron, that cannot. This distinction does not, however, affect the subsequent discussion here.

4.7 THE CATEGORY OF T-STATES

The concept of an energetic state of phenomena, the T-state, being not only an element of a *logic* but one that overturns, in certain areas, an axiom of commonsense logic, the law of the excluded middle, is the crucial innovation of my logic of and in reality. It is thus important to first make clear what a T-state is *not*: it is not an average of two or more elements, a static, scalar result of an arithmetical operation. It is not the result of a physical mixture or fusion; gray is also an 'average' of black and white, but this result is inert, without the capacity of change or development. Similarly, a T-state is not the static equilibrium that results from the neutralization of two elements, such as equal quantities of acid and alkali. At a microscopic level, some regions of such substances may depart from equilibrium, but the fluctuations are statistical in nature.

At a single level of reality, the second and third axioms of classical logic are essentially equivalent: there are no contradictions in the same time and place. In my extension of logic, a T-state resolves a contradiction at another level of reality. One example that is frequently given is the apparent unification in the quanton (T) of the apparently contradictory elements of particle (A) and wave (non-A). What is involved at the single, 'lower' level of reality are more or less mutually exclusive, antagonistic pairs that can be seen as resulting from the projection of a T-state on it (Nicolescu 1999). The T-state is the included middle or third term in that it is located in the model at an intermediate point in a complex configuration space. In contrast to the Hegelian triad, the three elements here coexist at the same moment of time. It should be re-emphasized that "A and non-A at the same time" does not mean that both are fully actual. One element is more or less actual, and the other is, correspondingly, more or less potential. 'At the same time' does not imply an instant of standard clock-time. Process elements deploy their own time and space, or space-time as I will claim in Chapter 7. The relevance of this concept to the problem of simultaneity in relativity theory will also be discussed later in this book.[19]

LIR is capable of describing a coherent transition between levels of reality. A given T-state (which effects the unification of A and non-A) is associated with another couple of contradictory elements at its higher level (A^1, non-A^1), which are in turn resolved at another level by T^1. The application of the logic of the included middle implies an open, incomplete structure of the set of all possible levels of reality, similar to that defined by Gödel for formal systems.[20]

[19] This present 'moment' is in fact a complex contradictorial conjunction of simultaneity and succession that is the consequence of the fundamental postulate applied to 'space-time'.

[20] Computational logic now includes concepts of formal systems as open, capable of handling changing or evolving information, replacing the Hilbert concept of formal systems as closed.

Concatenations of systems and dialectics never yield a third term in the sense of a Hegelian or Marxist synthesis. The T-state is not a term, but a state, and emergent T-states, at a higher level of reality, can also enter as elements into contradictory relations.

The purpose of defining T-states as a category is to be able to use the concept to evaluate both philosophical and scientific theories, including patterns of human individual and social behavior. It is in dynamic systems involving feedback in the biological, mental, social and political worlds, in addition to the quantum level, that examples of T-states are to be found. In order to see how two elements in dynamic opposition result in a third, a T-state, one must look closely at the tendencies of each of them toward identity or diversity, homogenization or heterogenization, forces of dissolution or forces of growth.

At the quantum level, a baryon such as the highly stable proton is composed of quarks and anti-quarks of various kinds that are held together by energetic particles called gluons, which bind the various quarks by 'exchanging' energy between them. As noted above, it is tempting to see the stability of a proton as due to this dynamic process between two opposing quarks, with the gluon playing the role of an included middle.

All living systems supervene on the inorganic level, where the former predominates, and on lower levels of organic structure. As noted, the latter supervene on still lower levels of reality, starting with chemical elements, molecular compounds, e.g., proteins, leading to cell structures, cells and organisms. Each of these stages can be considered a T-state relative to the one below it, but the concept of a T-state resolving energetic oppositions has greater explicatory power than supervenience, which does not describe an *interaction* between supervenient and subvenient elements, nor the concomitant interaction between the subvenient elements themselves. This point will be critical for my treatment of causality.

It should be noted, however, that each stage of cell division in embryogenesis is not a T-state, but a system of processes ultimately leading to (relative) non-contradiction, the phenotype. But the phenotype, the individual, is a T-state relative to the genotype, the 'site' of the counter-action between the actualized DNA and the residual chemical potentialities of the elements and compounds composing it. These potentialities can be considered as a biological 'memory' which can appear as a final cause of development, as will be discussed in connection with both causality and biology.

In addition to the T-states at the quantum level and in biology, the greatest number of examples is at the mental level. Their structure of these included middles is highly complex. As noted, phenomena at any level of reality can be characterized by differing actualization of primary trends toward non-contradiction (contradictional: identity, homogeneity or diversity, heterogeneity) or toward contradiction (contradictorial: emergence of new entities). Complexi-fication arises because these trends are themselves actualized or potentialized to a different degree, but never completely. In the resulting emergent elements that enter into further contradictorial relations, either homogeneity or heterogeneity is predominant, but the other is also always present. If one looks, for example, at any living system, it is clear that it embodies processes of growth and metabolism and/or decay at the same time. Thus it is not exactly correct to say only that, in living systems, diversity is actualized and identity is potentialized. Rather, the emergence of new forms, heterogeneity, is *predominantly* actualized and macro-physical processes of degradation, of homogeneity are *predominantly* potentialized, but at the same time the latter are actualized to a minor extent and the former is potentialized to a minor extent. A similar situation applies to the processes of perception and action. The homogeneous object in my consciousness is only potentialized with respect to the processes of actualization of its heterogeneous aspects actually occurring in my sense organs, of which I am largely unconscious. The inverse situation applies to efferent stimuli. But since actualizations and potentializations are never complete, there is also always some consciousness of heterogeneity in the first case and of homogeneity in the second.

The originality of this picture does not reside in its identification of a consciousness, a consciousness of consciousness (sometimes designated as awareness) and an unconscious. Rather, it is in its emphasis on the logical character of the origin of these higher-level structures in the PDO at the level of basic physics, the mechanisms for their emergence and the subsequent complexification of their interactions.

T-states in the socio-political arena can correspond, among other things, to new laws. Unlike compromise or ‘centrist’ positions, T-states are radically new structures that are sometimes developed to reconcile oppositions between groups that have been unable to succeed in suppressing or eliminating each other. One example of this is the situation of segregationists and anti-segregationists in the Southern United States before 1956, which led to the passage of laws against racial discrimination and the acceptance, albeit slow, partial and grudging, of racial equality.

I will discuss other exemplifications of T-states in the respective sections on the sciences and disciplines involved.

4.7.1 The Duality of Quantum Spin

There is an additional fundamental physical duality to which I should call attention, as it is necessary for understanding the emergent aspects of T-states. Quantum entities exist in two classes defined by the quantity of a property called spin: entities with spin of ½ are called bosons; those with integral spin fermions. All quantum entities can be said to exhibit or instantiate both particle and wave characteristics, and from this point of view a real entity can be considered as being an included middle T-state in a complex configuration space at a ‘higher’ level of reality. In the case of bosons, of which most common one is the photon, this T-state, however, is an *epistemological* T-state. The position and momentum of the photon are completely defined mathematically, as a combination or ‘superposition’ of less complex states, and the T-state here is a consequence, not to say an artifact of our theories. The photon, unless and until it encounters some sort of physical detector or molecule with which it interacts, does not enter into relations with other bosons based on any residual potentialities, except under highly unusual conditions.[21] The detector may bring out its particle or wave characteristics, but without changing the photon. It will 'emerge' from such interactions as a photon, perhaps with a different energy, but still nothing more than a photon. Photons *do* instantiate the property of non-separability, that is correlation of spin states over arbitrarily large distances, but that is another matter not directly related to the concept of emergence.

On the other hand, fermions, in particular electrons and protons, exhibit properties as T-states that can be expressed as being not closed to further structural dynamic interactions, as indicated in the discussion of the Pauli Exclusion Principle. Only electrons with opposite spins can occupy the same energy level or sub-level (shell) in atoms, providing the basis for the formation of chemical bonds and hence of molecules and macromolecular entities. I consider such quantum entities therefore as *physical* T-states with the potentialities for entering into the construction of the more complex entities – molecules, physical and biological substances, and so on. The T-states of interest in the subsequent discussion, at all levels of reality including that of biological and mental processes and events, theories, etc. will be of the 'fermion' variety. This description does not, of course, completely define the mechanism or the path by which, at a T-state, a given emergent entity is constituted. An initial approach will be made in Chapter 5 as part of my overall discussion of the categorial and physical structure of reality.

4.8 THE CATEGORIES OF SUBJECT, OBJECT AND SUBJECT-OBJECT

The construction of the categories of Subject, Object, and Subject-Object is an extension of the categorial predicates of actualization and potentialization. I start here from a conception of a *logical* subject and object (Lupasco 1947), that is, in relation to the logical values that I have defined as values of reality, reality values.

The actualization of such a logical value gives it the character of a cause, an agent, and potentialization the contradictory value of a patient, an effect. The

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[21] Under conditions of extreme cold, so-called Bose-Einstein condensates of large numbers of bosons can be produced. These objects, clouds of entities of the same kind, are of great theoretical interest but do not, in my view, require discussion in LIR terms, exactly because they do *not* instantiate dynamic opposition. Similarly, when accelerated to very high energies, collisions involving bosons can give rise to other entities, but these are again extreme conditions. The effective field theory description establishes the conceptual basis for the operation of different laws of nature at high energies that do not necessarily impact those at lower ones.

subsequent consideration of the former as a subject, or subjectivization and the latter as an object, or objectivization, should not be considered conventional, but a conclusion arrived at inductively, from scientific, philosophical and psychological points of view. The principle of antagonism always implies a logic that generates, as a structural and functional consequence, a logical subject and logical object in the above sense, such that, as implied by the category of Dynamic Opposition, the subject is always in a contradictory relation to the object. A dynamism that proceeds from potential to actual, that actualizes an energy, monopolizes, so to speak, the available configuration space in relation to itself. It becomes a center of existence, a subject. The dynamism that is potentialized is displaced from this center of activity and rendered passive, objectified, and transformed into an object (Lupasco 1951). Formalizing this, actualizations (A), potentializations (P) and T-states (T) can be replaced by the symbols S, O and, $\overline{SO}$ indicating subject, object and contradictorial subject-object respectively, in all of the Tables and formulas previously shown. The existence of a subject-object as an included middle is, of course, a consequence of the fundamental principle of LIR expressed by Axioms **LIR3** and **LIR4**… As previously, the first pair of columns refers to an element and its contradiction, the second to identity **i** and its associated diversity **d**, and the third to the operation of implication itself:

$$
\begin{array}{cccccccc}
\underline{e} & \underline{\bar{e}} & \quad & \underline{i} & \underline{d} & \quad & \underline{\supset} & \underline{\bar{\supset}} \\
S & O & & S & O & & S & O \\
\bar{S}\bar{O} & \bar{S}\bar{O} & & \bar{S}\bar{O} & \bar{S}\bar{O} & & \bar{S}\bar{O} & \bar{S}\bar{O} \\
O & S & & O & S & & O & S
\end{array}
\tag{4.2}
$$

For each pair of columns, the left corresponds to an element and the right to its opposition respectively, the first and third rows to the category of elements as (primarily) subject or object and the center row the category of 'half ' subject and object, written as 'non-', that I have called the category of Subject-Object.

I am aware that this is just a notation replacing one symbol with another equivalent to it, but the implications are substantial. It suggests that, for example, identity and all the aspects it can take on (invariance, permanence, conservation, etc.) on the one hand, and diversity or heterogeneity (variance, differentiation, etc.) can be respectively subject and object. The indeterminacy relations of Heisenberg can also formalized, as follows, where p is the momentum of a quantum particle and q is its position, S is the subject-observer and O the measurement.

$$\begin{array}{cc} \underline{p} & \underline{q} \\ S(A) & O(P) \\ O(P) & S(A) \end{array} \tag{4.3}$$

In words, this means that the intervention of the subject-observer who measures p more and more accurately, actualizing it, potentializes the position q, the thing observed, and inversely.

Finally, this notation indicates that where subjectivity and objectivity are functions of actualization and potentialization respectively, relative non-contradiction is actual and relative contradiction is potential.

$$\left[e_{S(A)} \supset \bar{e}_{O(P)}\right] \supset (\bar{C}_A \,.\, C_P) \tag{4.4}$$

In the situation in which a subject and object inhibit each other, the T-state is equivalent to an actual contradiction and potential non-contradiction, as in the microphysical, biological and mental phenomena in which as I indicated T-states are observed.

$$\left[e_{\bar{S}\bar{O}(T)} \supset \bar{e}_{\bar{S}\bar{O}(T)}\right] \supset (C_A \,.\, \bar{C}_P) \tag{4.5}$$

The property of actualization of appearing subjective, and that of potentialization of appearing objective, applies to the actualization and potentialization of contradiction and non-contradiction themselves. Lupasco applied this concept to *doubt*, one's having or experiencing, as a subject, an internal contradiction. At first, resolution of the doubt, non-contradiction, appears like something external, objective and potential at the same time. Inversely, if a state of certainty, non-contradiction, develops in me as a subject, it is the contradiction that appears external, objective and potential, which can be symbolized as follows:

$$(e_A \supset \bar{e}_P) \supset (\bar{C}_S \,.\, C_O)\ ;\ (\bar{e}_A \supset e_P) \supset (\bar{C}_S \,.\, C_O)\ ;\ (e_T \supset \bar{e}_T) \supset (C_S \,.\, \bar{C}_O) \tag{4.6}$$

In this approach, one should look for a subject and object in all knowledge and all science, according to this acceptation of the terms. The relation to the epistemological subject and object, the knower and the known, can also be discussed in this way. This category is as general as all the others, since it refers to process phenomena at all levels of reality.

4.8.1 Self and Other: Self-Reference

In the English language, the letters S and O also correspond to self and other, but this is a trivial coincidence. The key point is that, in LIR, applied to real processes, self and other are also complex dynamic processes that are linked contradictorially in the sub-category of Non-Separability. No self is a ‘pure’ subject; no other is a pure object.

The purport of ‘self’ thus depends on the domain of application involved. If one is in the binary linguistic or mathematical domain, self implies some form of classical identity. Self and other cannot be linked in classical logic, since this would be equivalent to partial inclusion of premises in conclusions that is excluded *a priori*. The situation in regard to the logical paradoxes of self-reference has become much clearer, of course, since the establishment by Gödel of the reciprocity between completeness and consistency in formal systems. Gödel’s work provides the basis for *paraconsistent* logic. For the time being, I note that the objects of Gödel’s theorems are abstract entities in the binary domain.

In real situations, however, use of the term in ‘self-reference’ requires further explanation. How can a real self refer to itself unless the self is somehow both self and other at the same time, in other words, a form of duality?[22] I suggest, as indicated above in the discussion of individuality in Section 4.5.1, that the LIR conception of dynamic opposition offers the basis of a solution to this problem; aspects of self and other are alternately actualized and potentialized. There is no ‘self ’ that is not partly ‘other’ in a potential mode of existence. With this in mind, the concept of self-reference in reality does not present the same difficulties as in language, where paradoxes of self-reference have a basis in the ambiguity introduced by negation. The LIR notion of self will be critical to the subsequent discussion of self-organization (Section 6.2.8.2), the discrimination between self and other of a living organism (Section 8.2.1).[23]

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[22] The Lebnizian form of argument can also be used in relation to knowledge.

[23] A discussion of the psychological self is outside the scope of this book, but it is interesting to note Jung’s foundational view of 1912–1916 (Jung 1971). He stated that the problem of opposites is an inherent principle of human nature, and saw the forces at work in terms of energies and gradients. The self was “characterized as a kind of compensation for (or result of) the conflict between inside and outside”, and even suggested that the self “can claim the value of a hypothesis analogous to the structure of the atom”. This may be one of the earliest

4.9 LIR AS A FORMAL ONTOLOGY: NEO AND THE CATEGORY-AXIOM FIT

I will now go back over the ground covered to show how and to what extent the categories I have introduced as constituting the formal ontology of LIR, NEO, and the features or properties that characterize them, fit the axioms of LIR:

LIR1: *Non-identity*: There is no A at a given time that is identical to A at another time.
LIR2: *Conditional Contradiction*: A and non-A both exist at the same time, but only in the sense that when A is actual (but never to the extent of 100%), non-A is potential (but never to the extent of 100%), reciprocally, proportionally and alternatively.
LIR3: *Included Middle*: An included or additional third state T emerges from the point of maximum contradiction at which A and non-A are equally actualized and potentialized, but at a higher level of reality, at which the contradiction is resolved.
LIR4: *Logical Elements*: The elements of the logic are all representations of real physical and non-physical entities.
LIR5: *Functional Association*: Every real logical element **e** is always associated, structurally and functionally, with its anti-element or contradiction, non-**e**, in physics terms, they are conjugate variables. This Axiom applies to the classical pairs of dualities, e.g., identity and diversity.
LIR6: *Asymptoticity*: No process of actualization or potentialization of any element goes to 100% completeness.

Category: Process

For reasons that will become apparent, I will start with the category of Process. The existence of change and the category of Process as the structure of change are among the concepts captured by the Axiom of Non-Identity. LIR is a theory that says that it makes no meta-theoretical sense to talk about any *process* being the same as another one, as this never occurs in reality, except for simple macrophysical objects, 'to all intents and purposes'. The problem of individuation of quantum objects has not yet been addressed in LIR. Quantum objects *do* instanttiate the category of Dynamic Opposition, and also exist in two types, fermions and bosons (see Section 4.7.1), the first being more 'diverse' than the second, at least in their capacity for having opposite spin.

However, the laws governing quantum entities and say, human beings are only isomorphic and not identical. Individuation of human beings and human reasoning is a reality. My axiom of Non-identity supports the concept of a 'limited

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clear intuitions of an isomorphism between the laws governing microphysical and mental phenomena.

productive circularity' of some ontological explanations, since in reality, no reasoning process involving the same or another individual is ever identical. This form of circularity also holds between the axioms and categories of LIR. Since the terms of the axioms are also considered as dynamisms, the ontology of the logic is also, without conflation or confounding, the logic of the ontology.[24]

Process also fits the Axioms of Conditional Contradiction and the Included Middle since all process entities instantiate the movement toward identifying or diversifying non-contradiction or toward contradiction, from which T-states can emerge.

Hartmann defines Process as a category that is intermediate between 'real time' and the 'causal nexus': processes advance in time, and sequence of states in a process *is* causality. Earlier states are causes; later ones are effects. This linear form of determination is the causal nexus. This picture is not very satisfactory, primarily because it begs the question of the nature of time as independently existing. A more interesting insight of Hartmann's, from the LIR standpoint, is his idea that the processes have opposites or counterparts, states or situations, and the relationship between processes and situations is a dynamic one, giving rise to the *conception* of dynamic structures in the evolution of the natural sciences. Further, "since 'becoming' (*Werden*) is the universal mode of Being of everything that is real, process is eminently *the* category of reality" (Werkmeister 1990). This is close to my conception of Process as the major *formal* category, but I suggest Energy as its material 'partner'. Hartmann seems also to have considered energy as a fundamental category, the 'dynamic substratum', together with another equally fundamental category, that of 'relation'.

The details of any hierarchy involved here are less important than the overall picture: process, energy and the relation of dynamic opposition are all categorial concepts that receive added meaning from their relation with the physics and metaphysics of LIR and with each other.

Category: Energy

There also appears to be a good fit between Energy or its quantum field equivalent as a category and the axiom of Conditional Contradiction – we have seen that energy instantiates all of the opposing ontological predicates. The concept of energy as self-dual or non-identical to itself seems satisfactory since energy is the locus of change. Energy can also be considered as its own included middle, 'between' extensity and intensity. What needs further discussion is the relationship between Energy and the previous category of Process. I have already defined the instantiations of energy as process entities. It seems impossible to separate energy from its instantiations in reality. What then should be the relation in theory?

In my opinion, the significant ontological difference between 'Process' and 'Energy' is that the former is *organized* energy undergoing change. Process

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[24] Nicolescu has suggested the term 'onto-logic' to characterize the logic of the included middle, as being a logic that is 'open' to ontology, but other workers in other contexts have also used this term in a different sense.

and Energy are thus both contradictorially related entities and epistemology-cal concepts: when we focus our attention on processes as entities, the concept of energy as the locus of processes is potentialized and *vice versa*, depending on which aspect is of interest, that is, has the most 'energy' behind it. Energy and Process are thus like some of the other entities we will meet, both the same and different. Energy is the locus of change, but it is not itself destroyed, but only changed in form in the classic sense. In LIR, structure and form are also dynamisms, following the principle of, and in the category of, Dynamic Opposition.

My overall approach allows one to move smoothly between statements about a quantum particle, for example, the photon, as an individual entity that can be described as the included middle between opposing 'particle' and 'wave' descriptions, and the real situation of an isolated photon that will exhibit particle or wave properties depending on subsequent experimental conditions. Although one could in principle talk about a photon as a 'process', the process description is certainly more useful at higher levels of reality.

Category: Dynamic Opposition

I have shown that the properties of the three first pairs of ontological predicates apply to energy, but in addition, energy is intrinsically antagonistic. In other words, actuality and potentiality, intensity and extensity, identification and diversification are properties or processes that are in an antagonistic or contradictory relation – dynamic opposition. The consequence is that for all phenomena, again, Axioms **LIR2** of Conditional Contradiction and **LIR5** of Functional Association apply to whatever set of dualities is under consideration. All real dualities fit them.

I will need later the additional ontological predicates mentioned in Chapter 3 of local and global, in part for the discussion of the structure of reality. To what phenomena might an interaction or 'overlap' between local and global apply? My answer is to all those in which the meaning of determined and undetermined, part and whole plays a key role. This includes all phenomena with the exception of those at the macrophysical level in which essentially no change, except over very long time scales, is present.

The same considerations apply to the dynamic relationship between internal and external. All of the predicates cited in this section, for all processes of interest, fall within the sub-category of Non-Separability.

Category: Subject, Object and Subject-Object

The same argument can be used in the case of subjects and objects. The interchangeable roles of actualizations and causes as subjects and potentializations and effects as objects fit the Axioms of Non-Identity, Conditional Contradiction and Functional Association. It may be a problem for some people to associate the term subject also with 'inert' physico-chemical matter, but I should recall that this misses the conceptual process involved. What characterizes a subject is the actualization of a reality value, physical and logical, a dynamism that can be just as much an identity as a diversity. Identity, to repeat, if one wishes to apply this reasoning to a brick,[25] means the end-process of contradictional macrophysical processes (ortho-dialectics) that are largely ones of identification, where the small but finite residual potentiality of being a non-brick might be actualized only on a very long time scale. Subject-objects, of course, fit Axiom **LIR3** of the Included Middle.

From this point of view, a theory that defines something real as an absolute actualization, rigorously non-contradictory, as for example the invariants of general relativity, is actually defining an ideal absolute subject, real in the sense *only* of abstract subject-of-thought. To consider that such entities belong in the sub-category NSC of Non-Separability of NEO is a form of category error. They belong in the realm of the separable entities of classical logic (sub-category SC of Separability) that, being non-spatio-temporal, are separated from - do not interact with - their opposites (or anything else).

The application of this category to phenomena implies two rules for the application of all the ontological predicates:

Rule 1: The opposition of three elements A, B and C can be reduced by induction to that between three pairs of two elements, as seen in nature, eventually with each element being the included middle between the other two.

Rule 2: Given three elements A, non-A and their included middle T, an included fourth term T^1 is not possible: any fourth term T^1 added to A, non-A and T, can be decomposed into two structures of included third terms (A, non-A and T) and (A^1, non-A^1 and T^1) (Nicolescu 2002). This agrees with a theorem of Peirce that he demonstrated by the use of graphs: all ‘four-tailed’ graphs reduce to ‘three-tailed’ graphs.

The basic concept is that a dynamic antagonism can exist only between two terms, two orientations, two systems, two systems of systems, two processes, etc. If there are three, two together, or their resultant T-state interact with the third. If there are more than three, they divide into two antagonistic sets. Subsequent processes of differentiation depend on further progressively dissymmetric dualities. A striking illustration of this is mitosis, the sequence of processes in the cell nucleus in which replicated chromosomes are segregated prior to cell division, followed by a series of doubling processes. Mitosis can be seen as a paradigm example of the logic of life.

Category: T-states

The category of T-states fits Axiom **LIR3** by definition, but this category is also in concordance with Axiom **LIR1**. A T-state is not identical to the elements

[25] It is the shared, probably incomplete understanding of these processes, unconscious or not, that facilitates consensus of what is meant by ‘brick’.

from which it emerges. As entities, of course, T-states also fit Axiom **LIR2** of Conditional Contradiction, since once constituted they are never wholly actual or potential. Could a dynamic opposition give rise to an entity that is predominantly potentialized? The answer is yes, but only where T-states are never very far from the 'mid-point' of actualization and potentialization, that is, at the mental level, and also, perhaps, at the quantum level.[26] At biological levels of reality, the values of the residual macrophysical component present in all living systems result in the emergence of predominantly actualized entities and processes.

In relation to T-states, there are three sub-categories of Process that I wish to define as they will be relevant to the LIR picture of the structure of reality: Emergence, Downward Causation and Closure. Emergence refers as implied to the emergence of new entities based in a determined but non-predictable manner on lower level substrates (the 'parts'). The T-state establishes the conditions under which such a new entity (the 'whole') can be formed. Closure refers to the existence of a substantially (but wholly) complete set of functional interactions in a complex entity. The process inverse to Emergence, Downward Causation, is one in which the emergent properties of the whole affect the properties of the parts. Further discussion of these categories will be made in Chapter 8 in relation to the biological level of reality.

4.9.1 A Check-List of Principal Dynamic Relationships

For the forthcoming discussion, it may be useful to have in one place for reference the principal relationships that are defined by the PDO and the categorial features analyzed in Sections 4.4.1.2 and 4.4.1.3. I recall that the most important 'movements' of the logical elements of LIR are from actual to potential, a state of actualization to one of potentialization, and from being primarily identities to diversities, *via* processes of homogenization or heterogenization. The word "primarily" should be understood as preceding each term to reflect Axiom **LIR6** that no real process goes to an absolute limit.

Principal Direction:	Potential → Actual (Actualization)
Principal Entity:	Identity (Homogeneity)
Principal Process:	Homogenization (Identification)
Principal Direction:	Actual → Potential (Potentialization)
Principal Entity:	Diversity (Heterogeneity)
Principal Process:	Homogenization (Identification)

[26] At our current stage of understanding, one can say just about anything one wants to about processes involving the quantum entities, supposed to inhabit the vacuum, that move back and forth between a real and a virtual existence.

Principal Direction:	Actual → Potential (Potentialization)
Principal Entity:	Identity (Homogeneity)
Principal Process:	Heterogenization (Diversification, Individualization)
Principal Direction:	Potential → Actual (Actualization)
Principal Entity:	Diversity (Heterogeneity)
Principal Process:	Heterogenization (Diversification, Individualization)

One can put these relationships in a table (Table 4.1), but I also wrote them out to avoid using too many terms in a single position in the matrix.

Table 4.1 Principle Dynamic Relationships of LIR

	Direction	
Entity	**Potentialization**	**Actualization**
Diversity	Homogenization	Heterogenization
Identity	Heterogenization	Homogenization

One thus says, for example, of an entity, that 'in' it, for the time being, diversity has been actualized in which case identity has been potentialized and *vice versa*. T-states have not been put into this list since it is to be understood that at the mid-point of any actualization and potentialization, a T-state is assumed to exist at all the points of maximum energetic contradiction.

This table reflects only one step in the ortho-dialectic processes of processes that constitute change, looking from the process standpoint. From the point of view of the entity, since no real process returns to the same point, if the process is going in the direction of non-contradiction (of diversity or identity, the net result is that it will be more of an identity or more of a diversity in cones-quence. In this scheme, the process that leads to more and more differentiated individuals, that is, biological processes, is one of heterogenization which should be distinguished from the contradictory process that creates homogeneous individuals from a multiplicity of entities.

4.10 THE INTERPRETATION OF LIR

Using this terminology, let me restate the way in which I believe the LIR system must be characterized. I believe by definition that LIR is, and can be seen as, a system that is *both* uninterpreted and interpreted. It is uninterpreted if this means that it may have direct applications to, or is an approach to improving theories in physics, biology, cosmology, cognitive science, etc., as well as ontology. The tools it has to offer are the explicit inclusion of the principle of dynamic opposition and the axiom of the included middle in the comparison of opposing theories and the opposing terms of theories; an analysis of the justification for certain dichotomies or dividing lines; and in the understanding of the psychological and historical basis for how science and philosophy, including logic, are 'done'. LIR can be compared, for example, with Cao's views on "how science develops" (Cao 1997). This does not mean that LIR replaces classical logic in these applications or elsewhere. LIR reduces to classical logic for the parts of them that are simple, non-interactive and consistent, that is, broadly, those in SC, the sub-category of Separability. However, LIR says that phenomena such as scientific discovery are complex processes that are in the sub-category of Non-Separability, NSC, and therefore require a dynamic logic for their understanding, as well as the material and formal categories of the New Energy Ontology NEO.

LIR is, at the same time, clearly an interpreted system since, as NEO, it offers an alternative to classical ontology, that is, an ontology based on classical logic that describes physical reality, the extant domain of the above theories, either incompletely or not at all.

On the other hand, the debate about the exhaustivity of a category can be seen as much less critical. The concept of the absolute completeness of a category, capable as a consequence of capturing all the elements of a certain kind, is not a necessary criterion. It should only, in a common sense manner that is in the spirit of LIR, capture *most* of them. As Campbell and Franklin (2004) have shown in their discussion of randomness and the justification of induction, certainty does not need to be the target of sampling but rather a reasonably high probability. LIR supports this refutation of the skeptical Humean view that induction can never be rationally justified.

One may thus begin any analysis of problems in a particular domain of science or philosophy by reference to one or another of the sub-categories, NSC or SC in NEO. Phenomena that fit into SC can be described adequately by classical or neo-classical logics. The process of 'raining', for example, although it is a real process, involving the exchange of energy (thermal, gravitational, physicochemical), fits comfortably into SC, as do all other macrophysical phenomena involving nothing more than physical changes of state. Other complex processes, such as variations in predator-prey populations, although involving living systems, involve them without reference to what makes them living. Nothing *meaningful*, literally, emerges at this level of reality, and the elements to which meaning that can be ascribed are at a lower or higher level.

In the other category of phenomena, NSC, in which the dual category features are non-separable, the interaction I call dynamic opposition is fundamental and functional, and provides the basis for the metaphysical – physical picture that emerges in LIR.

In practice, as we will see, it is the NSC category of dualities seen from the metaphysical standpoint that will be the ones of greatest utility in approaching unresolved issues and debates in philosophy and science. This is because NSC, and not SC, *also* contains the included middle T-states that emerge from the dualities at the point of maximum contradiction or its equivalent, leading to the view of T-states as a separate category, ontologically, prior to the entry of the T-state into a new interaction as and with another dynamic entity.

Before completing this discussion, I wish to return to the categoricity, or lack of it, of actuality and potentiality. If these are categories, then what are the entities, physical or abstract, that belong to them? A heap of bricks has the potentiality of being a house, and the actuality of being bricks, and one can consider, with Aristotle[27] that such actualities and potentialities are classes of entities. (I might add that the house has the potentiality of being bricks again.) I feel that there is a fundamental difference in the way the terms are applied here and in LIR; compare, for example, the potentiality of a carbon atom to form four covalent bonds and the *probability* it will do so under the right conditions. There is no dynamic relation between the bricks and what they *possibly* can become. In principle, everything has the *possibility* of becoming something else as a consequence of external intervention, which is clearly required in the Aristotelian case. My conclusion is that when used in this way, classical, binary logic is sufficient to describe the state of affairs, as in other cases where there is no existing dynamic relation between the entities *per se*.

Whitehead's statement of his ontological principle does not classify 'potentiality' and the 'givenness' of an actual entity as categories. Despite the well-known difficulties of making analogies with Whitehead's idiosyncratic terminology, there seems to me to be a similar relation between my potentiality and actuality and his potentiality and givenness as ontological predicates. There is a 'correlation' between them, and the "completion of givenness in actual fact converts the 'not-given' for a fact into 'impossibility' for that fact." More significantly, potentiality and givenness are meaningless apart from the entities to which they refer, and they are requirements for, in a nexus of actual things, the "process of supersession by novel actual things" (Whitehead 1998). This is a description of the metaphysical basis of what is designated in current terms as emergence.

From another standpoint, however, if actualization and potentialization are process entities in their own right, as well as predicates, they belong *them-selves* to the category of dynamic opposition and one can speak of the actuality, potentiality and T-states of actuality, potentiality and T-states. Nicolescu has given an interpretation to the nine resulting elements of the 3 × 3 matrix (Nicolescu 2002). Their domain of application may be limited to higher cognitive levels of reality, and I

[27] I am grateful to Johanna Seibt for this question.

leave it as an exercise for the reader to define his own understanding of the actualization of actualization as compared to potentialization of actualization.

These examples should suffice to show that a model with all the categories and all the axioms referred to each category can be constructed. To complete the discussion of the categorial structure of reality as seen in LIR, the relations within and between categories, that is, its morphisms and functors, should also be defined. This is done in the next chapter in the context of the LIR view of the structure of both reality and ontology.

References

Aerts, Diederik. 2001. Transdisciplinary and Integrative Sciences in Sustainable Development. In *Encyclopedia of Life Support Systems*. Oxford: Baldwin House.

Bitbol, Michel. 1991. Perspectival Realism and Quantum Mechanics. In *Symposium on the Foundations of Modern Physics 1990*, eds. P. Lahti and P. Mittelstaedt. World Scientific Publishers: Singapore.

Brenner, Joseph E. 2005. Process in Reality: A Logical Offering. *Logic and Logical Philosophy* 14: 165–202.

Botta Cantcheff, M. 2002. *Hodge-Type Self (Anti-self)-duality for General p-form Fields in Arbitrary Dimensions*. Frankfurt, Germany: Springer-Verlag, *EPJdirect* C6: 1–14.

Campbell, Scott and James Franklin. 2004. Randomness and the Justification of Induction. *SYNTHESE* 138: 79–99.

Cao, Tian Yu. 1997. *Conceptual Developments of 20th Century Field Theories*. Cambridge: Cambridge University Press.

Chalmers, David. 2002. On Sense and Intension. In *Philosophical Perspectives 16: Language and Mind*, ed. J. Tomberlin. Blackwell Publishers: Oxford.

Froger, Jean-François and Robert Lutz. 2007. *Fondements logiques de la physique.* Paris: Éditions DésIris.

Gill, Mary Louise. 2003. Aristotle's Distinction Between Change and Activity. In *Process Theories; Cross-disciplinary Studies in Dynamic Categories*, ed. J. Seibt. Dordrecht, The Netherlands: Kluwer.

Gomez, César. 1995. Electric-Magnetic Duality and Effective Field Theories. *arXiv:hepth/9510023*.

Hall, Everett W. 1949. The Metaphysics of Logic. *The Philosophical Review* 58: 16–25.

Hartmann, Nikolai. 1953. *New Ways of Ontology*. Translated by R. C. Kuhn. Chicago, IL: Henry Regnery.

Healey, Richard. 2004. Holism and Nonseparability in Physics. In *Stanford Encyclopedia of Philosophy (Winter 2004 Edition)*, ed. Edward N. Zalta. http://plato.stanford.edu./archives/win2004/entries/physics-holsim/

Hougen, Jon T. and Takeshi Oka. 2005. *Science* 310: 1913–1914.

Jung, Carl-Gustav. 1971. *Two Essays on Analytical Psychology.* Translated by R. F. Hull. New York/Cleveland, OH: World Publishing (Meridian).

Krause, Décio. 2005. Separable Non-individuals. *Representaciones* 1: 21–36.

Krause, Décio and Steven French. 2007. Quantum Sortal Predicates. *SYNTHESE* 154: 417–430.
Lowe, E. J. 2002. *A Survey of Metaphysics.* Oxford: Oxford University Press.
Lupasco, Stéphane. 1947. *Logique et contradiction.* Paris : Presses Universitaires de France.
Lupasco, Stéphane. 1973. *Du devenir logique et de l'affectivité; Vol. 1: Le dualisme antagoniste. Essai d'une nouvelle théorie de la connaissance.* Paris: J. Vrin (originally published in Paris: J. Vrin, 1935).
Lupasco, Stéphane. 1987. *Le principe d'antagonisme et la logique de l'énergie.* Paris: Editions du Rocher (Paris: Éditions Hermann, 1951).
Majid, Shahn. 2007. Algebraic Approach to Quantum Gravity I: Relative Realism. http://philsci-archive.pitt.edu/archive/00003345/.
Nicolescu, Basarab. 1999. *Le tiers inclus. De la physique quantique à l'ontologie.* In *Stéphane Lupasco; L'homme et l'œuvre*, eds. H. Badescu and B. Nicolescu. Monaco: Éditions du Rocher.
Nicolescu, Basarab. 2002. *Nous, la particule et le monde*. Paris: Editions du Rocher (originally published in Paris: Éditions Le Mail, 1985).
Penrose, Roger. 1991. The Mass of the Classical Vacuum. In *The Philosophy of Vacuum.* Oxford: Oxford University Press.
Penrose, Roger. 2004. *The Road to Reality*. New York: Knopf.
Rohrlich, Daniel, Yakir Aharonov, Sandu Popescu and Lev Vaidman. 1995. Negative Kinetic Energy Between Past and Future State Vectors. In *Fundamental Problems in Quantum Theory*, eds. D. M. Greenberger and A. Zeilinger. New York: Annals of the New York Academy of Sciences.
Poli, Roberto. 2003. Descriptive, Formal and Formalized Ontologies. In *Husserl's Logical Investigations Reconsidered*, ed. D. Fisette. Dordrecht, The Netherlands: Kluwer, pp. 193–210.
Schmidt, H.-J. 2002. Structuralism in Physics. In *Stanford Encyclopedia of Philosophy (Spring 2003 Edition)*, ed. Edward N. Zalta. http://plato.standford.edu/archives/spr2003/entries/physics-structuralism.
Schneider, Luc. 2002. Formalized Elementary Formal Ontology. *ISIB-CNR Internal Report 3/2002.* Padova, June.
Seibt, Johanna. 2002. Ontological Categories. The Explanation of Categorial Inference. In *Wahrheit-System-Struktur: Auseinandersetzungen mit Metaphysik*. Stuttgart, Germany: Olma Verlag.
Seibt, Johanna. 2003. Free Process Theory: Towards a Typology of Occurrings. In *Process Theories: Cross-disciplinary Studies in Dynamic Categories*, ed. J. Seibt. Dordrecht, The Netherlands: Kluwer.
Seibt, Johanna. 2004. General Process Theory; A Descriptive Framework for Dynamic Ontologies. Paper presented at the Conference *Dynamic Ontology*, September 8–11, in Trento, Italy.
Sklar, Lawrence. 1992. *Philosophy of Physics*. Boulder, CO/San Francisco, CA: Westview.
Smith, David Woodruff. 1999. Intentionality Naturalized? In *Naturalizing Phenomenology. Issues in Contemporary Phenomenology and Cognitive Science*, eds. J. Petitot et al. Stanford, CA: Stanford University Press.
Thom, René. 1988. *Esquisse d'une Sémiophysique*. Paris: InterÉditions. The reference is to Aristotle's *Physics*, VIII, pp. 5, 257b, 8–9.
Werkmeister, W. H. 1990. *Nicolai Hartmann's New Ontology*. Tallahassee, FL: Florida State University Press.
Whitehead, Alfred North. 1998. *Process and Reality; Corrected Edition*. New York: Free Press.

5 THE CORE THESIS OF LIR: STRUCTURE AND EXPLANATION

Abstract This chapter represents a transition between the theory established in previous chapters and applications of it in philosophy and science. It describes the core thesis of LIR and shows how it can function as a new methodology for talking about specific areas and theories of reality. It begins with a statement of the thesis and the two-level framework for analysis to which it leads, presented as a metatheory, and aspects of intertheoretic relations and part-whole relations are interpreted following the LIR axioms. The second part of the chapter deals with the structure of reality as defined by LIR both ontologically and metaphysically. This is the basis for subsequent analysis of particular philosophical and scientific theories and provides an introduction to discussion of the specific structural realism of LIR. The final Sections position LIR in relation to the on-going philosophical debates about the analytical/synthetic distinction and explanation and *their* relation to the LIR structuralist conceptions.

The ubiquity of hidden assumptions and definitions of classical logic pervade virtually all the aspects of interest to this study. For example, if one accepts the categories of LIR and NEO as applying to reality, they must apply to the conceptual as well as physical structure of reality as well, including relational structures, theories, including, especially the existence of real contradictions and inconsistencies at macroscopic levels of the real world. I will therefore highlight below the dynamic aspects of structure, without, at the same time, doing what would be just as incorrect as ignoring them, namely, discarding the commonsense notion of structural stability in the everyday world. My goal will therefore be, in the spirit of my logic, to maintain the necessary equilibrium between the different key notions in all of the above areas.

My conception of categorial ontology is also non-standard: since LIR theory is based on energy, there will be an additional hurdle to overcome: the age-old questions of form and the primacy of form – geometry and statics as opposed to matter (energy) and dynamics obtrude themselves on my thesis, blocking it as it were. I address these issues in some detail in Chapter 6, but to begin to remove some of the blocks, I have constructed my argument here, in Section 5.4, around two approaches, namely, *Gestalt* theory and catastrophe theory, in which these issues are discussed. This discussion will, I hope, further assure readers of the links that LIR has to other philosophical and metaphysical systems, and that a dialogue is possible.

5.1 THE CORE THESIS OF LIR

The logical and categorial concepts of LIR have now been developed to the point where I can make a first statement of the core thesis of this book: LIR as a formal (categorial) ontology gives us a way of talking about dynamic opposition as a part of theories of science and philosophy; the grounding of LIR in the physics of energy insures that I am talking about reality. Looking at a theory from the ontological standpoint means that one can *say*, for example, that some entities are neither entirely the same or different, and then relate this to the real opposing processes instantiated by or constituting the entity and its antagonistic dual to see what this means in reality.

In my view, progress in explanatory power may be possible when it is realized that reality both *has* the metaphysical structure proposed by LIR, and *is* actually something that should be understood as the extant domain described by NEO, whose categorial features fit the objective for a formal ontology defined in Chapter 3. In other words, according to LIR, reality instantiates the material categories of Energy and T-states and their major category features, as well as the formal categories of Process, Dynamic Opposition and Subject-Object.

I propose that the logic of/in reality could accordingly make contributions to scientific and philosophical theories, in two closely related ways:

- The theories currently used to describe the domain are themselves based on classical logic. Thus, these theories might be compared and reconstructed according to the principles of LIR, that is, their terms analyzed according to the above categories, and rules provided for the formation of the T-states involved.

- LIR can demonstrate that the (extant) domain that the theories in question aim to describe, reality itself, has been misconceived as a reality that follows the principles of classical logic and has been, accordingly, often misrepresented by classical ontologies importing or embodying these principles.

My claim is that LIR and NEO can achieve both of these objectives, in particular through the application of their ontological predicates and the category of Dynamic Opposition. However, I have implied a concept of what constitutes structure in the metaphysics of LIR. In order to position my thesis correctly as a logic and an ontology, prior to showing how it can be applied, I thus need to further characterize the kinds of analyses and explanations that can be made and the relation between metaphysics and ontology in general that yields a picture of the structure of the reality to which LIR applies. In the process, we will also see that theories such as *Gestalt* theory and catastrophe theory prefigure in part the principles of LIR. These points will be useful the more specific applications that follow, e.g., in physics and biological science.

As I have shown in Section 4.3, LIR is in one sense a scientific theory and, to the extent that its physical postulates or underpinnings can be disproved, it could meet Popper's criterion of falsifiability. There are problems with the Popper approach, but the idea is still useful in many cases. In another sense, however, LIR is a metatheory that proposes analyzing the extent to which other theories adequately represent the non-separable properties of real phenomena. In this regard, LIR suggests a new criterion of falsehood. Any theory whose argument depends on the absolute independence of the entities or interpretations under discussion may be biased in favor of one other, resulting in errors or omissions. For itself, LIR avoids this trap because it *assumes* the existence of a counter-theory with which it is necessarily in a dialectical relationship. Reality, for LIR, includes the existence both of LIR and anti-LIR and their conjunction.

My preferred conception of a scientific theory, as mentioned in Chapter 3, is the 'semantic' one, which sees theories as models or structures. These are extra-linguistic and in my terms dynamic entities as opposed to the syntactic conception as a set of statements or formulas governed by first-order predicate logic. LIR treats the relationship between theories and the world not only as an isomorphism. Real systems and their theoretical models are not totally independent entities, and the PDO provides an element of a formal and physical structural relation between them.

My approach is an unfamiliar one. This often makes it necessary, as well as desirable, to refer in a particular area of application to theories with which I do not agree fully or wish to refute but are very well known. It is from the opposition, if you will, of LIR with the other theories that *their* valid aspects can best be illustrated,[1] as well as the possible contributions that the LIR approach can make.

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[1] There is an interesting example here of the application of NEO to theories. A dialectical view of Batterman (*op. cit.*), suggests that a range of striking phenomena arise at singular asymptotic limits for the relation of two theories. The properties of systems at the limit values, he argues, cannot be derived from the more fundamental theories; instead, they require one to make use of a special-case theory involving elements of both the original two.

5.2 A TWO-LEVEL FRAMEWORK OF RELATIONAL ANALYSIS

The most general description of reality is that it consists of entities and the physical and relational structure in which they find themselves. In linguistic terms, one looks at semantics and syntax, in philosophy at parts and wholes and so on. This division brings with it what is often referred to as a tension between the structure and its elements, and I see in this 'tension' an expression of the instantiation of the PDO outlined in this book, namely, that elements and structures share, to a more or less actual or potential extent, one another's properties, both physically and also epistemologically, in the sense of alternating perspectives.

In the sense of the core thesis indicated above, there will be two types of tools that will be necessary to deal successfully with the two parts of the core thesis. For the structure of theories and their inter-relations, in particular reduction, the PDO will be used as a metatheoretical methodological principle for looking at the relations between entities in a domain of dualities or dichotomies, between either classes of entities or two individual terms. For the structure of reality as revealed by physical and biological science, PDO will be used as a quasi-natural law within the language of the scientific theory itself. I define a systematic normative framework as an outline of some clearly formulated set of requirements and rules, in this case of LIR itself.

Examples of the entities are the following:

Object Level [2]	***Meta-Level***
Data of Theories	Theories
Theories	Meta-theories
Becoming	Being
Element	Set or Class
Matter (-energy)	Symbol
Facts	Meaning
Part	Whole
Individual	Group
Semantics	Syntax

[2] Two-level frameworks are also used in the analysis of set theory and foundational notions of truth and existence in mathematics. To avoid paradoxes, one must move to the meta-level and use model theory or remain at the object level. The meta-level has additional resources that enable the removal objections to the founding of mathematics by set theory, although constructions at both levels are equally abstract. The details of the argument are not relevant; my point is that working between two levels, in the "higher" of which new notions can be incorporated, is a similar process in both real and abstract domains (Muller 2005).

It is clear that any implied separation between these subjects and those of science is arbitrary, since individual – group relations are studies by social and biological sciences. Another kind of relational structure is the relation between process or events and the explanations of those events.

Let me now suppose that I want to explore the relation between object level and meta-level entities. I therefore state the following theorem:

Theorem 5.1: Object level and meta-level entities are contradictorially related by Axiom **LR5** of Functional Association

To prove this, for example, in the case of matter and symbols of matter, I need to show that a symbol is both really and phenomenologically part matter and *vice versa*. That symbols are partly matter/energy is guaranteed by the process of the emergence of signs and symbols in the course of human evolution. Symbols therefore reflect the underlying dynamic opposition that was in operation at that level. Pictographic languages, such as Chinese, illustrate this rather directly, and the origin of some letters in Western alphabets in natural objects can still be detected.

But in what way does matter have the properties of symbol? This requires a different point of view, from what I might call a higher level of perception at a correspondingly higher level of reality. At this level, matter-nature is perceived as signs having intrinsic meaning.[3] This idea is a recurrent theme in art, poetry and religion. In fact it is in general the symbolic aspects of matter that are at a higher level of reality than the material aspects of symbols.

Individuals, as part of a group, contribute their individuality to it. But the group instantiates aspects of group psychology and this becomes part of the individual. What is the 'group part of the individual' is something instantiated at higher, more intuitive level, but not the less real for that.

At all levels of reality, I will assume that there is a conflict or opposition between epistemological elements and the energetic processes to which they correspond. I may and in fact always will focus on one or the other aspect, but there is present a contradictional relation, one aspect is actualized while the other is potentialized. This is the most significant isomorphism of natural laws[4] at different levels of reality.

In other words, I apply the category of Dynamic Opposition to entities at the two levels. I then find in the physical domain, the same distribution of entities

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[3] An excessive example is Pamuk's (fictional) description of the Turkish Hurufis who saw messages written in letters constituted by human features (Pamuk 1996).

[4] The question now arises whether this defining set of principles constitutes a new physical law, a law of nature. Their operation must be and I believe is consistent with existing physical laws. These principles might also be considered as being outside the domain of laws *per se*, including boundary conditions at real boundaries and interactions and constraints of the kind that Cat has called *anomic*. I will return to this question in Chapter 6 in the discussion of causality.

into Separable and Non-Separable; with and without the equivalent of an energetic relationship. In the latter, the actualization of one entity potentializes the other, in the former not. Such two-tier systems of phenomena (of perception, reality, meaning, etc.) have of course been proposed frequently. But my thesis is that only the antagonism within and between levels that is capable of explaining or rationalizing their existence and non-epiphenomenality for all logical elements that are not equivalent to those of binary logic. LIR mediates the relations of both horizontal and vertical transitions, and the *relations* themselves can be seen to be at different levels of reality. The next two sub-sections will discuss two examples of the application of the above framework.

5.2.1 Mereology

My framework involves two levels and several kinds of entities. Since LIR refers to the non-separability of some pairs of those entities, that is, their alternating actuality and potentiality, some horizontal and vertical part-whole relations may exist that require explicit attention. As might be expected, the classical theory of part-whole relations closely mirrors classical binary logic. One of its key axiomatic principles is that of asymmetry: two distinct things cannot be part of each other. Every object is distinct from its proper parts, and standard first-order logical language with identity is used for its formalization.

This simple theory runs into the same kind of difficulties as does the individuality of quantum entities, and for the same reason: it is a restatement of the standard theory of classes or sets as wholes and their elements as totally separated members of those wholes.

Standard part-whole theory, like classical logic, also contains some non-classical 'cracks'. The existence of parts that interact with the whole is accepted, despite the absence of discussion of that interaction and the difference between such cases and those in which no interactions exist. Parts may not be parts '*simpliciter*', and so on. One speaks of 'non-well-founded' relations of parts and wholes in set theory that involve membership circularities or closed loops. These cases suggest that the standard meaning postulate for 'part' is far too restrictive.

LIR states that the relation of parts to wholes may be dynamic, that is, that parts and wholes can share one another's properties, in the sense that aspects of the whole are potentialized in the parts, and aspects of the parts are potentialized in the whole. Any implied circularity is not perfect; for real entities the loop is never totally closed. The PDO applies as it does to classes and their members as laid out formally in Appendix 2. Specifically, it applies to a theory that includes an object level and a meta-level, and states that the parts that constitute the content of the object level share properties of the meta-level as a whole. At the level of physical individuals and groups, the situation is the same: the group has some of the characteristics of the individuals that comprise it, and the latter have or have internalized aspects of the group.

Even where there are no interactions of this kind, classical part-whole theory and binary logic do not fully apply, as the following discussion about problems of compositionality will show. It is already more or less accepted that standard binary logic cannot apply to a part-whole relation involving real entities in the temporal and modal world. The classical part-whole relation betrays, so to speak, its origins in mathematics. In non-classical extensional mereology, the notion of sum, which is the essential principle of compositionality, is modified or absent. In its place there is a combination of two different relations between parts and wholes.

The two relations differ primarily insofar as the applicability of classic extensional mereology (CEM) is concerned. The central idea of CEM is that of a *sum* as the essential principle of compositionality. The problems that are incurred with this notion in trying to handle the parts of entities that change in time are well-known. A typical strategy is to do two things (Bottani 2001): (1) show that in the normal temporal and modal world, the absolute part-whole relation, on which CEM depends, is neither true nor false for certain pairs of things; the absolute, a-temporal part-whole relation is the usual dyadic one – A is a part of B; and (2) define a triadic relation – A is a part of B at time T. Thus, even if CEM refers to the absolute relation, its essential principles apply to real processes, that in LIR include all apparently static objects, sometimes referred to as 'continuants', as well as people.[5] One retains the universality of CEM to all entities, and thus the intuitive concept of inclusion, but not its exhaustivity. The implied necessity in this picture of modifying standard binary logic to include temporal and modal aspects has been recognized by Simons. However, the limitations of such modifications were outlined in Chapter 1. Further, it is not clear how the two relations exist concomitantly.

The LIR view is that the absolute and non-absolute part-whole relations indeed have different logics, but that the interactive relation between part and whole that depends on PDO is not captured by them, given the classical conception of identity. The NEO categorial division into separable and non-separable process entities thus adds an additional dimension of 'non-classicality' to mereology as it does to logic.

5.2.2 Inter- and Intra-theoretic Relationships

Relations between theories and the data or observations they contain, as well as relations between theories, have been studied extensively. The following

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[5] In LIR, continuants are regarded as processual entities, and there is no epistemic cut between continuants and processes.

are among many the many subjects that might usefully be addressed by LIR: contradiction and opposition within theories; reduction; and theory change.

In Chapter 1, I mentioned the LIR view of the definitions of reduction of Kistler and Batterman. The dialectical view of Batterman (2002) offers an interesting example of the application of NEO to theories. It suggests that a range of striking phenomena arise at singular asymptotic limits for the relation of two theories. The properties of systems at the limit values, he argues, cannot be derived from the more fundamental theories; instead, they require one to make use of a special-case theory involving elements of both the original two. Theory change is another subject with an extensive literature, and I will return to it in Chapter 6. Here, I will discuss the perhaps less familiar topic of conflict or opposition between theories.

I assume, first of all, that it by now an accepted fact that real empirical data can be inconsistent, and that it is not irrational to accept inconsistent theories (Bueno and da Costa 2007). It is also clear that since nothing is absolutely certain in science, all theories are fallible and subject to revision. Further, most simply, a theory in which there is an inconsistency between it and specific observations should be rejected, pending further experiment. Contradictions that are internal to a theory, or exist between two theories can be handled, Priest suggests (2002), by an adjunctive paraconsistent logic, and this is acceptable in LIR as well, since the Axiom of Conditional Contradiction reduces to paraconsistent logic for non-dynamic relations.[6]

By *opposition* between theories I refer to the real, polemical interactions between holders of opposing views that may or may not be partially or (almost) totally incompatible. Such interactions are horizontal (intra-level) in my framework and can be viewed logically as instantiating the PDO as first one and then the other protagonist prevails in the argument. My reason for preferring LIR to some form of independence friendly logic (IFF) such as those proposed by Hintikka is that I believe such opposition is not a 'game'. There are two principal possible situations: (1) the players are solely in a survival mode, in which case the applicable logic is classical binary logic; (2) they are in a collaborative and/or partially irrational mode. Here, the possibility for emergence of an included middle position should be included in the logic, and it is in LIR.

Béziau proposes a "Logic of Confusion" to describe how different, incompatible viewpoints, including theories, may be put or handled together, using a paraconsistent discussive logic based on that of Jaskowski (Béziau 2001). This construction is successful, in my opinion, and Béziau looks forward to the extension of this logic of confusion to one in which is neither paraconsistent, nor paracomplete and in which implication is anti-deductive, perhaps in my sense of negative implication.

[6] Priest states, flatly, that reality itself is inconsistent. LIR says that reality is contradictory, but it is consistently so! Note that as phenomena approach, asymptotically, absolute non-contradiction, they also approach consistency.

In this strategy, a real-world situation is taken as the basis for theoretical analysis, which does not yet tell us much about our arguing philosophers or logicians. LIR will not answer the question of who wins the argument or if anything of value comes of it, but sees it as an example of the structure in and of reality that makes it, also, logical.

I propose the logic of/in reality, together with its PDO and associated ontology, as a metatheoretical scheme that can deal with scientific theories and their data, and with inter-theoretical relations, where those relationships involve some kind of real, structural or structuring interactions. Theories are today more generally viewed as classes of models, rather than classes of statements or propositions (the 'non-statement' view), and the model-theoretical or structuralist standpoint is more easily accommodated by the dynamic structuralist aspects of LIR, those that are derived from the dynamic structure of energy.

Like any good empirical theory that makes an appropriate representation of a field of experience, by this definition, LIR offers a structural model of at least part of reality. The fact that PDO holds between two theories is not intended to imply that it exhausts the relations between two theories, for example of reduction or emergence. That fact would, however, offer an element of *compatibility* between *some* theories. I wish to emphasize the 'some' because there are many situations where the degree of interaction is too weak.

The distinctions between inter- and intra-level reduction, like other distinctions, often become dichotomies. It is accordingly useful, and very much in the spirit of LIR, to look at the two types of reductionist activities as interactive. Wimsatt (2007) places the emphasis where it should be, namely, on how science is done. In this approach, an intra-level reduction is a successional one: when a new theory reduces to an old one, it is thought to replace it. The entities and relations involved are at the same level. This is reduction of theories in the physicists' sense. An inter-level reduction involves articulation of a lower-level mechanism, the operation of which is sufficient for the emergence of the higher-level system property; mechanisms and properties are at different levels. It is in this type of account that explanations and new predictions become available. This is reduction in the philosophers' sense, where the less fundamental reduces to the more fundamental.

The principles of LIR could be stated in the same terms as many of Wimsatt's heuristics for fundamental problems in philosophy and science:

- Look for robust tendencies (e.g., toward identity or diversity), and for conditions under which those tendencies are likely to be realized, rather than for absolute positions.
- Study context-sensitive inferences rather than ones that are context-free, along the lines of Aerts' analysis of non-classical contextuality, in which both system and perturbation have an internal relational structure (Aerts et al. 2002).

- Rather than looking for universal theories or principles which are foundational to all the elements of a given domain, look for the conjoint application of robust principles which may be heterogeneous in application, but complement each other to give a better fit to the details of the situation.

For LIR, I seek no more (and no less) than the status of *a* such a robust principle. Whatever universally applicable characteristics LIR may have, it would be counterproductive to make their establishment the central goal of any discourse. This will I hope be apparent in my treatment of complementarity in the next chapter.

Reduction*ism*, understood as a metaphysical doctrine that denies or discredits the explanatory and/or causal power of higher level entities or phenomena still has its advocates, as we will see later in this book. I will not enter into this further area of polemics here. I would say simply, with the chemist Roald Hoffmann (2007) that vertical understanding, corresponding to classical reductionism and horizontal understanding are involved in any scientific or philosophical undertaking, and human beings mix up the two modes of explanation. The process is a typically dialectic one and the rules of alternate actualization and potentialization of LIR apply.

5.3 ONTOLOGY AND METAPHYSICS IN PARALLEL

In Chapter 3, I began to discuss the relation between ontology, as the study of being, what is, and metaphysics as a universal discipline that is concerned with the fundamental structure of reality as a whole. Metaphysics therefore includes ontology and science, as well as the status and validity of metaphysics itself, as proper subjects of study. The LIR approach emphasizes the *relations* between the structure of reality and the role of the ontological elements in that structure, the fundamental dualities, recognizing that the relations between the elements also define a dynamic process of alternating actualization and potentialization.

The metaphysical world-view that is implied by the PDO is compatible with the metaphysical revision that has been "engendered by quantum mechanics" (Redhead 1995). I do not have to have a prior 'orthodox' concept of reality in order to define the best possible active role for what I observe, namely, that dualities are present at all levels of reality, starting with that of the quantum field. The dualities in question have a kind of part-whole relation to the world, but one need not assume that at the end of this analysis, one will have captured all the essential aspects of the world. I will not have, as a consequence, a 'Theory of Everything' (at which I was not aiming in the first place), but I will have a framework that can evolve in parallel with further development in the physical understanding of our universe.

The role of categories in ontology, independently of the formal mathematical uses to which they can be put, is essential in defining LIR as a conceptual structure that has additional explanatory power. In a categorial realist conception, as suggested by Thomasson (2004), "providing a system of categories can be seen as a, or even *the* central task of metaphysics". I believe a robustly realist position is made more plausible by the principles of LIR, since they improve our ability to discern intrinsic divisions and above all changes or movements in physical reality. For my purposes it is not necessary to decide for an ontological or metaphysical reading of the term 'category', and both can be used as they complement one another.

Von Bertalanffy questioned the concept of categories as a 'Western', ultimately bivalent concept, based on Whorfian reciprocal relation between language and world-view. I will not take a position on this issue here, but I feel that LIR naturalizes the debate on the cultural relativism of categories, as it provides a basis for understanding the differences in cultures in the same dialectical terms as other phenomena. I simply agree with von Bertalanffy's conclusion (Von Bertalanffy 1969) that "they (categories) must, in a certain way and to a certain extent, correspond to 'reality' – whatever this means in a metaphysical sense."

Seibt's definition of ontology is as an explanatory theory of truth-makers of sentences, and the project of ontology as a theory of truth-makers is a prudent one. It is distinguished from metaphysics by being metaphysically neutral, that is, ontological theories specify what makes sentences of the theory true without being committed to any particular theory of truth. Ontology in this sense is best compared with semantic theories of inference, which discuss patterns of formal and material inference. Such categorial inferences are the phenomena that ontologists try to explain by devising a description of the truth-makers for the sentences involved in them.

As one reads through the scientific literature, the terms ontology, ontological and ontological theory are found relatively frequently. However, there is rarely any reference to a process of drawing the categorial inferences regarding the most general entities of the domain that are the 'data' of an ontological theory. I can only conclude that 'ontological' is generally used as a synonym for what is *metaphysically* real. In the dynamic logic of/in reality, an inferential phenomenon is, exactly, a phenomenon, that must be characterized in the same way that all phenomena are by its dynamics as a process, by itself and in subsequent interactions.

The fact that Seibt founds ontology ultimately in agentive experience and intuition is a reason to look closely at the similar founding of LIR in experience as well as physics and being. I recall the reference to experience in the presentation of the axioms of LIR and in relation to the LIR definition of processes in Chapter 3. Because everything in reality is logical in the LIR sense of incorporating relations of dynamic opposition, the experience of those relations is also logical, and logic and experience become interchangeable terms. Further, in the epistemology of LIR, intuition is not something accidental and purely irrational, but is also linked contradictorially to knowledge in the usual sense.

My hope is that by the end of this book, I will have established the LIR system as 'serious metaphysics' in the sense that Bloomfield (2005) has given to this term. I have the same negative reaction to attempts to study the characteristics of 'possible worlds' that bear only hypothetical relations to this one, and I much prefer to focus on how things actually are.

I thus agree with a critique of a metaphysics that

> garners 'putative' knowledge about the nature of reality, our actual reality, by attending to worlds which are logically consistent but which are nevertheless impossible given what is actually true. Attending to these actually *impossible* worlds yields metaphysical 'knowledge' that is actually founded on ignorance.

My criticism of the philosophers who espouse such positions is that they accept a definition of a possible world as one that is *not* logically contradictory. The thesis of this book is the exact opposite. The real world is only possible because it *is* conditionally logically contradictory, that is, partly inconsistent, as pointed out in Chapter 3. A world that is totally non-contradictory is an abstract entity.

The metaphysical prescription is clear: one should stick to a discussion of those possibilities, or better, potentialities, which relate to the actual world – reality. This is the way to carry out the basic task of serious metaphysics, namely, to learn about the nature of the single truly real and actual world.

From a pragmatic standpoint, there is much to be gained in developing the ontological and metaphysical approaches in parallel. In formal terms, metaphysics can be an investigation into the reality and adequacy of a conceptual structure for a scientific theory TH (whose source is an ontology as a theory of truth-makers for TH, i.e., also a description of a model structure for TH) as well as a description of the entities of reality and their behavior. Advantage can be taken jointly of both ontology as a semantic level of interpretation and the LIR metaphysics of material categories in an interpretation in terms of the laws of physics. I claim that a complementarity exists between, for example, inference viewed from the two perspectives. The relation I propose can be seen as an example of the fundamental principle of LIR, since when the ontological aspects of a theory are actualized, e.g., the theoretical character of its constructs, the metaphysical and physical aspects is potentialized and *vice versa*. At the same time, it formalizes another example of agentive intuition, namely, that of 'looking at something from two points of view'.

I should repeat that it is essential not to confound, confuse nor conflate the ontological, metaphysical and logical standpoints. Ontology and metaphysics themselves are not totally separate nor the same but 'inform' each other not only heuristically, in what I might call a transdisciplinary spirit, although this is also a highly desirable goal, but also as models of reality, dialectically.

I will speculate further here and suggest that in fact logic in reality, metaphysics and the ontology that I have developed from them can be seen, non-metaphorically, as a triad, each member of which is the included middle of the other. If one concentrates on the interaction of the logical and metaphysical aspects of, say, the process of implication, as in my logical calculus, an ontology emerges, and so on.[7]

The philosophy of LIR is transdisciplinary, and any contribution it could make to research on reality – in physics, ontology and metaphysics – will require many interactions with other disciplines at both specialist and generalist levels. But it is a novel theory, and the discussion in this book should be seen only as a prolegomenon to the much deeper analysis that is required to take into account the enormous weight of prior work.

5.4 THE STRUCTURE OF REALITY IN LIR

I assume that reality, the domains of which all theories try to describe, has some logical and categorial as well as physical structure that can be further articulated beyond the bare establishment of the categories as the ontology of LIR in the previous chapter. Thus, the most important task at this point in my development is to insure that the structural characterizations of reality in LIR are sufficiently dense.

In previous Sections, I have referred to structures at various points, but the concept or 'structure' of structure – conceptual, mathematical or physical – has been left undefined. The description of reality in terms of levels also has left undefined the structure of the processes occurring at a particular level. I will begin this discussion by defining the conceptual structure of reality as it emerges from my LIR theory at this stage. This concept of structure will be the basis for the discussions of structural realism in science in Chapter 6 and cosmological structure in Chapter 7. It is important to distinguish three broad but certainly not totally independent definitions of structure: (1) as an object consisting of some physical parts – a building; (2) the relations of those parts to one another and to the rest of the world; and (3) a mathematical description of that set of relations. It is the relational description of structure that I will emphasize in what follows.

Seibt has suggested[8] that the structure of LIR, as a metaphysical metatheory, is in a sense as abstract as structures in mathematical category theory, that is, the structures have themselves other formal theories and real phenomena as their instantiations. Above, I have shown that the PDO is a theoretical, formal function that is to be interpreted *realistically as designating real properties of phenomena*.

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[7] I have adapted this idea from the 'trialectic view of reality' of Craciunescu in which each member of the triad of epistemology, poetry and metaphysics can be the included middle of the other two (Craciunescu 1999).

[8] Seibt, Johanna (2005, private communication).

In this section, I claim that the PDO categorized in LIR/NEO defines a non-mathematical structure of reality that matches the structures of the domains of application in philosophy and science to be addressed. In my view, there are both physical and conceptual structures to be described, for example, the structure of explanations in the context of LIR to be discussed in Section 5.5 below. LIR is also a *physical* theory about real relations, that is, antagonistic ones, that is an instantiation of the largely abstract theoretical structure referred to above, and its output are physical descriptions about at least certain aspects of reality. For example, at the microscopic level, structure is described by the physics of the uncertainty principle, which has an interpretation in LIR/NEO as a case of dynamic opposition.

I therefore need to look further at the 'organizational' structure of reality established by the categories of NEO; the structure of reality as prescribed by LIR; and the structure of the domains of application.

5.4.1 The Categorial Structure of Reality in LIR

The formal ontology of LIR, New Energy Ontology (NEO), like any other category theory, is an abstract theory about what there is in the world, and it is an abstraction from empirically gained knowledge, and in particular knowledge about its dualities, as indicated in Chapter 4. In the standard view, categories are supposed to reflect the most basic divisions among entities and are accordingly supposed to represent the most basic part of the structure of the world, arrived at by a systematic analysis of its objects.

I do not wish, at this point, to get into the discussion of whether Energy, for example, or Process, is in some sense more or less basic than, say, Existence, Becoming, Sense, or Essence, all of which are categories that have been claimed, in one system or another, to be the 'most basic'. What I see in category theory that is relevant to the core thesis above is some of the 'machinery' of the categorical approach that allows one to see the domain of application of LIR and NEO.

The relations between categories are as important as the categories themselves in defining the structure of the world. There are two ways in which these relations can be described, the first being part of formal, mathematical category theory and the second the more classical informal concept of links between categories.

5.4.1.1 Morphisms and Functors

In category theory, a morphism is a function between two objects in a category that defines the relationship between them, how the structure of one can be 'mapped' onto the structure of the other. In non-technical terms, a morphism guarantees that the two objects have, in some important respect, a similar structure and form. In category theory, the nature of the objects or entities in a group of categories is irrelevant. What characterize a category are its morphisms. In the NEO category of Energy, there is a classical identity morphism that maps Energy on to itself. If one takes two objects in the category of Non-Separability, say, the pair of a theory and its contradictory theory and another pair such as genotype and phenotype, the contradictorial aspects of the first map on to the second, no matter how disparate.

A functor is a morphism or function between categories that insures that the morphisms within them are preserved.[9] An example from NEO is a function (functor) that 'goes' from the set of processes within the category Process to the category Subject-Object and preserves the structure of Process in the sense that the actualized aspect of a process is a subject and a potentialized one an object. Again without going into technical aspects, the existence of these properties is an indication that my categorial scheme is valid.

The functors, at least informally, operate as might be expected: everything in Energy maps to Process; Process maps to Separable and Non-Separable; Non-Separable maps to Subject, Object and Subject-Object; and Subject-Object (recalling that 'subject' and 'object' refer to actualization and potentialization as agent and patient respectively) maps to T-states. This defines a kind of hierarchy and justifies my calling the relations functors.

Regarding the morphisms within all the categories, the mappings, it may be a consequence of the theory that they look very much like the axioms and ontological predicates themselves. If one takes two processes or T-states, etc., X and Y, then there is either a substantial contradictorial interaction between them or there is not. If there is, they belong in the sub-category NSC of the category of Dynamic Opposition. Within NSC, the single morphism or 'mapping' must be interpreted as the relation of dynamic opposition itself. This is true also of the category of Energy, in which the function of self-mapping, which is a standard operation in category theory, involves the same principle, but it is clearly non-classical in that it includes a self-duality. These results, which may be considered anomalies, arise in my opinion from the fact that category theory was designed to handle objects, including processes or events, whose major characteristic was their absolute identity.[10]

The above discussion further defines NEO as a categorial system, albeit a non-standard one. In principle, given five categories, there are twenty functors corresponding to the ten mapping relations and their inverses. Only some of these, however, are important enough to be discussed as such. The point of this exercise is that the set of functors between the five categories of NEO define a conceptual

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[9] I accept the concept of preservation here, in contrast to its use in propositional logic; truth preservation is not directly applicable in LIR.

[10] This picture nevertheless leaves place for the categorial features of both exhaustivity and exclusivity: an entity either instantiates contradiction or it does not. There is no partial contradiction. Similarly, to say that something is the same and/or different is exhaustive.

structure that in and of itself is a structure or structuring of reality in which dynamic opposition is operating in several different ways at the same time.

In his discussion of closed categories and toposes, Lawvere (1994) develops a categorical refinement of Hegelian opposition and defines an 'adjoint functor' that "is a precise realization of the allegedly nebulous notion of *unity-and-identity-of-opposites*". With these tools, he appears to resolve some of the problems I have addressed, for example, the relation between the subjective and the objective. Also, given two categories U and P, where U is a neighborhood of P, a new category B (I am simplifying somewhat) can be obtained that depends on a binary relation of 'interlocking' of sub-categories. Lawvere believes the system of adjoint functors expresses the objective dialectical relations at the heart of a given field. Since logic is the study of what is universal, one arrives at what he calls the objective logic of the field. Similarly, Magnan and Reyes (1994) state that in this way, classical logic appears as a particular presentation of the objective logic of the category of constant sets. Their search is for an objective logic of the universe of graphs that is richer, and they also suggest that universals of the mind may be expressed by universal properties in the theory of categories.

There categorial constructions seem to me to lack dynamic reality, despite references to them as models of becoming; the phenomena that are treated are, again, limited to simple processes. Perhaps too concisely, I could say that they lack any metaphysics. The reliance on the set of non-contradictory identities of classical logic is replaced by another set of abstractions, and this new instar of the ancient idea of the unity and identity of opposites does not suggest explanations of real change.

Classical propositional logic can be axiomatized in category theory, truth table semantics defined and the soundness and completeness of models proved. The classical functions 'true' and 'false' can be defined as categorical functions (arrows). Intuitionistic and modal logics can also be defined categorically, and even theories in various fields can be seen as being equivalent to the existence of specific functors between particular categories. I believe some forms of categorial construction can be, with suitable modifications, useful for formalization of the categories of LIR. Dynamic systems (evolutive sets), which are what LIR is primarily concerned with, can also be represented by functors. The morphisms in the category of such systems preserve the evolution and the morphisms between them are morphisms between functors, called natural transformations. From this standpoint, my categorial approach does not look too outlandish. It *naturalizes* (in the usual definition of bringing into science) the intuition behind the formal categorial concept of natural transformations.

5.4.1.2 Ontological Links

The LIR view should be contrasted with the integration made by Smith that shows a correct intuition although it retains the concept of entities essentially abstracted from their real-world dynamics. Smith (2002) explores an ideal notion of form as mathematical structure, which embraces logical, phenomenological and ontological form. Form "seems fundamentally mathematical." The formal entities referred to by Husserl as manifolds can be considered as complex states of affairs or partial possible worlds representable by forms of theories. Smith's semantics correlates the four Husserlian levels of form (expression, thought, meaning and object) and thereby integrates logic, phenomenology and ontology. This neo-Pla-tonist integration is interesting, but the logic involved is standard. In my view, it thus excludes the dynamic, contradictory properties of form, and thus does not adequately describe the real aspects of entities and processes.

Smith has listed the ontological links among entities in the different categories *assumed* in Husserl's ontology as predication, qualification, formation and representation and goes so far as to suggest that the Husserlian categories of Fact, Essence and Sense are themselves largely defined by such links (Smith 2004). These fundamentally different links entail a complex structure in the category scheme. An ontology is not a catalogue or list of objects or processes *per se*, but a general framework (= structure) for giving a suitable organization to such catalogues and lists. I note, however, that most ontological frameworks assume sets of independent entities, whereas my fundamental thesis involves the non-separability or non-discreteness (but not indistinguishability) of processes or events.

If I now look again at my list of major categories, I can also state what, in each case, is the link of the category to the entities in it:

	Link
Energy	Equivalence
Process	Change
Dynamic Opposition (SC and NSC)	Qualification
Subject, Object and Subject-Object	Representation
T-state	Formation

To give one example, the formation of T-states requires the involvement of entities in the sub-category of Non-Separability (NSC). In the example of Smith, rather than a sequence or hierarchy of categories, one finds a matrix of moderate dimensionality, 2 × 2 where formal and material categories link or apply to entities in different ways. The structure of my categorial scheme consists of the indicated five categories, but they are *not* mutually exclusive or intended to be exhaustive. The structure involves links between all of the categories taken two to five at a time, rather than a simple 2 × 3 matrix of two formal and three material categories. Nevertheless, the resulting conceptual structure is not unlike the one above defined in terms of functors. I consider that my conceptual structure can be used as a *grid* to be placed over the phenomena being considered to help develop aspects that can provide additional explanation and predictions of their evolution.

I claim that NEO is an ontology rich enough to capture the essential types of entities of reality. As a theory of change or becoming, I suggest that it is 'deep' enough in the Whiteheadian sense to determine what it is to be an entity at all, that is, to be, namely, something instantiating the fundamental principles of dynamic opposition, which in turn define, in the metalogic of LIR, what it means to exist. These could also be called modes of becoming, defining ways in which entities become the entities they are.

5.4.2 The Structure of the Domains of Application: Set Theory

My claim was that the structure of reality matched the structure of domains of application. While this will become more apparent in discussion of specific domains, to insure that LIR can be talked about formally, I need to provide a *formal* account of the structure of reality, that is, of the processes and other categories whose entities constitute reality in my view.

The standard, 'classical' language for discussing structure is that of mathematical set theory, of which the components are elements, pairs of elements, etc. and structural relations, in particular of sets to sets. A major problem being currently addressed within this framework is the indistinguishability of particles at the quantum and atomic level. Seibt has studied this problem from an ontological standpoint; the metaphysical development I will follow here is that of Krause (2005), because of its relatively facile translation into LIR terms. As I did in Chapter 1, I will state a standard view and then the significant conceptual differences with the LIR theory.

Definition of Set

The Cantor definition of the concept of a set is "a collection into a whole of distinct elements of our intuition or thought". This definition already comes into conflict with the principles of LIR, and, from my point of view, begs several questions.

D1: In the LIR approach, neither elements of thought, nor any other elements, can be considered as totally distinct. Non-separability and asymptoticity apply also to the concepts of whole and part, such that part and whole are also related contradictorially.

<u>Definition of Structure</u>

In a typical semantic approach, structures are set-theoretical constructs, that is, *mathematical objects* of the form **A** = (A, *R*) where A is a non-empty set and *R* is a binary relation on A. Physics requires higher-order structures of the same kind. In set-theoretical terms, a relation *R* is always constructed from the objects it relates.

D2: The objective of the analysis is completely different. The relation between two elements is grounded by the Axioms of LIR and the PDO, and I want to show what this implies for the real structure of a process. In other terms, given two sets A and B, axiomatically a bijection *f* from A to B exists such that substitution of B for A always entails similarity. In other words, they have a similar structure since only one reality relation exists at this meta-level, that of dynamic opposition.

<u>Quasi-set Theory</u>

A relational structure in the usual sense is a collection of sets (or quasi-sets) and the relations among them. Krause introduces the concept of quasi-sets in order to define relational structures where the relations involved do not depend on the particular objects being related. Quasi-sets are collections of elements of which one cannot say that they are identical to or distinct from one another. Formally, this is equivalent to saying that classical identity in its sense as indistinguishability does not apply to the objects in the domain. In still other terms $x = y$ and $x \neq y$ are not well-formed formulas in the logic of this theory.

D3: In LIR, entities are, by the fundamental axioms, *both* the same and different, both distinguishable and indistinguishable. This seems to me perfectly consistent with the interpretation of Krause for quantum cases. I need to distinguish in some more formal way between macroscopic process elements involved in an 'active' process and objects for which the dialectics are 'frozen' (cf. Appendix 1) that is, subject to an input of energy, they are to all intents and purposes in the 'classical' part of the LIR theory. This is similar to the quasi-set situation, for such 'M' (macro) elements that *are* distinguishable, the set-theoretical description has a classical part.[11]

I thus arrive at a concept of structure, also, as an entity in the category of Process, described by a theory of non-standard sets, NSC-sets involving either a

[11] This is again similar to the contextual concepts of Aerts. It should be considered the rule rather than the exception that macroscopic systems as well as quantum systems have classical and non-classical parts.

pair or a triple of non-separable elements, A and P, the binary reality relation Rl_B and the ternary reality relation Rl_T A, P and T. The NSC-set is like the quasi-set in that it is an entity that is a collection of something of a kind, although it cannot be regarded as a collection of (1) well defined and distinct objects; (2) indistinguishable objects; or (3) entities, process or other, with invariant properties.

The relational structures of reality in LIR are ones in which the involved relations (the NSC-relations) do not depend on the particular elements being related, and the issue of having an effect, described by the relation, without some individual causing the effect does not arise. Process elements are and are not individuals. However, if, as Krause shows at the quantum level, permutations of electrons or atoms are not observable, it literally 'makes no difference'.

In this sense, NSC-sets instantiate, like quasi-sets, the ontic sense of structural reality, the Ontic Structural Realism (OSR) of Ladyman and Ross (2007)[12] that all that exists are structural relations with the only relata being other relations. Descriptions that refer to any process of change (if I may be permitted a locution that is redundant in my own terms), *ipso facto* describe the logical if the not the total phenomenological structure involved.

D4: It is important to restate, for clarity, one essential respect in which LIR and its categorial ontology differ even from quasi-set theory: the relations of membership (of elements in a set) and inclusion (of sets in other sets) are not primitive except for ideal, non-spatiotemporal entities; part and whole share one another's properties in the LIR mereology (see above). Thus in LIR it is not only that quantum and certain non-quantum elements are separable non-individuals in the sense of being distinct and indistinguishable, and that elements are non-separable from the whole of which they are parts, it is that the parts *actually instantiate* aspects of the whole and *vice versa*.

5.4.3 The Metaphysical Structure of Reality in LIR

The structure of LIR as an ontology is thus one of a general but systematic framework. Its 'outputs' are ontological structural descriptions that are about the categories and their internal and external relations, as shown above. But LIR is also a *physical* theory about real antagonistic relations, and its outputs are also physical descriptions about at least some aspects of reality, subject to measurement as indicated in Section 1.7. LIR, in my view operates as both a meta-theoretical, general regulative principle of science and a law that can be internalized in the language of a given scientific theory proper.

[12] Cf. my discussion of Structural Realism in Chapter 6.

At the mental level, the structure of a reasoning process is given by LIR as a 'psycho-physics', in which the elements are the lower-level neuro-physiological substrates. However, this does not require *total* knowledge of the nature of those substrates in the same way that the elements of quantum physics do not need to be based on a final conclusion as to the 'ultimate' constitutive nature of the photon or electron. One thus has a metaphysical energetic picture of the structure of reality with potentialities as carriers from the lowest physical level to higher ones throughout nature. It is a restatement of the insights of the later Russell of propositions as "psychological occurrences" (Stevens 2006).

The question remains as originally posed by Lupasco (1967) "What is a structure?" The answer he gave was that structures are also dynamisms, not to be objectified and reified. Whatever rules one uses, "in order for these rules to generate a veritable structure, they must obey these logical laws or conditions necessary for its existence." Thus, using the method with which we may by now be familiar, one finds three types of structure, or rather, Lupasco said, *structuring* (*structuration*), one embodying primarily bonding forces and homogenization, another primarily heterogenizing forces and a third at a T-state between the two. Any individual structure is never rigorously actual, that is absolute in any sense, given the nature and logic of energy. It is a dynamic structuring that is always functionally associated with an antagonistic and contradictory potential structuring.

Lupasco made the following link between structure and form: the energetic dynamisms that constitute all matter and all existence, and the systems they generate, are

> pure structural forms, containers of containers, structures of structures, subject to an essential and ineluctable chain of transformation. There is therefore no such thing as a full and static form; devoid of a present, going always from past to future, or even inversely, temporality is immanent to form.

Every form, every system, all matter, in a word, is thus in LIR terms a real process.[13]

The structure of real processes involves the change of an energetic entity and its opposite or antagonist from a state of subjective actuality to one of objective potentiality or T-state. Structure is thus defined by the sub-category of Non-Separability. The values (degrees) of actualization and potentialization or T-state are logical in that they depend on this syntactical structure as well as being context-dependent.

What does this mean for a structural model or explanation? Does it make sense to consider them, also, as dynamic forms, subject to potentialization and the actualization of their contradictions? I think the answer is yes and no. As formal objects *qua* their meaning, the structural descriptions of LIR as such, like

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[13] Lupasco designated all such processes as 'non-ontological', which meant everything that was becoming, experience and logic. He used ontological to refer to being, which for him consisted only of affectivity (affect).

all propositions, belong in the category SC of separable, in this case non-spatio-temporal entities, the data of standard inference; however, considered as processes capable of change, they are from this point of view in NSC. I would include in the list of structural models those displaying a sequence of argumentation in which the advantage oscillates from one antagonist to the other.

The structures of all elements or entities in this non-separable category gain their explanations from LIR as a metaphysical but also physical theory. The elements *are* process structures, in the 'NSC-set-theoretical' sense and their deterministic dynamics is that described using the non-Kolmogorovian probability language proposed in Chapter 1. The criteria for applying this concept of structure-as-process, given a process of two elements are those indicated above as the requirements for application of the two-tier framework for analysis. Another way of saying this is that a 'structuring' seen externally is a kind of form; looked at internally, it consists of the processes themselves. Metaphysical structural explanation is a matter of picking out the elements in the category of Dynamic Opposition and showing what is involved in the operation of the PDO. Being very general, I can take as 'examples' the structure of existence – life and growth *vs.* death – and the structure of the universe – the increase of negative energy, the probable cause of the current expansion *vs.* the decrease of normal and dark matter-energy. After this it gets easier!

I will now mention two other theories of the structure of phenomenological reality, indicate their strengths and weaknesses and develop the LIR concept of structure based on the categories of NEO in relation to them as well.

5.4.4 Figure Versus Ground: Gestalt Theory

Two of the most discussed aspects of structure in reality that have been formulated as dichotomies in both ancient and modern philosophy are form *vs.* matter and figure *vs.* ground, in which the concept of form also plays a key role. Their analysis will illustrate how the concepts of LIR play out in relation to terms between which a relation of opposition is generally accepted. I will discuss the second of these first.

Gestalt theory was collated and formulated as a broadly interdisciplinary theory providing a framework for analysis of a wide variety of psychological phenomena and processes (Lupasco 1967). Its basic concept is that of an interacting figure, a form or process in a foreground that stands out against a background or 'ground'. Applications were also seen in non-individual reasoning processes, for example group dynamics. Köhler showed the existence of physical and psychological *Gestalten* with properties *similar* to the perceptive or phenomenal, in an attempt to establish an isomorphic relationship between phenomenal and physiological processes. The Gestalt psychologists determined empirically that one never perceives isolated elements that are somehow combined or associated into perceptions and objects and that, further, any modification of either figure or ground modifies the entire ensemble – a form. This amounts to a psychological exemplification of non-separability applied to sets and their elements (see Appendix 2).

The figure-ground duality as a structure in reality is easily incorporated into LIR, and without going further into its historical development, I can put the original positive contribution of Gestalt theory on a sounder theoretical basis. According to the fundamental principles of LIR, structures or forms cannot be reduced to syntactic assemblies that can be manipulated by substituting, for the organicity of the structures, that is, their dynamic stability, systems of simplified relations between terms. This would represent a reification of connections, characterizing terms only *via* positional values that negates *a priori* all the phenomenological characteristics of structures, including, in particular, the dynamic phenomenological shifts in perception that take place between figure and ground.

The Gestaltists did not show *why*, by virtue of what principle, interactions between figure and ground should exist and behave the way they do. In LIR, both figures and their related grounds are sets or classes. If one agrees that a set or a class is always a duality of sets or classes, one identifying and the other diversifying, linked by dynamic, structural interaction (contradiction), one can see that the adjunction of one more identity or diversity can modify their union. The psychological data reported by the Gestalt psychologists provide an illustration of the dynamic logic of the contradictory. Seeing that figures and grounds are related contradictorially, that is, alternately actualizing and potentializing one another, relates them to the processes of which they are the physical and logical consequence. Elements never just "come together" to generate an isolated form. Rather, since every element is itself a form, it is apprehended in the form in which it is included, and every form distinguishes itself as a form, in relation to the form that surrounds it, on which it appears, which constitutes a ground, which is also a form.

5.4.5 Form Versus Matter: Catastrophe Theory

Another ancient argument is whether form, geometrical position, or matter is more fundamental in the universe. In the last half of the 20th Century, Thom and Petitot developed a theory of morphogenesis, the origin of form, in terms of a relatively small number of topological graphs of geometric singularities, called catastrophes. In this theory, form is the most fundamental aspect of the phenomenological universe, that is, what is accessible to human perception.

Catastrophe theory (CT) abductively permits the classification and prediction of the singularities of the morphogenesis of a system, even without knowledge of the underlying dynamics or that of its macroscopic evolution. Petitot showed that in addition to providing a method for modeling phenomena studied in the natural sciences, CT was able to constitute an objectivity of phenomena of social sciences (humanities), language and thought. Petitot said that CT 'purified' phenomenology from the quasi-mystical Husserlian vision of essences, brought back to it the mathematics that Husserl had refused to accept and transformed its philosophical task into a scientific program. CT thus had the right to be considered the first synthesis of geometry[14] and phenomenology and a serious option for the naturalization of phenomenology.

The reason that it is essential to discuss CT at this point is that it constitutes *a direct challenge to the fundamental principle of LIR, namely, its grounding in the irreducible and oppositional duality of energy*. If form is in part as fundamental as CT claims, then, in the spirit of LIR, a proper theory should not exclude, either matter (energy, force, substance) or form, but show how the two work together.

CT, however, was an attempt to be "the creation of a theory of morphogenesis *in abstracto*, *purely* geometric, independent of the substrate of the forms and the nature of the forces that create them." CT is to a certain extent a local theory of the most general possible undifferentiated substrate, in which one can see a resurgence of the Aristotelian scheme of *hylomorphism*, matter aspiring to form. The resistance of biologists to CT was supposed to be due to the underlying idealism of this concept and the tradition in physics of the ontological primacy of energy (force) over form, whereas the CT position is that "there is no reason to think that force has in principle a deeper ontological status than form."[15]

This principle is constitutive for CT, as it rehabilitates *formal* causality beyond material causality and affirms that for all reality, the morphological-structural order is constrained by a mathematics, by Platonic ideas – laws of form – that nature is 'obliged' to realize. However, and we will see here the rationale of this long excursion into idealism, Petitot insists that this principle, and thus presumably CT, "is only valid *locally*, the integration of local accidents into a global structure giving back all their rights to the real and specific internal dynamics, unreduced, i.e., to 'matter'. Matter often imposes additional constraints, but the macroscopic global appearance, form in the usual sense of the term, comes about by the aggregation of a great number of local accidents, and the statistics of these local catastrophes, the correlations that control their appearing in the course of a given process, are determined by the topological structure of the internal dynamics. "It is by the topological richness of these internal dynamics, their more or less integrated character, that is explained, finally, the almost infinite diversity of the appearances of the external world."

[14] This is not the only attempt at the geometrization of human concepts. Mazzola, in his 'geometric logic' of music indicates that the Yoneda 'revolution' in mathematics achieves this, but he also explicitly states that this categorial approach is based on an 'absolute' logic derived from the three fundamental classical axioms (Mazzola 2002).

[15] The intuition that form is fundamental goes back to Plotinus and Plato, and I see it as defining a type of personality or mentality that is simply the opposite of those who seem satisfied with a view of matter (or matter-energy) as fundamental. The concept of form as fundamental, in the LIR view, is wrong only if it is considered to be *exclusive*.

In my view, the CT approach is a 'textbook' example of the reduction of heterogeneity to the non-logical status of accident. Even for those who are not familiar with the ideas of this book, the above separation into local and global regions in which different principles apply may look suspect. Energy is not an 'undifferentiated substrate'. LIR undercuts the exclusivity of the CT approach since neither form nor matter-energy need be considered primary in the sense that matter-energy also has structure, = form, given by antagonism. It is in fact what I designate as the *foundational differentiation* of the effective quantum field that is the origin of form and everything else.

In a later paper, Petitot and Smith (1997) claim that it is *separation* that accounts for phenomenal reality and *discontinuities* that serve as a central organizing principle of the phenomenal world.[16] The authors appear to be maintaining the principle of bivalence as a total exclusion or disregard, with the laudable objective of coherence, of one of the terms of a dichotomy or duality. According to my categorial scheme, the Petitot-Smith approach would be applicable only to phenomena in the category SC. Indeed, most of the examples used in the paper refer to simple, macrophysical changes of phase.

Thom thought that the principal epistemological and ontological interest of CT was to go beyond the antinomic disjunction between a mathematically determined physical being and linguistically described phenomenological appearing (*apparaître*) and then reconcile them by integrating catastrophic infrastructures into the mathematical determination of phenomena. CT proposes that one can postulate that these infrastructures constitute an objective correlate of the qualitative linguistic descriptions in sciences, which are founded in "things themselves". The consequence is that one could go beyond the division of the subjective and the objective and convert this 'central problem' into a scientific one. In his reworking of Thomian idealism, Petitot (1988) asks how,

> if one adopts the standard doctrine of objective explication by invisible entities (forces, atoms, fields, etc.), governed by principles and laws capable of being defined mathematically from the geometry of space-time, can one 'redescend' from such an objective, mathematically determined reality to visible morphologies?

The answer based on LIR is that one *cannot* using the standard doctrine of forces, etc., because it excludes the key antagonistic principles which allow differentiated entities to be built up by and from them. Most importantly, the principles of LIR provide for what Petitot described as "reciprocal interactions between an entity and its environment that allow for 'emergence' (Petitot put emergence in scare quotes) of morphologies by self-organization of material substrates." From this point of view, one does not need to speak of the appearing of phenomena or manifestation as irreversible processes that the laws of physics, interpreted as in this book, cannot describe; the observable discontinuities of a phenomenon do not

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[16] I note that these authors claim no causal predictive or explanatory power for their theory.

have to be separated from its physical objectification, and the relative continuity of its existence.

If the separation proposed by Petitot and Smith exists, how can the phenomenon, in its appearing, not be degraded to a "simple subjective-relative appearance? How can a realist doctrine and an ontological conception of the 'semiotic constraints of the perceptive organization of the real' be reached?" Petitot proposed that a transcendental objectivity of pure manifestation can be constituted by identifying manifestation and morphology. A geometrico-topological analysis defines, for every spatio-temporal process, 'factors of phenomenological invariance' that play a fundamental role in their verbal description and consequently the linguistic organization of our vision of the world. "Can one not admit that these factors derive from the real properties of the objects of the external world, and manifest the objective presence of formal entities linked to these objects, and of which one can say that they are carriers of signification?" Given the correlation between manifestation and meaning, the synthesis between phenomenology and objectivity permits the foundation of meaning in phenomenological objectivity. If one admits this, CT can permit a geometric modeling of ordinary verbal thought that can "replace *semantic* intuition, with its immediate subjective character, by *geometric* intuition, that spatializes its object, and distances it from the thinking subject."

Now, one can perfectly well construct an idealist metatheory of transcendental objectivity, but it unfortunately tells us nothing about the real world. I have shown that the separation of subjective and objective leads to category errors, and this discussion is a further example, that also shows the consequence of separation of geometry and energy. Petitot also makes the statement that the factors of phenomenological invariance, the catastrophic infrastructures of phenomena, constitute *"third terms – up till now totally missing – between description and explica*tion, between appearing and objectivity (Petitot-Cocorda 1985)." These third terms, however, cannot be dynamically included middle T-states, as there are no dynamic or even complementary interactions between the opposites involved, as I claim there are, for example, between appearance and reality.

Petitot's major project was to reformulate the Husserlian phenomenological reduction to lived experience in terms of critical reduction to phenomena by reinterpreting the original giving intuitions in terms of transcendental esthetics and schemes. For this, a mathematical formalization of categorial intuitions is essential, resulting in a new conception of the relationship between mathematics and reality. The development of mathematics realizes an authentic dialectic of concepts which transcends them and this dialectic insures a schematizing function which makes the Kantian *a priori* historical and diversifies it in regional ontologies. If catastrophe theory can pretend to be implicated in a constituting fashion in experience, it is because it is based on mathematical theories which instantiate and resolve problematic dialectic concepts (Hegelian syntheses suggested by Lautman as "Ideas"). The impression that one retains from these conclusions of Petitot is that of arriving back at real phenomena after a lengthy detour. If phenomena themselves instantiate dialectics, then they (the dialectical relations) can be considered as ontologically constitutive, and the dynamic view of dialectics in LIR provides physical explications of them.

There is an assumption by Petitot that his *theory* could be the source of objectification of the virtual aspects of phenomena. It is possible that Petitot really means that an objective phenomenal reality precedes intrinsic mathematical reality, but then he should say so, and provide adequate characterization of those 'virtual aspects'. My criticism of CT is not that it possesses a transcendental signification in its own terms for the constitution of a morphological-structural ontology, but that a link to real phenomena is not made.

A major objection made by Petitot against logic is that *it* is inadequate to give an adequate account of real phenomena. On closer inspection, it would appear that the logic under attack is classical, exactly that which, in contrast to LIR, is absolute, idealized and abstract. If so, it never had the capability of providing an adequate description in the first place.

In his dynamic structuralism of language, to explain denotation, the relation of description between language and external reality, Petitot-Cocorda (1985) postulated a phenomenologically real, non-linguistic *third term*, the state-of-affairs. Is this to be considered as an included middle in the sense of LIR? I think not. Petitot proposes this term for constraints imposed by the physical world, leading to catastrophe theory as a synthesis between phenomenology (appearance) and physical objectivity (reality). This synthesis makes possible the mathematical definition of "factors of phenomenological invariance" as objective formal entities. In LIR and NEO, the approach to states-of-affairs is not to seek invariants in them. An invariant is by definition excluded from being a part of a reality in which elements undergo change. The phrase used by Cassirer of "invariants of experience", as well as the one above, are for me oxymorons. I mention the Petitot program[17] simply as reflecting another view of general relativity as geometry, excluding a functional dualism of the LIR variety.

In order to complete the general discussion of the methodology of application of LIR, since LIR is proposed as theory of explanation, I must also look at what *this* means and to what extent LIR can answer 'why'-questions. The theory of explanation itself is an area of current philosophical debate, and it is therefore appropriate that I define (explain!) what I mean by explanation, that is, *its* elements or structure.

[17] As a further indication of the exclusive role of geometry, Petitot quotes Deleuze to the effect that the *a priori* of his structuralism is *topological* and not logical.

5.5 WHAT IS AN EXPLANATION?

The key questions to be asked in this connection are "What is an explanation?" and "What are explanations of?" Answers to these questions developed over the last half-century tended to focus on linguistic aspects of explanation, explanation as a set of propositions of some kind. The necessity of relating explanation to an underlying theory of real phenomena has now been recognized, but attempts are still made to restrict this to a purely formal operations of deductive inference, dependent on a standard first-order, consistent logics or neo-classical inconsistent logics. In the last few years has it become apparent that such approaches provide only partial insight into what really constitutes an explanation, namely, a description of both why and how a phenomenon is observed.

5.5.1 Two General Failures of Explanation

In both philosophical and logical texts, one is struck by the frequent similarity of the forms of argument used and of the description of the difficulties encountered by the respective theories. I will characterize these, for brevity, as 'both-at-once' and 'spontaneity'. The common property of such attempted explanations is that they are in fact nothing but descriptions of phenomena, lacking a detailed characterization of any underlying set of principles or mechanisms that could entail the changes involved. Some ancient and current examples serve, as much as anything, to show the persistence of the problems and difficulties.

5.5.1.1 'Both-at-Once'

The idea that the world instantiates situations which can be described as two opposing things existing at once is mentioned in the Diamond Sutra in Buddhist Scriptures (ca. AD 350) – neither a thing (dharma, for which some ten meanings have been given), nor a non-dharma. The Jains (Stcherbatsky 1962), however, also in the first half of the 1st millennium, made similar statements positively, taking what might be called the first real dialectic position. The nature of reality, they said, is permanent and impermanent at the same time, finite and infinite, particular and universal. They realized that a being with absolute identity would be unrelated to all others and could not exist, but without some identity, it would be indistinguishable from everything else. Many authors use this construction when they are unable to provide a satisfactory explanation of the phenomenon under study. However, no explanation is given of how such states of affairs might be instantiated, and the phrase 'both at once' can only be understood metaphorically.

Barel (1987) developed a concept of paradox as contradiction, an entity being at the same time digital and analog, discontinuous and continuous, and *as a metaphor*, particle and wave. The part of a phenomenon is at the same time smaller and larger than the whole, and inversely. An intuition of intermediate states is present, but it remains too arbitrary to be useful.

A related expression that is often used is 'fusion'. One senses here a sincere, not to say desperate desire to understand and explicate a phenomenon, but almost no serious meaning, even in conceptual, philosophical space, can be given to fusion (or mixture). Superficially dynamic, it actually describes only a simple stochastic process. It may imply an interaction between two terms or elements that fuse, but it fails to give an adequate picture of the rationale, content or consequence of the change involved.[18]

A relevant example for this study is the view of quantum mechanics developed by Bohr. In his Copenhagen interpretation, to explain problems of quantum measurement, he saw that quantum entities had to be described as both continuous waves and discrete elementary particles at the same time. He avoided contradiction and paradox by defining a concept of complementarity, equivalent to 'both (A and not-A) at once'. This interpretation is now generally conceded to be inadequate, but totally satisfactory replacements have not been developed, as I will discuss shortly.

In summary, although the phrase 'both at once' fails as explanation, it points towards situations in reality that can are targets for better explanation, whether in philosophy or science.

5.5.1.2 Spontaneity

In work in process ontology, philosophy and metaphysics, dealing with quantum reality, life, consciousness, and emergent organization, there still regularly appear in the argument points of admission of impotence. Whether the authors regard teleology or chance as fundamental, they postulate some arbitrary kind of 'spontaneous processes' and/or underlying idealized structures as the basis for order in the universe throughout ascending hierarchies of complexity. New laws and properties accompany emergent processes, but no foundation or underlying cause is suggested for their existence. I note 'chance as spontaneity' in Peirce; Bohm's underlying unity; Varela's autopoiesis; the 'creative spontaneity' of Rescher; Popper's propensities; Kauffman's spontaneous computational 'order for

[18] A recent example (Miller 2006) is the search for a 'bridge' between two traditionally opposed hypotheses about how we infer the mental states of others: simulation theory (mirror activity) and theory of mind (use of abstract rules). It is suggested that rather than being mutually exclusive, the theories may describe "two processes we can mix together".

free' plus evolution and Salthe's 'autonomy' to name a few examples. These issues are important, since the invocation of spontaneity is directly linked to critical metaphysical problems of the underlying existence of continuity *vs.* discontinuity and determinism *vs.* indeterminism in the universe, as well as the importance of cause in scientific theories.

Peirce (1998), for example, shows here again the combination of a correct new intuition, that metaphysics cannot require that all the details of phenomena are determined by law ("Now, metaphysics has always been the ape of mathematics") and a, from my point of view, classically false one, namely that the variety in the universe is arbitrary and "*This variety must be attributed to spontaneity in some form.*"

An interactive Internet project proposed by the authors of the encyclopedic Principia Cybernetica Web (PCP) attempts to answer fundamental philosophical questions, and the site is organized as a complex network of mutually dependent concepts and principles. The authors' intention is to ground philosophy in change and development, rather than static concepts of matter, substance or mind, but they see evolution as the expression of a blind variation and selection process. The universe 'self-organizes', resulting in the 'spontaneous emergence' of more and more complex organizations. What is provided is hardly more than an idea. Spontaneous emergence is no more grounded here than in far less sophisticated models from Aristotle on. These remarks do not apply to the concept of spontaneous symmetry breaking (SSB) in statistical mechanics and quantum field theory. In the former, SSB can be described as a change in the order of a system due to instability under small statistical perturbations. In the latter, 'spontaneous' refers to a situation in which a member of a set of symmetric physical states is conceptually selected as a ground state, in which case symmetry, conceptually again, is said to be spontaneously broken. The basis of the term is not in question here.

Even Husserl fell back on spontaneous beliefs as the basis for transcendent intuition, that which places us in contact with the causally connected individuals that constitute the domain of natural realities. In his idealist system, it is the source and foundation of our belief in the world and nature.

I thus restate what I consider the failures of spontaneity and simultaneity as explanations:

- The absence of an explanatory mechanism for the apparent co-existence, frequent or occasional, of opposing or contradictory elements
- The lack of physical grounding of critical concepts of evolution and emergence, and recourse to one of spontaneity, above the quantum field level

The problems are, in my opinion, unfortunately quite general. They also occur in discussions of the relatively new disciplines that that appeared in the last twenty-five years or so, namely, cognitive science, complexity science and systems science. These sciences accomplish a number of important tasks in breaking down artificial barriers between the classical disciplinary divisions in and between the natural and social sciences. Their openness to social and political problems and humanistic intuition are congenial to me personally, but I feel that most lack sufficient fundamental physical grounding to be adequately rigorous or explanatory.

5.5.2 The LIR View of Explanation

My claim is that something like a logic of reality is required for explanation that includes the antagonistic or contradictory aspects of the phenomenon under study. If LIR were only a restatement of the intuition of the prevalence of conflict of opposing forces in the world and of cyclic phenomena in nature and human affairs, it would not have much new explanatory value. The essential addition of LIR is the demonstration that this intuition has a scientific basis, grounded in the physics of the universe that can be formalized as a logic or logical theory. In my view, a theory that did not take into account the *existence* of constitutive dynamic opposition at cognitive levels would in my view already be likely to be incomplete or misleading, and in any event not provide a satisfactory explanation of the phenomenon. To say that a trend toward reductionism in philosophy or science is frequently, or always, followed by one toward anti-reductionism is nothing more, as it stands, than an astute observation. In LIR, most of the explanations will be metaphysical ones, with application to metaphysical problems, but in some cases, the explicit definition of the PDO may have applications in science *via* suggestions of directions of research.

Any explanation has two components, what is to be explained, the *explanandum*, and the explanation or *explanans.* The *explananda* are the phenomenal or conceptual elements or entities ***e***. By an explanation can be understood an act of explaining, *EA*, or the piece of information conveyed under the act, *EI.* In fact, both are necessary for explanation, something that results in a change in the state of knowledge (hopefully an increase) of its receiver. One also can and should differentiate between causal explanations, which refer directly to a (clearly) physical event, and conceptual explanations, which are based on abstract relationships. These would include relations defined by classical logic. Even in these latter cases, it is necessary to maintain the proper order of *explanans* and *explanandum* such that former provides the basic concepts used in the latter. Both types of explanations involve act and conveyed information, but the validity of causal explanations depends further on the causal relation itself.

Assuming a certain degree of background knowledge B – well-recognized theories, laws and 'facts' from other disciplines, the essence of my explanations in the context of LIR will causal ones be a situation description S of phenomenon in terms of the categories of NEO.[19] An explanation is usually said to be successful if there is a relation of logical entailment, in this case a deductive one, between [S, B] and ***e***. I have shown, however, that classical logical entailment is tautological in real situations. Thus one must be satisfied, in my view, with explanations that will never be *completely* satisfactory. This is a well-recognized weakness of theory, which has been recognized by Bueno and da Costa and is one of the justifications for their concepts of quasi-truth and partial structures in quantum phenomena, but LIR gives this weakness itself a further theoretical basis. The term explanation can refer both to relationship between a theory and a phenomenon and between the description of the situation and a phenomenon. In the latter case, it would be more reasonable to call it an expanded description.

There is one sense in which my categorial structure is open to criticism: it states that essentially everything is a process and instantiates actualization and potentialization and subject and object entities. I disagree. It is true that LIR is doing its explanatory work in the 'thin' sense of explanation that *metaphysical* theories can afford: structural description. I argue, however, that further structure is given to my explanations by the different way in which I have defined structure as process, that is, including the "quasi-empirical" reality values as its elements. I suggest that there is a net gain in explanatory power once it is seen that all five categories of NEO involved in a description of a phenomenon, and their interrelations, are categories of real forces at work in them and not abstract classes of some kind.

There is a further implication of LIR as 'experimental metaphysics' to use Redhead's term (Redhead 1995): the method of valid argument in current philosophy itself embodies tautological assumptions of classical logic. I do not wish the validity of my argumentation and explanation to be judged by such standards, exactly as I refuse a definition of logic as excluding the real world. I accept the consequence that efficiency will be the only criterion of the value of my approach. I will claim, non-defensively, that the consideration of dynamic opposition as fundamental, with regard to statements about laws of nature,[20] provides a new and at least as satisfactory basis for ascribing validity to my logic as to proceed along the lines of a proof-theoretical justification of the laws of classical logic (Dummett 1993). I do not need to consider logic as concerned *solely* with the validity of forms of argument, represented by propositional inference schemas, requiring a notion of truth under interpretation. I do *not* take truth for granted and I *do* inquire into the meaning in reality of the notion of truth, as in Section 2.3. The pattern of inference I will use in discussing particular theories is the one defined by LIR,

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[19] Hung (2005) describes a theory of projective explanation to describe explanations in science, among other reasons to include the role of the observer. An observer characterization O describes the mental constitution of the observer including his perceptual frameworks, beliefs, etc. It would be perfectly congenial to a metaphysical discourse such as this one to include myself as O. This would give logical status to my own prejudices.

[20] There are several key issues revolving around the existence and domain of application of laws of nature – 'scientific laws' – with which I will deal in Chapter 6.

namely, from some reality values of actualization, potentialization or T-state to other such values.

5.5.3 Explanation and Metaphysics

One debate about the nature of explanation can be readily approached using the concepts of LIR. As summarized by Bird (2005), Explanations can be further placed in two categories, subjectivist and objectivist, with the following characteristics:

- Subjectivist (S-explanation): explanation = act of explaining and what is provided by that act; anti-metaphysical – explanations are not natural objects and do not constitute part of the way things are; typically, incomplete; the relation between *explanandum* and *explanans* is syntactic.
- Objectivist (O-explanation): explanation = natural phenomenon independent of subject; deals with the way laws and facts relate metaphysically; typically, complete; relation of semantic entailment.

Hintikka and Halonen have championed formalized S-explanations as being most significant, but their theory has been severely criticized by many authors, for example, of not distinguishing an explanation from the act of providing one, as I have done above. In their defense, they say that they do consider dependence relations required for the derivation of the *explanandum* from a background theory, but are suspicious of attempts to posit metaphysical causal powers to back up such relations of dependence. As evidence, these authors point to explanations made in ordinary usage (e.g., of beliefs) that are accepted by people who do not observe causality playing any role in them. This is probably true, but it does not mean that causal processes are absent.

Sintonen (2005) mentions that the major contributor to a theory of explanation, Salmon (1998), finally embraced a two-level or two-tiered view in which relations of statistical relevance (the first level) are to be accompanied and substantiated by causal relations, and it is only at this second level that explanatoriness emerges.

A full discussion should await my development of the LIR view of causality, but the following claims are already possible using the LIR concepts in hand:

1. The two-tiered view of Salmon exactly fits the LIR two-level framework of relational analysis: the movement from actualization to potentialization at the phenomenal level is dependent on statistical considerations, and explanatoriness is the T-state emergent as a consequence of the causal relations also present.
2. Causality seems clearly essential to explanation, and if causality poses problems for formalization, one is well advised to move away from formal approaches, e.g., those that emphasize deduction as the primary feature of the explanatory process. Deducibility is metaphysically too weak to support an account of explanation.
3. In LIR, *subjectivist* stances can be given their proper value by bringing them 'home' to a metaphysical framework as real, dynamic phenomena. On the other hand, problems with *objectivist* stances can be answered by re-introducing the subject making the explanation, at least, when the explanation does not involve 'explaining' why some proposition or theorem is true, but why, and how, some phenomenon has occurred. Such real-world explanations are bound to be incomplete S-type explanations, but this is acceptable, as there is greater assurance that they are *relevant* in the sense of relevant logic (Chapter 1).

Some authors seem to have an intuition of a correspondence or other relation between S- and O-explanation. LIR provides a basis for establishing a contradictorial relation between them that will enable both forms to be applied complex situations, for example of debate about explanations!

5.6 THE ANALYTIC/SYNTHETIC DISTINCTION IN LIR

As a further introduction to the methodology of LIR and as an illustration of how some of its concepts can be applied, using the framework suggested above, I will look at the relation between sentences and reality that is implicit in the analytic/synthetic distinction. The reason that this philosophical issue is introduced is that it is critical to much further discussion of applications of LIR for which standard notions of language, truth, inference and the logic of propositions must be 'translated' into the physical or metaphysical conceptions of LIR.

In Chapter 2, I discussed the LIR conception of truth as the truth of reality, that is, of the status of real processes tending toward non-contradiction or contradiction. This is in contradistinction to a concept of truth as the truth-value of sentences. However, for my applications of LIR to philosophy and science, I will be presenting a theory, consisting of sentences. Now, when I write a sentence, I want you to believe it's true. If you can't or won't, you should at least believe that I believe it's true. In both cases (I omit some pathological ones) the truth basis of my sentence is at issue, and I would like to be clear in what sense I want the truth-value of *my* sentences to be understood, and what meaning I wish them to have.

This discussion, I believe, is essential because LIR statements look like what are termed *synthetic* statements, that is, ones whose truth depends on matters, in particular, contingent facts about the world, to which I have ascribed a certain dialectic *structure* (see Section 5.4). Such statements are distinguished from *analytic* statements that are true by virtue of their meaning alone.

Meaning arises from the syntax and rules of the language used. Quine believed this distinction could not be made since sentences depend both on the conventions of language use and facts about the world. In addition, this definition of meaning is both circular and non-naturalist, in my terms; it lacks a link to reality. Because there is no principled way of distinguishing cognitive processes involved in analytical or synthetic statements, Quine's view has been called 'holism', since there is no way of selecting which of the causal relations involved in psychological states are also involved in the determination of meaning.

Naturalistic theories of mental states define their meaning in terms of their psychological causal relations to other mental states, such as both beliefs and behavior. This is the causal-role theory of content in cognition. If one assumes that analytic sentences exist, meaning must be something separate and distinct from other factors, but some way is still required for making this distinction. The way to do this while avoiding circularity is to have some other, non-semantic, syntactic characterization of the internal psychological states. I do not believe, however, that such structural relations need to be defined as immutable and independent of spatial and temporal location for human beings. Such distinctions *only* are valid for systems like computers, where there is total separability between software and hardware.

My claim is that LIR provides support to a naturalistic, causal-role theory of mental content and a naturalistic means of drawing the analytic/synthetic distinction. This is because LIR *always* defines a real relation between the intensional notions or aspects of a phenomenon and the extensional ones. Kaye (1995) claims that his causal role theory of content identifies the meanings of representations in the brain with the causal relations of representations that are determined by their structure and by the structure of cognition. Despite the incomplete knowledge of the details of the causal relations within our mind/brains, LIR defines the operation in them of dynamic opposition as a structural or better structuring principle. It is possible to say, now, that an analytic statement is true in virtue of the causal relations resulting from its syntactic structure and, as well, the causal relations that it stands in by virtue of the structure of the cognitive system that contains it. The consequence is that an absolute distinction between analytic and synthetic statements does not need to be fully maintained, without going to the other extreme of having to deny variations in content for different psychological subjects.[21]

[21] This means that there is not a single rigorously identical concept that all subjects must share.

In conclusion, analytic claims can provide insight into external reality, but only if coupled with a non-semantic theory that provides some basis for explanation of the coincidence between our concepts and the properties or real phenomena of the world. By starting from the side of the phenomena, LIR permits progress in this direction.

5.6.1 The Inferential Role Description

The causal role theory of mental content is a functional role theory in that it identifies content with the *role* of a representation in cognition. Here, I wish to analyze an inferential role account according to which the meaning of a mental term is identical to the role in the totality of inferences that the individual makes. In defining such a categorial account in my system, one would first need to identify the inferential role of the scientific terms one wishes to interpret with LIR or NEO and then show that the definitions of the categories in LIR fit these inferential roles in the scientific language and thus adequately capture the content of the scientific concepts involved. As a model that may help in understanding the relation between LIR and NEO, I have selected the example of the term 'perception'

1. The Scientific Term: 'Perception'

2. The Scientific Concepts: About 30 from the light source to the conscious thought and resulting behavior ('Action').

3. The Inferential Roles of 'Perception' in the Language: The inferential roles of this term relate to the meaning to me of perception, that is of all the inferences I make such as, for example, how (1) physical stimuli become mental information; (2) mental and physical states can affect 'Perception'; and (3) an analysis of 'Perception' is essential to my theories, etc.

4. The Interpretation of 'Perception' with LIR/NEO: 'Perception' is a set of processes of processes, etc., in which an inflow of energy in a first step actualizes, in a system of chemical and electrochemical gradients, depolarization (excitation) of nerve cells which is followed by the actualization of their re-polarization (inhibition) and the potentialization of excitation, followed by further similar post-synaptic transmissions which eventually become the trace that is the conscious percept.

5. The Definitions of the (Relevant) Categories in LIR:

Process:	Change
Subject-Object:	Agent-Patient/Actual-Potential

Energy:	Effective Quantum Fields
T-state:	Emergent Included Middle

6. The Fit of the Definitions of the Categories to the Inferential Roles of 'Perception': The categories assign meaning to all aspects of the mental representations that constitute, for me, my patterns of inference-making about 'Perception', e.g., that it can lead to new notions or that I may be overloaded and make erroneous judgments and arguments.

7. The Capture of the Content of the Scientific Concepts of 'Perception' by the Definitions of the Categories: In the concepts of 'Perception' we have: energy in micro- and macro-physical, chemical and electrochemical form; dialectic of excitation-inhibition; changes at surfaces; a subject-object relationship between the energy and the perceiver; plans and ideas as T-states.

Kaye has criticized the inferential role account of mental content as circular since a characterization of truth conditions seems required for analysis of the semantic assignments that in fact are or involve truth conditions themselves. LIR undercuts this objection since I use the concept of dynamic opposition to delineate the extension of a concept syntactically. My inferential role semantics do not only involve or exist as truth conditions, but 'reality' conditions. Thus I claim that besides causal-role theories of content, the notion of inference is available to me as a meaning naturalist and scientist as well as to formal ontologists.

The LIR approach thus permits a clarification of the 'role' of the causal and inferential role descriptions respectively. In this example, I see another instantiation of the LIR two-level system of analysis: the causal role theory is itself synthetic; the inferential role theory analytic and they are in a contradictorial relation *vis à vis* the data – the phenomenological representations. The categorial inferential role theory serves in my view as form of control mechanism to check, as in the American expression 'reality check', that one has successfully modeled and/or ontologically interpreted a term or a process. From this, it is not too far fetched to suggest that the performance of philosophy is a dynamic and dialectical process itself, in which one oscillates between analytic and synthetic approaches, each serving as a control of the other.

My choice of perception as the object of the mini-analysis above was thus not entirely arbitrary. Causal theories of perception (Boyd 2002) as well as of knowledge in general have had a role in defending scientific realism and insuring that scientific findings and terms have philosophical as well as scientific relevance. I will return to the LIR version of scientific realism in the next chapter.

5.6.2 The Syntactic – Semantic Distinction – and Conjunction

Placing semantics in the group of object levels and syntax (structure) in that of meta-levels corresponds more or less to standard practice. What however might be the consequences for their 'working' relation in LIR?

To answer this question I must first recall the notion of structure in standard logic. Structure for a well-formed formula in first-order predicate logic (FOL) is like a line in a truth table of sentential (syllogistic or term) logic: both yield, syntactically, that is, by virtue of structure alone, values of truth or falsity. A structure in FOL consists of a domain and the assignments of (1) objects in the domain to names of the logical language; (2) properties or sets of objects in the domain to one-place predicates in the language; and (3) multiple relations or objects to multiple predicates. The relation of their respective definitions of implication also links semantics and syntax, but the discussion centers as usual on the preservation of truth-values with which LIR is not directly concerned.

The lines of the 'reality' tables of LIR are like the above structures as they were (axiomatically) defined in Chapter 1. On the other hand, the metaphysical structure of reality was developed from the considerations of the semantics of LIR in Chapter 2. Instead of well-formed formulas that are true or false as above, both LIR viewpoints yield the real state of the system, its values of actualization, potentialization or T-state that describe its elements. For me, this functional relation between syntax and semantics is a further reflection of the relations of the underlying physical reality. All of the pairs of phenomena listed thus have structural or syntactic and semantic aspects, as will be seen in the various applications in the following chapters.

By this time, it should be clear that the LIR semantics is far removed from semantics as traditionally conceived, that is, as a ruled correlation of uninterpreted symbols with bare, non-structured objects, with or without 'temporal parts'. In the dynamic view of Peruzzi (1994) "What exists is real interaction, schematized in patterns on whose symbolization syntax operates". I will refer to this article on several further occasions.

The existence of what I consider functional links between syntax and semantics is also illustrated by systems using standard logics for work on the categorial structure of natural language. Categorial grammar analyzes *linguistic* syntax and semantics in terms of type theory and the lambda calculus (van Benthem 2003).

The purpose of such exercises is to provide a perspective on parameters for linguistic description, needed for explanation in linguistic frameworks. Categorial derivations are made that consist of binary assertions of the form:

- Expression *E* has syntactic category *C*
- Term τ has semantic type *a*

As shown by van Benthem, the two viewpoints work in tandem, so that parsing a string of words with syntactic categories produces a description that uses correlated semantic types. He further indicates that the application of categorial logic and categorial grammar to language could have further ‘naturalistic uses’. The assignment of reality values to phenomena *via* the conceptual and logical structures of LIR is a development in this direction as well.

What I have now defined is a concept of the structure of reality that does not depend on any transcendental notion of human experience such as that present in Heidegger or the neo-Kantian phenomenology of Petitot. I have also established a framework for analysis that is broadly applicable to dualistic entities in philosophy and metaphysics. In the next chapter, I will provide a preliminary outline of a potential LIR philosophy of mind and phenomenology, as well as defend new interpretations of the major philosophical issues of causality, determinism and continuity. Combined with critical changes in the standard conceptions of time and space in Chapter 7, they will be the basis for a contradictorial view, in Chapter 8, of emergence and the related problems of life and evolution.

References

Aerts, Diederik, Jan Broekaert, and Liane Gabora. 2002. Intrinsic Contextuality as the Crux of Consciousness. In *No Matter, Never Mind*, eds. K.Yasue. Amsterdam: John Benjamins. *Advances in Consciousness Research* 33 ISSN: 1381–589X.

Barel, Yves. 1987. *Le paradoxe et le système*. Grenoble, France: Presses universitaires de Grenoble.

Batterman, Robert W. 2002. *The Devil in the Details. Asymptotic Reasoning in Explanation, Reduction and Emergence.* Oxford: Oxford University Press.

Béziau, Jean-Yves. 2001. The Logic of Confusion. In *Proceedings of the International Conference on Artificial Intelligence*, IC-AI. Las Vegas, NV: CSREA Press, pp. 821–826.

Bird, Alexander. 2005. Explanation and Metaphysics. *SYNTHESE* 143: 89–107.

Bloomfield, Paul. 2005. Let’s Be Realistic About Serious Metaphysics. *SYNTHESE* 144: 69–90.

Bottani, Andrea. 2001. *L’universalité et l’incomplétude de la méréologie extensionelle classique.* In *Méréologie et Modalités*, *Travaux de Logique, CdRS*, Vol. 14. Neuchâtel, Switzerland: University of Neuchâtel, pp. 75–94.

Boyd, Richard. 2002. Scientific Realism. *The Stanford Encyclopedia of Philosophy (Summer2002 Edition)*, ed. Edward N. Zalta. http://plato.stanford.edu/archives/spr2002/entries/scientific-realism/

Bueno, Otávio and Newton C. A. da Costa. 2007. Quasi-truth, Paraconsistency, and the Foundations of Science. *SYNTHESE* 154: 383–399.

Craciunescu, Pompiliu. 1999. *L’état T’ et la transcosmologie poétique*. In *Stéphane Lupasco; L’homme et l’œuvre*, eds. H. Badescu and B. Nicolescu. Monaco: Éditions du Rocher.

Dummett, Michael. 1993. *The Logical Basis of Metaphysics.* Cambridge, MA.: Harvard University Press.

Hoffmann, Roald. 2007. What Might Philosophy of Science Look Like if Chemists Built It? *SYNTHESE* 155: 321–336.

Hung, Edwin H.-C. 2005. Projective Explanation. *SYNTHESE* 145: 111–129.

Kaye, Laurence J. 1995. How to Avoid Holism and Draw the Analytic/Synthetic Distinction. http://www.cs.uchicago.edu/philosophyProject/LOT/KAYEAS.html

Krause, Décio. 2005. Structures for Structural Realism. *Journal of the Interest Group in Pure and Applied Logic* 13: 113–126.

Ladyman, James and Don Ross. 2007. Every Thing Must Go. Metaphysics Naturalized. Oxford: Oxford University Press.

Lawvere, F. William. 1994. Tools for the Advancement of Objective Logic: Closed Categories and Toposes. In *The Logical Foundations of Cognition*, eds. J. Macnamara and G. E. Reyes. New York: Oxford University Press.

Lupasco, Stéphane. 1967. *Qu'est-ce qu'une structure?* Paris: Christian Bourgois.

Magnan, François and Gonzalo E. Reyes. 1994. Category Theory as a Conceptual Tool in the Study of Cognition. In *The Logical Foundations of Cognition*, eds. J. Macnamara and G. E. Reyes. New York: Oxford University Press.

Mazzola, Guerino. 2002. *The Topos of Music. Geometric Logic of Concepts, Theory and Performance.* Basel, Switzerland/Boston, MA/Berlin: Birkhäuser Verlag.

Miller, Greg. 2006. Probing the Social Brain. Report on the Cognitive Neuroscience Society. *SCIENCE* 312: 839.

Muller, F. A. 2005. Deflating Skolem. *SYNTHESE* 143: 223–253.Pamuk, Orhan. 1996. *The Black Book.* San Diego, CA: Harcourt, Brace.

Peirce, Charles S. 1998.The Architecture of Theories. In *Philosophers of Process*, eds. D. Browning and W. T. Myers. New York: Fordham University Press (originally published in *The Collected Papers of C. S. Peirce*, Vol. VI, eds. C. Hartshorne and P. Weiss. Cambridge: Harvard University Press, 1935).

Peruzzi, Alberto. 1994. Prolegomena to a Theory of Kinds. In *The Logical Foundations of Cognition*, eds. J. Macnamara and G. E. Reyes. New York: Oxford University Press.

Petitot, Jean. 1988. *Logos et Théorie des Catastrophes*. Geneva: Editions Patiño.

Petitot, Jean and Barry Smith. 1997. Physics and the Phenomenal World. In *Formal Ontology*, eds. R. Poli and P. M. Simons. Dordrecht, The Netherlands/Boston, MA/London: Kluwer.

Petitot-Cocorda, Jean. 1985. *Morphogenèse du Sens.* Paris: Presses Universitaires de France.

Priest, Graham. 2002. Inconsistency in the Empirical Sciences. In *Inconsistency in Science*, ed. J. Meheus. Dordrecht, The Netherlands: Kluwer.

Redhead, Michael. 1995. *From Physics to Metaphysics.* Cambridge: Cambridge University Press.

Sintonen, Matti. 2005. Editorial. *SYNTHESE*, Vol. 143: 2. Referring to Wesley Salmon. 1998. *Causality and Explanation*. New York: Oxford University Press.

Smith, D. Woodruff. 2002. Mathematical Form in the World. *Philosophia Mathematica* 10: 102–129.

Smith, D. Woodruff. 2004. *Mind World.* Cambridge: Cambridge University Press.

Stcherbatsky, F. Th. 1962. *Buddhist Logic.* New York: Dover (originally published in Leningrad, USSR: Academy of Sciences of the USSR, 1930).

Stevens, Graham. 2006. Russell's Repsychologising of the Proposition. *SYNTHESE* 151: 99–124

Thomasson, Amie. 2004. Categories. *The Stanford Encyclopedia of Philosophy (Summer 2004 Edition)*, ed. Edward N. Zalta. http://plato.stanford.edu/archives/sum2004/entries/categories/

Van Benthem, Johan. 2003. The Categorial Fine-Structure of Natural Language. http://www.illc.uva.nl/Publications/ResearchProjects/PP-2003-20.text.pdf

Von Bertalanffy, Ludwig. 1969. *General System Theory.* New York: George Braziller.

Wimsatt, William K. 2007. *Re-Engineering Philosophy for Limited Beings.* Cambridge, MA: Harvard University Press.

6 LIR, METAPHYSICS AND PHILOSOPHY

Abstract The discussion in this chapter will provide the tools for analysis of several meta-philosophical questions, including deciding what kind of principle the PDO really is and what the meaning is of such a principle being 'constitutive'. LIR is proposed as a way of resolving the dichotomies of cause and non-cause, determinism and indeterminism, and continuity and discontinuity. These analyses will enable a definition of the specific form of scientific-structural realism, including a metaphysics of relations, that LIR supports. A critique of current realist and anti-realist views places LIR in relation to current controversies about laws of nature. The relationship to the dialectics of Hegel is explored, to avoid the misconception that the ternary LIR system of actualization, potentialization and T-state is equivalent to Hegel's triad. The chapter closes with a brief summary of the LIR view of the domains of philosophy, including the philosophy of mind and the related issues of the naturalization of phenomenology.

6.1 INTRODUCTION: CAUSE AND DETERMINISM

In the first half of this book, I have referred informally to a discipline or body of knowledge designated as metaphysics and to a number of different relations between metaphysics and my logic of/in reality, LIR. I have discussed the structure of reality and the relation between my ontology and its categories and metaphysics. There are several fundamental, closely related problem areas that are considered to lie in the domain of metaphysics, some of which I have alluded to, that I will now address in detail. They are generally presented in terms of dualities, but the LIR logical system is founded on these dualities as fundamental properties of nature. For this and other reasons, I believe the logic and ontology of the system I have designated as the logic of and in reality can provide a substantially new approach to the relations between them and the knowledge that this can occasion.

Let me first distinguish between determinism and cause and their opposites, indeterminism and effect. Determinism refers to a series of causes or the absence of them. Its relation to indeterminism is that of A to non-A. The relation of cause to effect is that of one entity to another one, A to B. The A/non-A case is clearly governed, in the LIR view, by the axioms of Conditional Contradiction, Functional Association and so on. LIR will apply in the A/B case in general if the axiom of Functional Association holds. The task is therefore to show that it holds as a theorem in the cause-effect case.

In the discussion of determinism, the focus is on the time-dependent sequence of causes (and presumed effects) rather than on a specific instantiation of it. The sequence is often considered to begin concomitantly with the universe itself. Spontaneity, one of the terms I have just criticized, is usually presented as an effect *without* cause. I might characterize its use as irrational, were it not for the large number of respected thinkers who have had recourse to it in one context or another.

The problems of cause-effect and determinism-indeterminism are closely, not to say inextricably related, but I have to start somewhere, and I have chosen to start with the more experiential question of causality or causation.[1]

6.2 CAUSALITY IN LIR

The difficulties associated with the problem of causality and finality,[2] in my conception, is the consequence of a world-view based on a classical logic of identity. For Kant and his followers, causality was nothing more than a rational synthetic order imposed *a priori* on the a-logical, noumenal givens of diversity, such that experience could be possible. Cause and effect became condition and conditioned, and his implied rigorous determinism was equivalent to a conception of a non-contradictory universe. No chance, then, since this would have to arise from some irrational principle of negation, destroying the logic of identity. No efficient cause since this would look too much like a mysterious agent or power. This would also be outside classical logic, and which might imply the notion of an adverse agent, and thus contradiction or some other kind of functional interaction between instances of identity and diversity! No final cause either, because a finality, an effect that has not yet been completed, that is still virtual or potential, implies the antagonistic forces that were preventing or would prevent that completion, present at the same time, in other words, another contradictory dualism that would be contrary to classical logic.

In contrast, the LIR categories of ontological dynamic opposition and change as process in the elements of reality that are modeled in LIR can accomplish two tasks: (1) a basis for the existence of causality and finality is possible;

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[1] I shall use causality when focusing on the more theoretical or philosophical aspects of the phenomenon and causation on the more physical ones, but total consistency is difficult if not impossible, and I ask the reader's indulgence in adapting his own distinctions, if any, to my 'inconsistency'.

[2] The problem of causality has been referred to a the "black hole at the center of our universe" (Schaffer 2006).

and (2) the relation between them and an interpretation of where they should properly be applied can be established.

Without contradiction, if either affirmation and negation, or identity and non-identity were the absolute, non-developing bases for existence, one or the other always true and self-sufficient, there would be no place for change or cause. Self-causation would also be excluded, since this would also imply a change from an initial definitive state. A reality that is rigorously non-contradictory or rigorously contradictory in the physical/metaphysical sense I have proposed excludes both cause and effect, because it can only be a reality that is rigorously static. The same situation obtains as in the discussion of being in Chapter 3: being cannot be logically conceptualized without non-being.

The antagonistic structure of LIR not only implies cause, but that causality and finality themselves are logical processes. The results in the complexification of the notion of cause, as different species of causation correspond to the different entities in the category of process. The relativity of contradiction, the movement toward *both* limits of contradiction and non-contradiction, means that at the heart of logic in the expanded sense I have given to it, there are two inverse and antagonistic causalities: any identity, for example, that is more or less an identity, is the *effect* of all the series of identities which ‘went’ from potentiality to actuality, by the process of ortho-dialectics, and are, consequently, both effects and causes (Lupasco 1987b). The same scheme applies to a given non-identity (diversity), determined by the series of more or less actual diversities. This negative (diversifying, not negating) causality, like all negative logical functions, has been ignored for the usual reason of the general tendency to focus on positive identities as the only carriers of reality.

In addition to these two causalities, however, there exists an additional causality of antagonism that determines them, in which a given actualization is the cause of the contradictory potentialization. Thus, to the series of causes and effects, or cause-effects of the same order, of identity or non-identity, is added a series of contradictory cause-effects. A given identity or diversity causes, by its actualization, the potentialization of the given diversity or identity respectively, which becomes its contradictory effect. From this, it can be shown that each cause C is (1) the effect of (relatively) non-contradictory causes; and (2) causes non-contradictory effects of the same order, at the same time as it, C, is the cause of the contradictory effect and the effect of the contradictory cause.

No understanding of a dynamic view of phenomena can be had without following the implications of this form of argument, as can be seen in its application to necessity and universality, on the one hand, and contingency and particularity on the other. Both sets of terms are caused by themselves and, at the same time, each set is caused by the other. The series of relative necessities and contingencies are caused by the series itself, from the point of view of its being a dynamics going from actual to potential; at the same time, necessity is the cause of contingency and *vice versa*.

The same reasoning applies to the epistemological subject: as actualization, it is the cause and effect of itself and, at the same time, cause of the object that is the consequent effect, as a contradictory potentialization, of this actualization. The category of Subject-Object characterizes the process of cause-effect. Causality is thus, as actualization, always primarily subjective in the standard sense, the source of subjective idealism. Similarly, what is potentialized is also the cause-effect of itself, as object, and also the cause of the subject. The object is the knowable or known, the intelligible, the real, what has the function of reality and the 'truth' of reality, the source of realism, which is then just a logical function like idealism, both functions of the causality of antagonism. In order to visualize this, one has to imagine any movement from cause to effect as a highly non-linear, multi-dimensional process. Feedback occurs not only in the general systems sense, between, say a conscious objective of executing a plan of action (non-contradiction) and the unconscious elements that went into its creation (contradictions), but with the potentialized aspects of non-execution of the plan.

The contradictory interaction of the two main causalities of non-contradiction generate by mutual inhibition (semi-actualization and semi-potentialization of both), a causality of contradiction, a series of logical values in the category of T-states. The causalities of non-contradiction are the cause of the causality of contradiction, and the latter is the cause of the former. One can then make a key link with the concepts of immanence and transcendence, since (1) the causalities of non-contradiction, of rationality and irrationality respectively can be called transcendent to the extent they transcend contradiction; but (2) these causalities are the cause of the causality of contradiction, that can be called the causality of immanence or immanent causality. Logical values that imply immanence and transcendence 'cause' themselves reciprocally. An essential corollary of this point is that there are no 'pure' immanent and transcendent phenomena. One cannot, therefore, separate completely immanent 'real' events and transcendent 'abstract' facts (statements, propositions, categories, etc.) *qua* their existence but only *qua* their meaning by abstraction and elimination of any dynamics, that is, as non-spatio-temporal entities.

Since all energetic phenomena imply antagonism or dynamic opposition, this in turn implies, at some point, a potentialization becoming actual and an actualization becoming potential. The latter, as an efficient cause, generates a final cause, the locus of which is in the antagonistic dynamism that it potentializes. An antagonistic efficient cause is thus the source of every final cause and thus of every consequent process of actualization that results from it, and a final cause is the source of every efficient cause, by the corresponding process.

The LIR approach, that redefines causes and effects in dynamic terms, means that they are not to be separated from phenomena as such, provided the phenomena are sufficiently complex, that is, are in the sub-category of Non-Separability. LIR supports the view of some philosophers that properties just *are* dispositions, but with the dynamic logical structure suggested. The use of the copula 'is' and 'are' refers primarily to the exemplification of properties. It is in this predicational sense that I have postulated above that the properties of intensity and extensity 'are' energy, and *vice versa*.[3]

This fundamental concept, that phenomena *are* their own causes and effects, or better cause-effects, can be illustrated by the following perhaps brutal example, which is nevertheless more pertinent that billiard balls or iron balls on cushions. It requires, but this should be a matter of course, that one distinguishes between proximate and distal causes: they may have different mechanisms. Pro-gun lobbyists clamor that "Guns don't kill people; people kill people". They are right here (although wrong on everything else). My point is that the psychological intentional structure that is the actualized cause of the event is also the potentialized effect, to be actualized eventually in terms of recognition of guilt, acceptance of exposure to punishment by oneself or others, or total repression of the event into the unconscious. I believe most psychologists would accept the statement that such repression is a real process entity that has the 'potential' of being a cause of further behavior of some sort.

The concept of some kind of reciprocal relation between cause and effect is not novel. It is a commonplace that it may be difficult to decide whether A causes B, B causes A or both. Is a bad leader, for example, the result or cause of a bad social and political climate? What LIR does is place this concept in a *logical* context, in which it can be related to the functioning of other phenomena, as well as receive an explanation as another instance of a process of Conditional Contradiction.

6.2.1 The Metaphysics of Causation

In this section, I will make the discussion of LIR view more concrete by discussing it with reference to the questions generally posed about the metaphysics of causation, following the outline of an article by Schaffer (2003).

1. Relata

The entities in the cause–effect relationship are called *relata*; they are considered to be in the categories of events (coarse-grained) or else facts,

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3 Cao (1997) mentions an early (1894) attempt by Hertz to describe the coupling between two particles: "The motion of the first body determines a force, and this force then determines the motion of a second body. In this way force can be with equal justice be regarded as being always a cause of motion, and at the same time a consequence of motion. Strictly speaking, it (force) is a middle term conceived only between two motions". Einstein replaced the mysterious "middle term" by the electromagnetic field, which can exist independently of the particles, but, given the LIR view of causality, Hertz' intuition of an included third term and cause-effect may be relevant at levels *above* those of fundamental physics.

situations, tropes, states of affairs, etc. (fine-grained), and their number varies from two to four, when it is considered to include causal alternatives (counter-factual events, ones that could have happened but didn't).
LIR: there are two relata that are processes, including events and some facts, in the category of non-separable entities. Other events and facts, also with two relata, including propositions *qua* their meaning, are in the sub-category of Separability. The former, which also may include the latter at the same time, instantiates the two chains of causality; the latter only the standard chain of simple proximate causes.

2. Immanence and Transcendence

Events, etc. are considered real and immanent, while facts, as true propositions, are considered abstract and non-spatio-temporal.
LIR: immanence and transcendence are related contradictorially, and are not absolute, but refer to the relative degree of contradiction and non-contradiction respectively. Both facts and events can be immanent or transcendent. If there is no antagonism, contradictorial interaction, there are only simple causes and effects in the everyday sense.

3. Absence

Since absences can be involved in causal relations, they are considered transcendent in one standard view as being non-occurrences, negative existential statements, involving negative properties, whereas another standard view denies that absences can be causal.
LIR: *It is practically a paradigm statement of the LIR view that absence can be causal – immanent or transcendent in the sense of 2.* This is what I meant earlier by the giving adequate ontological status to the negative aspects of phenomena.

4. Individuation

Individuation (see 1.) is supposed to lie on a continuum from extreme coarseness (simple events) to propositions, the most finely individuated.
LIR: I see the continuum in a different manner, in terms of antagonism, in the sense that there can be coarse events with little antagonism, and fine events involving substantial antagonism, and *vice versa*.

5. Relation, Determinacy and Connection

The nature of the causal link has been the source of the greatest controversy. One finds two sharply opposing views: the causal connection is indeterministic, defined in terms of probability; a cause raises the probability of an effect (see below, probabilistic causation). The other view that is an account that talks as in LIR about change, energy and process considers that cause is physical producing. The way it is formulated, the standard process view leads to problems, and attempts have been made to combine the two to insure causal connectedness as well as explain the disjunction or disconnecttion between distal and proximate causes. The causal connection is understood in terms of the probabilities of processes.

The difficulties have led to further concepts such as *primitivism*, which says that causation is irreducible and in fact the notions of probability and process cannot be understood without reference to causation, and analysis is impossible because there *are no more basic concepts*. Similarly, *eliminativism* says that science has no need of causation: it is a "retrograde relic of Stone Age metaphysics" in the absence of some other scientific scheme.

LIR: The LIR argument from the dynamic opposition in physics is a more basic, scientific concept that allows one to retain the advantages of cause-effect against the arguments for primitivism and eliminativism.

Lowe's definition of the metaphysical concept of agent causation (Lowe 2002) requires, for agent A to cause event e, another event x that 'involves' A and it is x that causes A. Involvement might consist is something like x causing a change in the intrinsic or relational properties of A, but this is hardly satisfactory. The problem of involvement is resolved in the LIR picture: it is the dialectical connection between A actualized and e potentialized.

6. Direction: The Temporal Order of Cause-Effect

The standard view (which I share, to be perfectly clear) is that the causal order is the temporal order, but there are arguments for the alleged possibility of 'backward causation' in reality.

LIR: Most of the arguments, some of them from physics, depend on a form of counterfactuality which is contrary to experience. Gödel's proof of the possibility of time travel seems to be either an artifact of his mathematics, require an unlikely classically conceived topological structure of an independent space-time or some form of spontaneity. The fact that some equations of physics do not define a direction of time is true, but I am talking about the real, globally entropic world.

A corollary of this aspect is that the temporal order should be analyzed in terms of the causal order, rather than *vice versa*. This entails that the causal order cannot be based on the temporal order (circular argument). The temporal direction can be understood in terms of intrinsic physical asymmetries; an independent 'time' is not a primitive.

Another argument against a temporal causal order is that simultaneous causation is possible. This has already been undercut classically since any real event 'takes time'. The contradictorial view of simultaneity I will present also disposes of this argument.

6.2.2 Non-contradictory Causalities in Science and Philosophy

The complexity of this approach to causality notwithstanding, it can be used to show a certain order in varied aspects of thought, including developments in science and philosophy.

Classical science took into account, in my view, only the objective causality of identity, universality and necessity, because induction was its basic method. Deduction, defined in classic logic as a conceptual tautology, could not involve causality. An objective causality concentrates on the potential, that is, the object, losing its 'efficiency' of moving from potential to actual and looks more and more like a network of static relations, e.g., of condition to conditioned, of intelligible laws. The notion of cause disappears into the active subjective causality of diversity, of the particular and contingent, to which ignorance (not-knowing) and appearance are attributed. It is thus not surprising that the notion of cause disappeared from science.

The subjective causality of diversity is, however, that which is dynamic and operational, creating the configurations in which physical, biological and mental 'matter' are instantiated. The subjective causality of identity (the causality of deduction), in potentializing diversity, objectifies and makes cognizable the causality of diversification. There is no 'science' of this causality, but it can be considered as the source of intuitive, pre-scientific philosophies and metaphysics of negation, chaos, irrational change, of a fundamental anarchy. Here can be found the basis for the ideas of Schopenhauer, Bergson, Hume and some Eastern religious traditions, which, rather than a causality, tries to represent what *is*, an ultimate reality behind appearances.

In fact, the objective inductive causality of negation or heterogeneity, the contradictory cognitive effect of subjective deductive causality of identity, is the basis of the potential causality that actualizes itself as the apparent exclusively efficient cause of living matter or biological phenomena, that is, the operative causality of induction. These phenomena accordingly are characterized by the absence of an objective causality of identity and seem to behave according to some law or principle of intrinsic variability, of irrationality and contingency. This apparent principle is itself the result of a process of potentialization and hence of objectification of the negative causality of non-identity or diversity.

One can therefore speak of a negative causality and negative deduction, whose actualization potentializes positive causality and deduction and allows the existence of diversities and irrationalities and not nothing. The 'drive' of positive causality, toward homogeneity and identity, is that of macrophysical phenomena, and the inverse negative causality toward heterogeneity is that of living systems. As we will see in Chapter 8, while the former is accepted 'naturally' as a consequence of the application of the 2nd Law of Thermodynamics, there is little serious discussion of what might be any fundamental principles governing the latter.

6.2.3 Finality

Further to the above, I propose that final causes also instantiate the categorial features of potentiality and actuality. Every potentiality is a final cause for the dynamics of the process in which it is involved. Thus, if a process of identification or diversification is an efficient causality as it actualizes itself, this is, at the same time, a teleological operation. It becomes an effective cause, but it is caused, moved, as such, by the final cause that is its potentiality. A logical dynamism, as an actualization, negates its teleology, developing its causality and ‘then’, in potentializing itself, inhibits its causality and develops its finality. This is the origin of the reciprocity between causality and teleology as finality or final cause. One of the first consequences of this is that processes themselves will develop systems that are both efficient causes and final causes at the same time or neither. This well describes the complex causal behavior of quantum phenomena to which neither a rigorous causality nor teleology can be ascribed.

Lupasco put it as follows:

> Every logical value, vector or operation, precisely because it exists only because of the existence of a dynamics, that is, of a contradictory vector, comprises, in its nature and existential structure, a causality which is only possible because of a finality, and *vice versa*.

The *effective* cause of every event is the *passage* of its state or amount of potentiality to a state or amount of actuality, by overcoming the opposed, previously actualized amount of energy. What is in a state of potentialization, on the other hand, constitutes the *final* cause of what will occur.

Lupasco combined these notions in the following key passage:

> Thus every dynamism, every system, includes energetic events which can be, in turn, due to the intrinsic properties of energy, first effective cause by actualization, then final cause by potentialization.

This implies, further, two types of teleology, one of identity, universal and necessary, synthetic and spatial and one of heterogeneity, particular and contingent, analytic and temporal, as final causes, as potentialities, that is, as potential non-contradictions. Any entity, to the extent that it is partly potentialized, is also a finality, a final cause relative to its actualization, that is, to its subjectivity, to its own state as subject or agent. By looking at entities as effects of contradictory processes, *known* as effects of prior non-contradictory causes, one can show that they will eventually *look* less and less like final or efficient causes but rather a progressive stabilization, which nevertheless retains some causal or final aspects. One can see this by using the category of Dynamic Opposition applied to knowledge. By looking at causality in relation to the processes of knowledge of knowledge and knowledge of ignorance, one arrives at a basis for logical thought, the thinking processes that humans actually carry out of being able to even *conceive* of notions of cause and effect, because thought itself embodies processes of efficient causality and finality. One can see this relation in the mental operations of a child or an animal: their intelligence includes relations of cause and effect, without knowledge of those relations as relations of cause to effect.

A tendency to ascribe the functioning of the universe as involving solely equilibrium and non-equilibrium thermodynamics as the *only* operative causal principle remains strong. The key conceptions are those of Prigogine of dissipative systems far from equilibrium, continued by Salthe among many others. "The thermodynamic view focuses upon a final causality that operates universally.[4]" I will give a LIR interpretation of the thermodynamic view in Chapter 8.

Although the development given here includes an explanation of how commonsense, everyday notions of cause and effect arise, it will not (and probably did not) satisfy people who look only at bare (simple) events (I hit the key and a letter appears on the screen, etc.). In *L'énergie et la matière psychique* (1987a) Lupasco wrote:

> This causality of antagonism adds, to the classic unilateral causality, linear, on the surface, mono-dimensional, gliding, so to speak, from one fact to another, a second causality, in depth, of facts which are perturbed and potentialized by the antagonism of the classical causality and which are ignored by current science. To every causal sequence corresponds an antagonistic causal sequence, inherent in the nature of the energy that constitutes them both.

It should thus be clear that the causality of antagonism and its resulting contradictorial determinism do not replace the chain of causes and effects of commonsense causality and determinism; they add another parallel chain with the indicated dual antagonistic and contradictorial structure. One or the other system of causality is the dominant one, depending on the complexity of the entity or process.

However, that there is by no means a consensus even on what constitutes 'commonsense' or 'classical unilateral causality' will be seen in the following sections. Do these remarks weaken the contradictorial approach? I do not think so; the domain of operation of classical causality, could be considered, in my view, a domain of processes and events that, if not abstract and transcendent, are primarily at the macrophysical level of reality to which a binary logic applies. As suggested, it would be in a dialectic relation with the mental and quantum domains, in which the primarily applicable causality would be one of antagonism or contradiction and the applicable logic LIR.

When he writes on causality, Peirce shows his essential, but in my view partial grasp of the problem (Peirce 1955): "Final causality cannot be imagined without efficient causality; but no whit the less on that account are their modes of action polar contraries." Thus, he can envisage that an efficient cause could in some way be detached from a final cause, and then would "not even possess efficiency." *Post hoc* and *propter hoc* remained disconnected for Peirce. It is very interesting to read how he pursued this thought in relation to his concept of class:

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[4] Salthe (2004). I note again here the recourse to spontaneity and putative external higher scale structures as final causes in preference to any inherent, internal constitutive dualism or antagonism.

"Every class has its definition, which is an idea (?); but it is not every class where the *existence*, that is, the occurrence in the universe of its members is due to the active causality of the defining idea of the class." This seems to be a clear, negative consequence of maintaining, in the absence of contradiction, a functional separation of class and member of class, as well as of efficient and final causality.[5]

6.2.4 Dispositions and Powers

Potentialization and actualization thus have a central role in the LIR theory of cause, but I would be remiss not to refer in a little more detail here to philosophical attempts to account for the operation of cause by appeal to the notions of dispositions or powers, properties of an entity that are alleged to confer causal powers on their instances, enabling them to effect change.

It is far from clear what these powers, dispositions or capacities mean, that is, are these in some sense additional properties over and above the initial property (see discussion of properties in Chapter 3)?

The following initial distinctions can be made between categorial and dispositional properties:

Categorial Properties	***Dispositional Properties***
Contingent	Metaphysically necessary
Inward-directed (Intrinsic); Actual	Outward-directed; Modal (possible)
Non-causal	Causal

The debate involves, among many other things, whether all of these distinctions are real. For example, even though the manifestations of dispositions may be non-actual, this does not mean that dispositions themselves are non-actual. Thus, everything would be categorial. From another point of view, properties are all dispositional, both or neither. One can retain some of the intuitive difference between the two by assuming, first that categorial means non-dispositional, and that it suffices for a property to be dispositional that it play some causal role essentially, where that causal role is described purely in terms of the relations between categorial properties, and it is a necessary condition of a property's being categorial that it play no such role.

The LIR approach cuts through the analytical debate about the relation between categorical and dispositional properties and their role in cause. The NEO category of Dynamic Opposition supports the view that properties may be both

[5] The application of LIR to a theory of classes and sets must be postponed to Appendix 1.

categorial and dispositional in the sense that properties instantiate, contradictorially, all of the elements of the two descriptions, as actualities and potentialities, elimination of the inward-outward 'cut', and so on. Throughout this book, elimination of a cut or separation is to be understood as a reference to the existence in reality of a contradictorial interaction. In NEO, only properties in the subcategory of Separability (SC) combine 'freely' without necessitating anything real, but in NSC, dispositional properties, which are equivalent to real potentialities, cannot combine or operate without something changing or being changed. These dispositional properties are in this sense more fundamental aspects of nature, but my theory retains the advantages of the categorial perspective in the sense of its capacity for implications 'upstream', that is, the area of *categorial* inference.

As far as the conception of properties as dispositions or powers is concerned, powers to act and be acted upon, there seems to me to be no need for a separate category. In the LIR conception, properties are active and passive, or better active/passive processes. Dispositions, powers and propensities (Popper's term) are equivalent. Properties may be categorial and/or dispositional, as indicated above, but in neither case do they 'bestow' powers on particulars: they *are* powers. Another statement of this, again in the perspective that properties are causal powers, is that of Shoemaker (1982): "What makes a property the property it is, what determines its identity, is its potential for contributing to the causal powers of the things that have it." I only would add to this that a property is characterized by its diversity, and by the interaction between identity and diversity as well.

The contradictorial relation between actuality and potentiality in LIR thus provides additional arguments against attacks on the reality of 'potencies', defined as dispositional properties that include potential manifestations (Bird 2006). My demonstration that what is potential as well as what is actual is real answers the critique that only the actual is real. The modal argument (*possibilia* are not things that exist in other worlds but not in this one) against the objection that potencies involve unrealized manifestations of possibilities that, accordingly, violate naturalism is supported by a view of unrealized possibilities as real potentialities, whose reality does not depend on their manifestation if this is prevented by an actuality.

My picture is supported by the position of Heil (2005), that manifestation of a disposition is the manifestation of reciprocal dispositional partners, and that in such a manifestation it is often – perhaps always – impossible to characterize one object (sic) as cause and another as effect. Heil argues that properties have both dispositional and qualitative intrinsic aspects, but he does not say why or how they have them. I of course agree with these concepts of 'co-dependence' and dual-aspect and only point out that it they make even more sense in the context of the LIR process metaphysics.

This is 'in essence' an argument *against* kind essentialism and *for* the existence of some metaphysically necessary laws of nature. If electrons, for example, are defined with respect to their ungrounded dispositional properties, including charge and spin, essentialists would claim that there is no deeper structural explanation than the behavioral dispositions of the electrons and their essence: to be an electron is just to have those behavioral dispositions. I am thus in agreement with Drewery (2005) when she states that for this conclusion to be valid, the nature of the properties must include their possible causal powers as well as their actual ones; one needs only to replace possible by potential and add their alternation to recover LIR. This conclusion fits the category of Energy in NEO: the existence of energy (as we know it) and its underlying field (as we postulate it) are the only contingent things in the universe; they are the universe.

6.2.5 Probabilistic Causation

Probabilistic Causation designates a group of philosophical theories whose objective is the characterization of the relationship between cause and effect using the tools of probability theory (Hitchcock 2002). These are of direct interest for the understanding of the LIR view of cause and effect, or better cause-effect. My approach is also probabilistic, in the sense that the logical values of LIR were axiomatized as something like probabilities, but one may legitimately ask the question as to whether and how LIR is similar to or different from current theories of probabilistic causation.[6] The following discussion amplifies the argument in Section 6.2.1 above.

The motivation of probabilistic approaches to causation has been the difficulties with the current regularity theories of causation, derived from the simplistic Humean concept that effects simply invariably follow causes.

Probabilistic theories of causation handle a number of correlations between events that are causal in nature, and describe spurious correlations where events follow in time but the prior is not the cause of the latter. The problem, similar to that in causation itself, are the connection between causation and probability is the requirement that causal relata be propositional in character in the sense in which propositions are conjoined, extended or negated.

The principle of antagonism provides a structure of reality that embodies causes and effects as operators with the same logical structure as the rest of reality I claim, therefore, that LIR can also provide the causal 'structure' needed for a theory of probabilistic reduction of causation. In LIR, It is not a significant issue that effects do not invariably follow potential causes. The example of the smoker who does not contract lung cancer is only a specific case of potentiality not automatically leading to actuality. This implied partial indeterminism is of course acceptable to me, although apparently it is not to regularity theorists. Since probabilistic theories of causation require only that a cause raise the probability of its effect, these are also compatible with indeterminism.

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[6] Some current theories of causation result in the failure of reduction of causation to probability, but in those that do not, a theory of the systematic connections between causation and probability is of philosophical interest.

I defined the logic of/in reality as, among other things, a theory of change. In it, change follows some fundamental dynamic pattern of alternating movement from a state of actualization to one of potentialization. The change from predominately one to predominately the other of two opposing elements depends on statistical and probabilistic parameters at some stage of the process at all levels of reality. However, I have not discussed whether or not the statistical generalizations of standard statistical mechanics are appropriate here. As pointed out by Sklar (1992), it is not clear what could ground the introduction of probabilistic and statistical notions even in simple macrophysical systems. Non-equilibrium systems in LIR follow the rules of entropic asymmetry insofar as they are physical, following the 'arrow of time'. However, at, for example, the biological level of reality, anti-thermodynamic processes (of heterogenization or diversification) take place, only part of which is subject to statistical factors. The PDO applies most clearly, outside the quantum world, at the level of mental and social phenomena, when the opposing elements are often close to equal in energy, leading to an emergent included middle (T-state). To the extent that statistical probability issues remain open in all physics, it is clearly beyond the scope of this study to decide *how* the energy necessary to effect a change at these higher levels 'gets where it should go'. The massing of people outside the Ukrainian Parliament building in the winter of 2004 was followed by a change of government, although identifying the point at which change became inevitable is not obvious.

Perhaps the simplest statement that can be made at this stage of development of LIR is that statistical and probabilistic effects, as implied by the axiomatization of the logical values of actuality, potentiality and T-state as probability-like are not incompatible with the overall determinacy and indeterminacy of the universe discussed in Section 6.5. Also, the deterministic but highly irregular behavior of chaotic systems, although they tend to be relatively simple ones, can be discussed in LIR provided scope is retained for some degree of return from chaos toward order. I can agree that the property of chaotic systems to magnify or amplify non-deterministic quantum events could mean that chaotic unpredictability is physical/metaphysical rather than epistemological.

LIR can shed light on the debate about common cause principles, the idea that simultaneous correlated events must have prior common causes (Arntzenius 1999). I will not go into the details of the various principles, especially as most of them seem to fail at least part of the time. One is left with simple local situations, in which one has a correlation among fairly natural localized quantities that are not related as cause and effect, and one can find a fairly natural localized prior common cause that confirms the absence of such relation (screens off the correlation). In complex systems, such as the coordinated flights of certain flocks of birds, there are so many scattered microscopic causes that specifying them as common is a practical impossibility and would trivialize the notion of common cause principles. I regard such systems as single unified systems, and do not demand a common cause explanation for the correlated motions or properties of their parts. In the case of the flock of birds, at 'equilibrium', it acts more or less as a unit, and reacts as a unit, possibly in a very complicated way, in response to its environment, due to the myriad connections between its parts that 'make' it act as a unit. I rather focus on the very complicated way the shared contradictory dynamic aspects of the bird–flock relation (the same as those of a set and its elements), as well as external environmental constraints, as the source of the correlated behavior. There is no need for a 'leader bird'.

Summarizing, the fundamental PDO is a principle of physical causal order at whatever the level of system happens to be, from microscopic to macroscopic. LIR is in this sense a hybrid theory, but rather than combining a spatio-temporal connection between cause and effect with a problematic probabilistic theory of causation, it states that the elements of the spatio-temporal connection, the cause-effect processes themselves, have the characteristics of probabilities.

Hitchcock (2002) sees a causal principle in operation in the microphysical world, but wonders to what extent, as I claim, it 'percolates up' to the macrophysical world. He devises test situations that bring out a distinction between *A* being 'causally relevant' to *B* when it makes some difference, positive or negative, to the probability of *B* in some test situations, a promoting, inhibiting or interacting cause. *A* is a positive or promoting cause of *B* if it raises the probability of *B* in all test situations. One can test this by substituting non-*A* for *B*. The relation of dynamic opposition is then one first of causal relevance, since *A* inhibits or potentializes non-*A*, which then becomes the promoting cause of *B*. My postulate, again, is that one can combine the probabilistic aspects of cause and effect with a requirement of spatio-temporal connection between cause and effect (contiguous process). This can be considered a relation of causal dependence that reflects the transitivity of causation, and perhaps also provides an explanation of the asymmetry of causation, in that the asymmetry between cause and effect is that of the actualized or potentialized probabilities themselves.

Hitchcock discusses the work of Spirtes, Glymour and Scheines and proposes the following scheme: (1) given a set of factors and a system of causal relations among those factors, call this the *causal structure* (*CS*). In LIR, this would be a series of causes and effects of alternating antagonistic terms (factors). (2) Let *T* be a theory connecting causal relations among factors with probabilistic relations among factors. This is what I have proposed as the relation between the degrees of actualization and potentialization and probability (see below). (3) Then the causal structure *CS* will be *probabilistically distinguishable* relative to *T*, if for every assignment of the probabilities to the factors in *CS* that is compatible with *CS* and *T*, *CS* is the unique causal structure compatible with *T* and those probabilities. Hitchcock says that this probabilistic theory of causation can have many "properties of distinguishability", but the one of most interest that he mentions is that the "actual causal structure of the world (assuming there is such a thing) is probabilistically distinguishable relative to *T*". It seems rather as if the property of *T* was the content of *T*, but this confusion disappears when the relation between them is seen as contradictorial in the two-level sense of Chapter 5.

It is not obvious what type of distinguishability properties a theory must have in order to constitute a reduction of causation to probabilities. This is a somewhat tautological way of saying that there is a certain unicity to structural cause and effect relations, something that emerges naturally from LIR. The problem is to insure that the reality values of LIR, which I have proposed as having probability-like properties, can be modeled by the notion of probability in the more standard sense, as here. However, there is no reason to assume that values of probability and values of reality are unrelated. In fact, the latter reduce to the former, in the physicists' sense of reduction to something simpler, for simple phenomena, mirrored by the reduction of thermodynamics to statistics. Probabilities in dice-throwing are not different from the probability of changing one's mind: they lack the latter's dynamic elements.

6.2.6 Possibility, Potentiality and Probability

The difference between the terms of possibility and potentiality follow the general LIR scheme of domains to which binary and ternary logics apply respectively, that is, the former does not involve dynamic interactions, and the latter does (Lupasco 1967). That something *s* is possible implies only its own negation, that of the impossibility of it happening (not the negation of possibility "it is not possible that *s*"). An element being potential does not *imply* its non-actualization. The actualization may not occur, but it would require an input of energy, via an accident or event, that is extrinsic and unpredictable, even if deterministic.

The possible involves a random choice without any determinism or energetic capacity, a disjunction between a yes and a no, without an antagonistic 'partner'.[7] This contradiction is suspended and disappears in the yes or no as isolated states, that is, in pure non-contradiction. The potential, on the other hand, contains or is always accompanied by the actual – that which opposes it and prevents the potential from becoming actual or actualizing itself. Potentiality thus not only implies a rigorous form of determinism, which is not found in the possible, namely the energetic capacity, or oriented dynamisms, but also what maintains the phenomena in their potential state, that is, the actualization, more or less strong, of the inverse and antagonistic dynamisms. One can still use the term possible in the sense that the potential is the 'possible' consequence of some input and then effect an abduction from the observation of an energy state to its causes. The possible can give the impression of a finality, a final cause, as if it were energy in potentialized form. Once actualized, acting, this energy appears as an efficient cause. As discussed above, however, every phenomenon must be considered as combining both efficient and final causes, which is not possible for the merely 'possible'.

At any point in time, every dynamic phenomenon will be actualized and potentialized to a certain, probabilistically determined degree. The key point is

[7] On one recent view, epistemic possibility, what one knows about a possibility, is context-dependent and shades over into probability. This concept does not affect the distinction made here, since the set of binary choices still applies as the only one available.

that the sum of the probabilities of the event must be greater than zero but less than 1, since complete final states cannot be achieved by complex process entities. As with all potential entities or processes, potential probabilities, the non-observed values of a system, are also realities. They consist of different degrees of actualization and potentialization and intensity gradients and orientations as well as levels of antagonism and the aspects and characteristics of the categorial properties of their energetic make-up. A potential structure is thus not a structure that is simply possible. The former is either realizable or already realized, which is not true for the latter, which is simply imagined.

6.2.7 Actualism and Possibilism

The reason for making clear the difference between possible and potential refers to the philosophical discussions surrounding the truth of claims about what might have been possible in the past. Actualism is the philosophical position that everything there is, everything that can be said to exist in any sense, is actual (Thesis A) (Menzel 2003). To be is to be actual; being is actual. Possibilism is the denial of this thesis, that is, it states there are things which are not actual, but could have been, and the things that *are* include possible but non-actual objects. Actualists agree that certain things could have been, but wish to account for the truth of this statement without assuming the existence of any non-actual objects (*possibilia*).

The system outlined in this book rejects the basic thesis of actualism, which is again classical logic in yet another form: what exists is not only actual, but also *potential*. Something is both actual and potential, however, if and only if a relation of dynamic opposition exists between the phenomenon and its energetic contradictory complement. Possible but non-actual objects, in the possibilist account, abstract entities, are acceptable as imaginary objects, ideas or concepts with only a 'mathematical', non-spatio-temporal existence, but it is classical logic that applies to these.

As indicated in Chapter 1, philosophers interested in this field use the tools of modal logic, in particular the concept of *possible worlds* to investigate the truth of modal statements like "it is possible that" or "it is necessary that". Even these abstractly conceived worlds have given rise to extensive discussion as to whether they consist of sets, states of affairs, or properties or propositions. Irrespective of their exact nature, possible worlds have certain theoretical tasks based on a notion of classical truth, and the concept cannot be used for the logic of reality without modification, if at all.

The arguments of the two sides are extremely complex, and will not be reproduced here. One line leads to the introduction of a distinction between concrete and non-concrete objects and a consequence that objects that are concrete on our world are non-concrete in another world, i.e., contingent. The 'new actualism' that results is virtually the same as possibilism, as contingent non-concreteness is nothing but the possibilists' mere possibility. Both new actualists and possibilists define two modes of being: actuality and contingent non-actuality, using different terms. Nothing in this philosophical discussion seems to me to describe the interactions obtaining in the real world and in being in the sense of Chapter 3, to which the logic of/in reality applies.

6.2.8 Potentiality and Micro-causation: Manipulability and Intervention

The LIR theory of causation dynamically links cause and effect explains them in terms of the potentialities of the entities present at the microphysical, biological and mental levels of reality. This approach provides a natural explanation for Sober's picture of causation (Sober and Shapiro, 2007) *vs*. epiphenomenalism in terms of the relation between macro-causation and micro-causation.

Sober's theory is one of a group of formal philosophical approaches to causation that depend on the relatively new notion of manipulability. According to these theories (Woodward 2001), causes are regarded as handles or devices for manipulating effects. In the versions of interest here, the anthropomorphic aspects of manipulability are avoided by a concept of an 'intervention' I, which does not have to involve a human being, effecting a specific change on a variable X with respect to another variable Y that characterizes what it is for X to cause Y.

Sober's major objective was to prove that such a macroscopic property X, in particular a mental one, with a physical (neurobiological) micro-supervenience base, MSB(X) need not be causally inert, that is, it can have causal powers that are those possessed by the MSB(X).

The apparent absence of these additional causal powers provides the master argument for epiphenomenalism, taken to show that the mental property X is causally inert. The crucial mistake in this line of reasoning is that it requires one to consider a counterfactual situation that is in fact impossible: the two elements, X and MSB(X), as in a theorem of LIR, can never be separated in reality, and it is in any case irrelevant to the question of whether the mental property X, or any other supervening property, is epiphenomenal with respect to the candidate effect term Y.

The key points of this picture, without giving the entire argument, are the following:

- Definitions: For two phenomena (macro-variables) X and Y, where X is the putative cause of Y, are associated macro-states of X and micro-states X_{ij} of micro-variables MSB(X), where MSB(X) is the micro-supervenience base of X. Micro-supervenience is defined as
- Claims:

(S1) Macro-causation entails, that is, implies and requires micro-causation. Some properties of the micro-variables of X cause Y, together with X.
(S2) The converse is not inevitable: one can have micro-causation without macro-causation.
(S3) Some macro-variables are causally inert (epiphenomenal) even if their MSB's are causally efficacious with respect to Y.
(S4) The source of an instance of epiphenomenality as a 'pseudo-process' is to be found in a common cause of X and Y, inducing the relation described by the term 'screening-off'. If one does not see the common cause, it looks as if the relation between X and Y is not one of cause and effect but of some non-causal 'correlation'.

The basis for S1 is that if X is to cause Y, then there must exist macro-states of the variable X, X_i and X_j, such that an intervention on X that changes X's state from X_i to X_j will be associated with a change in the state of Y. If true, then there also will be an intervention on the micro-variable B(X), changing it from some state X_{ik} to some state X_{jl} that also must be associated with a change in Y.

My first remark refers back to my definitions of properties and processes, in which I showed that they, also, are related dialectically. 'X' above should be also seen as a process, and this is suggested by the reference to X as a macro-variable.

The core concept I propose is that of the structure of the micro-supervenience base, the micro-variables, in terms of *potentialities*. Specifically, the changes in state from X_i to X_j and from X_{ik} to X_{jl} are changes from potential to actual, following the scheme of LIR. It is the residual potentialities of the molecules of the billiard balls that, actualized, cause them to rebound (quasi-elastically, to all intents and purposes), but it is the absence of such potentialities at the macro-level that makes them causally inert, and requires us to look for the origin of causality in the mind of the player. I accordingly formulate the following theorem:

Theorem 6.1: Phenomena are causally efficacious at their level of reality, as a consequence of their micro-supervenience base, if and only if they are involved in interactive dynamic processes at that level.

I can now give an interpretation of the two critical terms in this combined approach – intervention and association (of X_i to X_j and X_{ik} to X_{jl} with a change in the state of Y). In reality, in any dynamic system, e.g., a mind, there is always some process in progress that has the potential of being a cause and, accordingly, constitutes the intervention that starts the causal process. But its potentialities and actualities are contradictorially linked to those at the lower level of the MSB(X), and their association is the Functional Association of Axiom **LIR5**. As I will suggest in Chapter 8, the causal role of micro-potentialities is the same here as for emergent processes of morphogenesis.

The difference between the billiard balls and mind is that, at the higher mental level, dynamic oppositions of the same form as those at the atomic and molecular level are present. If this is the case, then it becomes straightforward to discuss situations, in particular at more complex cognitive and social levels, where it difficult to decide which variables are macro- and which micro-. The relation becomes that suggested above: X and Y are both cause-effects, and in the Sober formulation, micro-causation *may* entail macro-causation. This aspect of the LIR view is one of causal realism, namely, that a thing or entity at level *n* may have its own causal powers interacting with other entities at the same and/or a higher level (Emmeche 2003).

LIR supports Sober's contention, *contra* Kim, that qualia can be causes. From the empirical standpoint, whether a macro-property is functionalizable, that is, reducible to some physical functional role, makes no difference to whether it may have causal powers. Function and cause are not mutually exclusive. To see whether a quale causally influences a behavioral event, one needs to hold fixed any common causes they have; however, one should not hold fixed the micro-supervenience base of the quale, since it is not licit in either theory to assume that higher level properties operate by some kind of 'magic'.

The LIR picture resolves, I believe, another issue, namely, whether explanations made at and for higher levels of reality are in some way more valid than those at micro-levels, that is, whether macro-explanations might not entail micro-explanations. The two-level system outlined in Chapter 5 also applies to explanations: explanatory, logical and causal 'talk' all follow the same principles, because the micro-explanations refer back to the fundamental physical oppositions involved.

6.2.8.1 Intervention

Intervention is defined so as to include not only counterfactual changes in variables but also *bona fide* experimental changes or manipulations that one can make, in some cases, in order to observe effects. Such moves are, however, considered from an LIR standpoint as dynamic processes. The two views could be considered compatible, were it not for the fact that the variables are generally considered, in the manipulationist theory, to be classical, involving idealized, absolute entities. A functional separation is maintained between cause and effect, reifying them as entities separate from the property-processes they are supposed to operate on. For example, the intervention I must completely change any causal relationships between X and *its* prior causes. Nevertheless, one comment of Woodward suggests some underlying common intuition. He suggests that philosophers do tend to think of causes as properties or events, but that it is possible to move back and forth between such talk and a representation in terms of variables.

When there is no well-defined notion of change or variation in value, a manipulability theory will not see genuine cause, but some form of epiphenomenality.

LIR not only defines values of actualization and potentialization as applying to causes-as-events, but to the 'moving back and forth', the epistemological shift, also considered as a physical, dynamic process. A domain in which there is no well-defined notion of change is likely to be, in my theory, one in which the only connection is absolute disjunction (cf. Appendix 1), and where, to all intents and purposes, a binary logic is adequate.

6.2.8.2 Some Remarks on Self-Organization

If there is one area to which concepts of causality have been applied in a non-rigorous manner, it is that of self-organization. If I assume a standard definition of a system (an LIR discussion is provided in Appendix 2), a self-organizing system is defined as distinguished by the formation of some states or entities arising from the reciprocal or collective interactions (encounters) between its components, *quite independently of outside inputs*. In the light of LIR theory, however, the critical terms of 'self' and 'independent' are seen to involve question-begging assumptions, as discussed earlier in connection with Axiom **LIR5** of Functional Association and the sub-category of Non-Separability.

In a standard discussion of self-organization, such as that of Debrun (2000), the encounters are between elements that are really, as opposed to analytically, distinct. Debrun sees self-organization occurring in two situations, which he calls primary and secondary, referring to simple elements and organisms respectively.

The consequence of any self-organizational process is the constitution of emergence of a new form, or of a restructuring, by complexification, of an existing form. The problem is how this comes about in the absence, by definition, of any organizing identity in the case of primary self-organization. Debrun proposed that although, here, the elements are totally distinct, and no global finality is present in the system, finalities – intentions or projects – do exist at the element level. In LIR, however, all elements instantiate both diversity and identity, that are related dialectically. The finalities or final causes can be seen to be the residual potentialities in and of the elements that are the effects of their constitution by prior processes.

The chemist George Whitesides has designed and fabricated elements of plastic and metal, using nanotechnology, that indeed self-organize into rather complex structures when placed in the appropriate environmental context. But the 'self-organization' of these inert elements exhausts their potentialities. No further change can occur without further input of energy as information. The original input came from Professor Whitesides as an identity and efficient cause, and he then exits and is absent from the system.

In self-organization at the higher level of an organism, one is dealing with a system of processes that already expresses identity, diversity and their conjunction in T-states. For the elements involved in processes and processes of processes, the distinction between them is clearly less absolute (Debrun used the rather Lupascian term “semi-real”). The LIR explanation of the dynamics of what is called self-organization is made in terms of alternating dominance of actualizations and potentializations. The potentialities present, for example, in a mental entity, have the critical role for an actualizable restructuring. In LIR terms, even in the case of primary self-organization, some residual identities are always present to provide ‘direction’ in addition to the obvious diversity of the distinct elements. At their level, to repeat, it is exactly these potential identities that are the finalities in the Debrun description. They are the carriers of the structural information required for any further organization to proceed. In the LIR description, an additional level of physical/metaphysical explanation is provided for the phenomenon of self-organization *via* the PDO.

Under these circumstances, the most reasonable view is that self-organization is not, in and of itself, a ‘self ’-evident mode of system formation and change. All systems involving alleged self-organization also involve some degree of organization-by-external-agent, although the two are, again, dialectically related. Varela refers to something like my view of self-organization (Varela 1999) when he states that coupled non-linear oscillators can give rise to kinds of self-organization that result in the emergence of neural structures from the component level. A local-global interdependence is necessary to understand the emergence. The components “attain relevance” through their relation with their global correlate.

In the further dynamical systems language used by Varela (and also by van Gelder, see Appendix 2), a satisfactory description incorporates a role for both stability and instability, defining both stable and unstable regions in the phase space of the system. However, the system then, allegedly, flops *spontaneously* (emphasis mine) between them even in the absence of external driving forces, and by definition, of any internal physical attractors (identities that would function as organizers). Varela makes the geometry of the phase space and the trajectories of the dynamics, which enfold both the boundary conditions and the “current arising” in one synthetic whole do the organizational work. This is considered quite a general characterization, applicable to complex non-linear and chaotic systems.

This is perhaps all right as far as it goes, but as I discuss in relation to Varela’s view of time, it does not go far enough. One is again left with critical process terms that fail to describe the structure and the dynamics of the relation or correlation. I suggest again that the critical step in the organization process is not spontaneous, in the sense of uncaused by outside agents, which the use of “self-” without qualification implies. New organizational structures are the effective consequences of the potentialities residing in the components and/or introduced during the original constitution of the natural system or artificial experiment.

There exist, in addition, mathematical theories of self-organization. However, that is just *all* they are – ways of showing how ideal objects can organize themselves into more complex states or structures. These will not be discussed further as I consider that they do not apply to my current critique of a principle of self-organization that allegedly applies to physical, spatio-temporal entities.

6.3 CONTINUITY AND DISCONTINUITY

A further major area of metaphysical debate is that of the nature and role in the universe of continuity and discontinuity. It seems to be characterized, among other things, by a substantial amount of apologetics: 'space' and 'time' are alleged to share the property of continuity, which is the basis for space, time and space-time continua, all composed of infinitely many dimensionless points. However, whether there are such continua composed of such points in reality "remains a legitimate question in both physics and philosophy (van Inwagen 2002)". As Penrose has pointed out, and as discussed in detail in Chapter 7, both Einstein's theories and standard quantum mechanics depend on the assumption of real number space-time continuity, but there is serious doubt as to whether its mathematics is appropriate for describing the ultimate constituents of nature (Penrose 2005).

Further, if the concept of continuity is problematic, what about the basis for the appearance of discontinuity? How can one go in biology, as discussed for example in catastrophe theory, from factors involving continuous thermodynamic change to mechanisms of genetic regulation that involve the discontinuous intervention of the biochemical structures needed for hereditary control? How can one conceive a discrete categorization of the continuous substrates of biological or higher-level systems by some immanent operation of discontinuity (Petitot-Cocorda 1992)?

We thus have a series of explanations of continuity, but they seem questionable. We have a concept of discontinuity, but no explanation. Two essential concepts must be introduced here to prepare a description of the situation in LIR terms: the continuum hypothesis and the foundations of differential calculus.

6.3.1 The Continuum Hypothesis

The continuum hypothesis refers to a conception of the universe founded on geometry, the Cantor-Dedekind view, as discussed by Longo (1999), which sees not only in mathematics, but everywhere, continuity as ontologically preceding the discrete: "The latter is merely an accident coming out of the continuum background." Points are derived concepts, even if 'non-dimensional'. In this view, geometry (statism, cf. the next section on statism and dynamism) is in some deep sense more fundamental than dynamics, that is, energy in the standard view. This hypothesis has the advantage of corresponding to our intuition and experience, integrated into and confirmed by mathematics, of continuity in our perception of ‘time’ and linear movement.

Penrose, on the other hand, had the strong intuition that “physics and space-time structure should be based, at root, on *discreteness* (emphasis his), rather than continuity”. This discreteness is evidenced in quantum mechanical spin, combined, however, with a fundamental notion of expressing phenomena in terms of a relation between objects, rather than between an object and some background space (Penrose 2005).[8]

It is clear as discussed in Section 3.7.1 on abstract objects that in the construction of the mathematical continuum, objective realities are not found in the mathematical entities involved, but in the process of constituting these entities as conceptions. There can an interaction, dynamic in LIR terms, between the applicable *mathematical* logic and intuitions about continuity. Stating this somewhat more strongly, since the establishment by Gödel of the reciprocal relation between consistency and completeness in formal mathematical systems, the situation is no longer absolute. One should not be forced to choose between geometry and discontinuous objects and their relations. This opens the door to a different foundational principle, using the principles of LIR, in which both continuity and discontinuity are fundamental and are dialectically related.

A more serious critique of the above conception of the continuum is that it is restatement of a conception of general relativity (GR) as a pure geometrization of the world, from which the subjective aspects of space and time involving observers have been eliminated as inessential ontologically. It is one of the major conclusions of this book that the other readings of the physics and mathematics of GR that are possible, that restore the balance between geometry and energy that exists in reality are supported by LIR.

6.3.2 The Problem of Differential Calculus

In principle, the usual notion of differential calculus captures the apparently simultaneously continuous and discrete nature of changing phenomena. According to LIR, however, this position only displaces the philosophical and metaphysical problem. Change at an instant is what differential calculus presents in formal terms. It is well recognized, however, that this implies an inconsistency – continuity and discontinuity at the same time. It begs the question of whether reality is composed of ‘points’ and ‘instants’ in the sense used in the theory. If it is not, then differential calculus, like classical logic, is *not* capturing the essential

[8] Penrose saw larger cosmological structures as being possible (‘spin networks’ and ‘spin foams’).

property of real processes and systems, since it assumes that such points exist. Only in the most recent work on general relativity is the concept of a 'point-event', first codified in the Buddhist logic of the 6th century AD,[9] receiving an adequate interpretation (see Section 7.6).

One possible mathematical language for formalizing the contradictorial view of continuity and discontinuity is that of Smooth Infinitesimal Analysis (SIA), developed by Bell (1998), and discussed in detail below as an exercise in the application of LIR principles. Bell quotes Weyl to the effect that "we are employing the principle of gaining knowledge of the external world from the behavior of *its* (emphasis mine) infinitesimal parts." However, I feel that Weyl made an error in the 'its'. Nothing has yet been adduced to prove that Bell's infinitesimals (or any others in standard calculus) and those of the external world (if such exist), are the same.

I propose the following physical and metaphysical arguments in favor of an interactive, contradictorial relation between continuity and discontinuity. The physical argument runs something like this: if there is continuity and discontinuity of real entities at the quantum level, that is, both discrete quanta and continuous frequency of wave phenomena, and they are intuitively and mathematically opposite, by the LIR theory, they must also instantiate the key axioms of Conditional Contradiction, Functional Association and Asymptoticity. Accordingly, continuity cannot exist without discontinuity (or discreteness) throughout nature, and continuity actualized implies discontinuity potentialized. Asymptoticity has another consequence: no real element can be an infinitely small point of space or time since in reality, a lower bound is determined by the Planck constant, 6.62×10^{-34} Joule-seconds. The infinitesimal quantities of space and time of differential calculus cannot exist in reality.

I suggested above that continuity and discontinuity is a pair of ontological predicates, where the former is inherent to or related to homogeneous extensity and the latter to changes in levels of energy in phenomena. The differentces in level between which energy as heterogeneous intensity falls are themselves extensities. It is the discontinuous *passage* from one level to another that represents the intensive quantity, the movement of transformation; higher and lower forms (e.g., chemical energy and heat) are actualized extensities, with greater or lesser potential for further transformation.

The LIR metaphysical approach also looks at the implications of the logical reasoning process for continuity and discontinuity: the contradiction between continuity and discontinuity, the impossibility of their simultaneous co-instantiation at the quantum level is mirrored in the processes of logic and thought. From the point of view of logic, the dynamisms, as processes, of affirmation and negation (better, affirming and negating) do not show any obvious or conceivable

[9] The 'point event' language, or jargon, in the authors' own terms, continues to be used in the branching-space-time (BST) explanation of the existence of causal probabilities. By, again, the authors' own admission, their account is "decidedly preliminary" (Weiner and Belnap 2006). Cf. the discussion and reference in Section 5.5.1.1.

discontinuity. In other words when we affirm or negate something, we do not do so in steps. But logical thought itself, insofar as it is the potentiality of these two contradictory, antagonistic actions and both coexist, as inverse possibilities, demonstrates the existence of an immanent, constitutive discontinuity in reality at this level as well as at the quantum level.

In the LIR approach, the heterogeneity of intensity is not a series of independent elements or extensive stages, it is an attempt to differentiate (movement of differentiation of) something that wants to stay the same, the extensity of which resists and opposes this change. In this movement, there is a continuity that is not measurable by extensive values. As these values are potentialized, it looks as if extensity contains discontinuity and intensity is a continuous dynamics. Lupasco saw the continuity in extensity, despite its divisibility and capacity for adding new entities, as for example, new premises are added in defeasible deductive logic, in its aspect of identity extending from one thing to another. Thus, intensity is a continuous non-identity with respect to itself; extensity is a continuous identity with respect to the other. Intensity and extensity are continuous as dynamisms, considered as independent of one another, and from this point of view accessible to the techniques of differential calculus. But, discontinuity is inherent in their existentiality, since neither can exist without the other, without operating on the other: intensity and extensity reciprocally 'discontinuate' each other. The differences of energy level that result in 'something happening' are not due to intensity or extensity alone but to their intersection. Analysis and synthesis are continuous dynamisms, homogenizing and heterogenizing respectively, but their necessary discontinuity is what constitutes their existentiality.

6.3.3 Paracontinuity and Paradiscontinuity

The current 'non-constructive' trend in mathematics (Longo 1999) based on the availability of the Gödel theorems and the non-standard mathematical analysis of Robinson (NSA) support alternate intuitions about the continuum that logic can 'offer'.

D'Ottaviano and her students (Carvalho 2006)[10] have studied the foundations of differential and integral calculus using tools available from paraconsistent logic and non-standard mathematical analysis. This is an important current issue, since, for example, dynamic systems theory (DST) claims that the same basic laws that govern simple physical systems also govern the laws of complex systems, e.g. cognitive (or cognizing) systems. Therefore, such systems can be described by the mathematics of physics, especially, of non-linear dynamics rather than by the computational symbolic systems approach (which uses the rules of classical and neo-classical logic and syntax.) Thus proponents of DST believe that standard differential equations are the most appropriate tool for modeling human behavior and human knowledge. My critique is therefore also directed against DST.

[10] The term paracontinuity is sometimes referred to as quasi-continuity.

D'Ottaviano and Carvalho show that the principle of L'Hospital, the 17th century mathematician who codified infinitesimal calculus, can be formulated rigorously. This principle states that it cannot be said of any two quantities separated by an infinitesimal whether they are the same or different. The continuity in an interval on the (real or hyperreal) number line is to be replaced by a paracontinuity.[11] This concept also defines a para*dis*continuity, and that paracontinuity and paradiscontinuity are in fact the same. The principle also holds for relational *entities*.

This does not mean that the standard calculus is wrong for the real world; it is valid for simple phenomena, is capable of making predictions and so on. My proposal is that, for complex process phenomena in the real world, a dynamic relation between continuity and discontinuity extends the indicated relation between paracontinuity and paradiscontinuity for an abstract line composed of abstract points. The calculus for the LIR picture remains to be formalized; it should not contain either infinite or infinitesimal elements, and it will depend on the contradictorial notion of the structure of space and time discussed in the next chapter. Nevertheless, it can already be postulated that since, by Axioms **LIR1** and **LIR2**, two elements of the real extended world can be, alternately, almost equal, the paraconsistent picture can apply (D'Ottaviano Itala, 2006, private communication).

6.3.4 Smooth Infinitesimal Analysis (SIA)

As indicated above, my conclusion is that SIA is not appropriate as a description of the real world, but the description of the domain of thought to which it applies enables the contrast with the realistic concepts of LIR to be clearly delineated.

Bell states that SIA applies to *smooth worlds* and that the fundamental object in any smooth world ***S*** is an indefinitely extensible homogeneous straight line ***R*** – the *smooth*, *affine* or *real (number) line*. Applications of SIA are presented for differential and integral calculus, physics and hydrodynamics of macroscopic systems, and synthetic differential geometry.

Any reasonable division of the world, however, must involve something like the following categories, although one can argue (indefinitely) about the best grouping:

- Abstract mathematical or other non-spatio-temporal objects
- Macroscopic physical objects and processes

[11] The term has been applied to certain geologic strata, characterized by moderate discontinuities between them.

- Microscopic physical objects, biological and psychological agents and emergent processes

Whatever else may be true of the above, the real world of the third category is not a smooth one. As suggested above, in my theory, it instantiates *both* continuity and discontinuity which are both present in any phenomenon, e.g., the quantum of action (frequency and quantum number).

Poli has proposed (Poli 2004) that SIA provides "the conceptual background for development of a non-speculative mathematically based theory of *tendency* and *potentiality*," which seems required by a processual interpretation of ontology, in which processes are the basic ontological items. The points of the 'life trajectory' of actual events are identified with the 'linelets' used in SIA as the fundamental units of objects in it. Linelets are too small to have either possibilities or directions, but potentiality and tendency can be ascribed to them.

This thesis thus appears to depend on three interlocking assumptions: the real world is (only) smooth; potentiality and tendency can be ascribed to linelets (and to timelets, the corresponding infinitesimals of time in SIA); because SIA has its origins in category theory, and category theory can apply to physical phenomena, SIA can apply to physical phenomena.

I do not feel these assumptions regarding SIA are justified, and other explanations of potentiality and tendency, such as LIR, are possible. The reasons will appear in the following discussion of the basic concepts of SIA, their logic and the comparison that Bell makes between SIA and NSA, which is derived from standard logic.

The fact that the infinitesimals of SIA (and its precursors) prove to be useful heuristic devices is not *en soi* a proof of their existence, except as entities in an idealist ontology. The way Bell (or Thom) defines a continuum, several things follow in the consequent theory, *viz*., its consistency and the failure of the law of the excluded middle (LEM). The formulation (used by Bell) for LEM – every statement is either definitely true or definitely false – cannot be generally affirmed within smooth worlds. In both Peirce and Brouwer one finds the requirement that a faithful account of the *truly* (emphasis mine) continuous will involve jettisoning LEM as is required in intuitionist logic.

In LIR, LEM fails in reality, in the sense of Axiom **LIR3** above. There is no logical price to be paid if it fails in SIA. However, this failure does not imply that the real world is a true continuum; discontinuities, including the 'flip' from actual to potential, are also present and require explication. Similarly, Peirce's proposal that immediate consciousness involves a non-punctiform, extended infinitesimal of time can be explained by a contradictorial view of simultaneity and succession, and space-time that is deployed by objects, rather than being a locus of them (see Chapter 7 on the origin of 'space-time').

Bell states that non-zero infinitesimals exist only in a potential sense, and this potential existence suffices for the development of infinitesimal analysis in smooth worlds (SIA). Also, that the law of non-contradiction (Axiom **CL2**) continues to be upheld in ***S***.

This is my point! In such worlds, there is no transfer of energy in any form. In the real world, for change to occur, one needs both actuality *and* potentiality, and this distinguishes them from smooth worlds. Further, Bell shows correctly that one cannot, in ***S***, single out an actual non-zero infinitesimal, "for such an entity would possess the property of being both distinguishable and indistinguishable from 0, which is clearly impossible". In the real world, again, these two predicates are contradictorially related as per Axiom **LIR2**, and can be ascribed to the same real element.

It is clear by this time, as Bell confirms, that we are dealing with an intuitionist or constructive logic. Note that LEM is not even explicitly denied, it is not affirmed, and thus can remain in those parts of SIA and related systems, such as topos theory, in which classical logic holds.

There are additional points in Bell's SIA, however, that are *prima facie* contradictions in terms, despite the (inconsistent!) fact that they are intended to guarantee consistency! For example, infinitesimals are alleged to be intrinsically varying quantities, as a consequence of their being in a "nascent or evanescent state", and this varying takes place over a definite domain, with a definite codomain in which it takes values.

The above contradicts the assumptions of a *smooth* world since discontinuities have been reintroduced in the form of definite domains and as change in the form of a needed reversal between nascent and evanescent (virtual particles appear from and disappear to the vacuum discontinuously). The principal applications in calculus, geometry and physics are only possible because they have been restricted to abstract areas in which classical or consistent intuitionist logics hold. Thus, Bell has arrived at the limits of thought of iteration that Priest has shown involve *dialetheias*, true contradictions (Priest 1995). In mathematics, of course, such problems do not arise: two functions can, by Bell's Constancy Principle, have identical derivatives that differ at most by a constant.

I conclude that Bell's SIA is a theory of abstractions, unsuitable for an ontology that purports to deal with the world of real change. As Bell himself concludes, SIA is a theory of infinitesimal geometric objects, designed to provide an intrinsic formulation of the concept of differentiability (see Section 6.3.1), and perhaps not more than that. The real world is not differentiable as a whole, although a continuum of states exists between (almost) fully actual and (almost) fully potential. The infinitesimal units of which Bell's objects are constructed are, from my point of view, pure *intensity*, and thus cannot exist, any more than can any idealized, abstract constructs. Despite their interesting properties, to assign them any role in real phenomena, with the exception of description of pure physical processes totally dominated by the 2nd Law of Thermodynamics, seems to me abusive. Applications to systems such as computer science, artificial intelligence and data processing are included in this group, but all of these require no more than a binary logical system, sufficient when there is no exchange of energy *qua* the elements or terms of analysis. They thus clearly belong in the sub-category of Separability.[12] Everything else, life, growth and mind, as well as photons and the vacuum, requires a ternary logic capable of handling the fundamental antagonism inherent in energy, and hence throughout nature, and the inconsistencies and contradictions that derive from it.

6.4 STATISM AND DYNAMISM

One of the oldest debates in classical philosophy is whether statism is more fundamental than dynamism, in other words whether there is some static, geometric identity underlying all dynamic phenomena, or whether it is a self-sufficient force or energy that is responsible for them in some still unexplained fashion. This debate appeared in the discussion of catastrophe theory in the previous chapter. Let me say that if the ideas in this book are valid for discussion, the classical question is reopened, since neither statism nor dynamism is required to be rigorous or absolute. Every factor in some static view of the world, say, of intensity or extensity, cannot by Axiom **LIR6** be a pure potential nor an absolute actualized entity. Similarly, no pure dynamism exists in the classical sense, due to the antagonism with statism that constitutes it. There can only be, accordingly, dynamic geometries and geometric dynamics.[13] Statism is thus no more absolute than dynamism, and those who had difficulty deciding whether energy was a static quantity or a dynamic order, or neither one or the other while looking like both, or some form of mathematical symbolization, were closer to the truth as I see it.

Another problem had been to try to reconcile the conflict between an appearance of continuity in time and space with an intuition of the existence of its divisibility into “instants” of time and “points” of space of indeterminable size. The problems of the homogeneity of space, and its ‘divisibility by itself’, and a similar homogeneity of time and the existence of idealized ‘points’ of space and ‘instants’ of time can be superseded by a dynamic view of relativistic space-time, presented in the next chapter, that might be seen as part of a ‘dialectical turn’ toward a cosmology (and a cosmogony) involving opposition in the LIR sense.

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[12] Elsewhere, Bell discusses variable sets that are intended to provide a feature of continuous variation, since abstract sets are not only discrete but static, and their elements undergo no change. However, all the entities involved remain abstract in my conception, instantiate *Separability* and are therefore inadequate to provide a model of real physical change. The unification described of the continuous and the discrete is an achievement of category theory that applies to mathematics (Bell 2006).

[13] “Geometrodynamics”, a concept of John Archibald Wheeler, should be examined in this context, as well as its recent developments, e.g., the topological geometrodynamics of the Finnish mathematical physicist Matti Pitkänen.

This eliminates the need for arguments against statism and in order to insure the existence of dynamism and discontinuity in addition to those suggested in the previous section.

It is nevertheless useful to see the relation of the concepts of extensity and intensity, as well as of homogeneity and heterogeneity, to another metaphysical duality that I have not previously dealt with, namely limits and their absence, non-limits, or limitation and illimitability. In this discussion, I will refer to the continuities of time and space as their homogeneity and the result of any metaphysical divisibility as their heterogeneity.

The first step in the development is to differentiate between homogenization and heterogenization as processes, acting on some substrate, and their result, a homogeneity, an entity consisting essentially of an identity or a heterogeneity, consisting essentially of a diversity. Taken as independent dynamisms, neither extensity nor intensity has conceptual limits, but the limits of real entities are a kind of extensive property, an identity. In contrast, intensity is non-limiting.

Let us then see what this means in terms of the further properties of identity and diversity, as these might impact on the properties of the entities involved, specifically, what happens to their limits or the boundaries between them. The best way to put this is that heterogeneous entities indeed instantiate individual limits, despite the fact that heterogenization is a dynamism *en soi* that destroys limits that, so to speak, previously existed. Homogenization involves the destruction of limits also, but only insofar as these were differences, expressions of diversity, with the result being a new identity.

These dynamisms are also related: they consist of an intensive heterogenization that is accompanied by the inverse of an extensive homogenization. Through the first process, there is fragmentation of limits in principle to infinity; through the second, a reconstruction of limits up to the limit of the 'same' by the 'same', the idealized limit of identity of A by A. An example is that of rock cliff near a sand beach. Sand is produced (many small limits) when part of the cliff, a single large limit, is destroyed by 'heterogenizing forces' (erosion). The differences between individual grains are an expression of diversity, while being at the same time an identity (the beach). The sand limits could be suppressed by homogenizing forces. For example, heat and soda ash (energies) could transform the sand into a glass object, a new identity, the size of the original cliff, going in the direction of, but obviously never reaching, the original identity. The LIR logical universe is thus never entirely finite or infinite, but is a transfinite complex in which one of the aspects of its formal dynamic constitution is an 'eternal' conflict of illimitability and limitation.

6.5 DETERMINISM AND INDETERMINISM

A complete discussion of the concepts of determinism and indeterminism, of necessity and chance, and of the controversies around the implications of quantum mechanics is obviously beyond the scope of this book. Nevertheless, the *form* of many of the controversies and arguments for one view or the other being more fundamental suggests that we may be witnessing the phenomenon of dynamic opposition in operation at the levels both of reality and of theory.

It is generally agreed that some more or less complex forms of prior cause determine all processes and events at macroscopic levels. As noted, there are substantial problems with the commonsense notion of cause, and LIR suggests two major conceptual additions: a set of contradictorial relations between cause and effect for entities in the sub-category of Non-Separability, and that these relations constitute a chain of causality that is instantiated in parallel with the standard one. The problem is at the quantum level, since it is also generally agreed that at this level, the world is indeterministic; for example, one cannot define *any* causes, hidden or not, that determine when a given radioactive nucleus will decay. The further and greater difficulty is that local statistical or probabilistic causes also seem ruled out. The correlation between distant particles (cf. the Bell inequality experiments) can be explained by referring back to their origin, as components of a single system, but the existence of the correlation cannot be explained probabilistically. The correlation seems to be an irreducible fact, totally unlike any commonsense notion of a causal chain of occurrence.

As Sklar and others have pointed out, the ‘weirdness’ of quantum phenomena have a psychologically destabilizing effect on people, so that they tend to seek explanations that will insure that either determinism or indeterminism is the prevailing mode of existence at the human level, such as the denial of any notion of an objective world, branching worlds, and so on.

The simplest statement of the LIR view is the following: the world is both deterministic and indeterministic, and, in addition, cause and effect are not separable, but are in the contradictorial relation suggested above. However, the possibilities offered by this view have not been explored primarily if not exclusively because of the tendency of people to avoid apparent contradiction. The first proposal is to change the view of causality at the nuclear level. Does this mean that radioactive decay the ‘effect’ is somehow its own cause? This starts to look too much like the theological argument of the uncaused cause, but I believe Lucas (1961, 1990) has shown a way out. He suggests that entities involved in quantum relations are not simple events, but possible (I would say potential) events, which are far from simple. Above all, one needs to include a concept of potential causes between such events, although it was not clear to Lucas if there was a “more straightforward way” in which these entities existed or could be known than the standard space-time they were supposed to supplant. I made one suggestion above of the existence of two chains of causality, and propose that the contradictorial LIR causality would apply to ‘possible events’.

I cannot state what, at the nuclear level, the potentialities are that are operative in radioactive decay in the same way that I can describe the potential of the carbon atom for forming covalent bonds. I can only say that given the apparent ubiquity of such potentialities, and the dualism of the effective quantum field, suggests their existence at this level as well. The key idea here is that of the 'influence' of the quantum level. As discussed elsewhere in this book, it is the potentialities that are the carriers of dynamic opposition to higher levels and not actualized quanta. In any event, effective indeterminism at this level does not preclude determinism at any other, but only that it is, effectively, potentialized.

These ideas clarify the concept of Nicolescu that quantum indeterminacy is fundamental but the concepts of the trajectories, speeds and positions of particles are not. A generalized indeterminacy, which would go beyond the problem of trajectories of particles and agree with the concept, first considered by Heisenberg, of the indeterminacy of natural language, is of course possible. "Natural language can not express with arbitrary high precision all of its elements, because the way of expressing acts[14] in an essential manner on what is expressed. The indeterminacy of natural language is just one example of the generalized indeterminacy generated by the Gödelian structure of Nature and knowledge." This is only one of many expressions of the failure of natural language to conform to the principles of bivalent logic.

Any such indeterminacy must, however, be associated with determinacy, by Axiom **LIR5**. In the LIR view, natural language, as well as quantum phenomena, is both determinate and indeterminate in a manner that ultimately undercuts Wittgensteinian skepticism about the impossibilities of communication between individuals. Extension of the Gödelian argument outside the domain of mathematics and number theory is justified if a functional association is made with the PDO in complex, macroscopic emergent systems, that is, in those domains in which T-states are instantiated.

6.5.1 A Philosophical Argument

In the section on continuity and discontinuity above, I noted that there are two continuities, one extensive and the other intensive, related antagonistically, that could give rise, when and where they are of equal force, to the actualization of discontinuity. The principle of determinism can be introduced essentially as a quality, something that exists as a phenomenality in physical and logical systems, in relation to the continuities – an extensive determinism and an intensive determinism or indeterminism. The argument runs as follows: in the same existential form, the two continuities cannot exist with equal reality; therefore every physical system, as well as each logical thought, can only be hybrid phenomenalities,

[14] One might justly say 'interacts' here.

oscillating between determinism and indeterminism At the point of semi-actualization and semi-potentialization of each, an a-determinism emerges, what Lupasco called "the discontinuity immanent in logic". (The two terms determinism and determinacy, for a principle and a quality respectively, exist in English, but the latter seems more appropriate and will be used subsequently.)

To describe a physical entity, one requires, as a minimum, two factors, one each of intensity and extensity, that is, of speed or momentum and position. When Heisenberg discovered the principle of indeterminacy (or uncertainty) he initially attributed the inability to determine both with the same precision not to a relation of opposition or interaction, but some combination of fundamental indeterminacy and determinacy of the "two faces of Nature", in other words, some kind of independent identity behind phenomena, either a geometric extensity, pure causality or some other abstract invariant. Regardless of what choice of this type is made, one falls into the same metaphysical trap: if everything is determined, a logical (in the standard sense) chain, everything is identity, in which case from where and how can, even in our minds, the unpredictable, the continuous, non-identity emerge? If on the other hand, everything is indeterminate, from where and how can necessity and invariability emerge, however ideal or ephemeral they may be? The only solution is to ascribe, to all phenomena, aspects of both determinacy and indeterminacy that are related contradictorially, that is, when one is actualized, and the other potentialized. If quantum mechanics suggests that the world, at the deepest level, is genuinely indeterministic, the logic of/in reality supports Einstein's intuition that a *deterministic* theory of systems is *also* required at some level to provide a necessary underpinning for an essentially statistical description (Sklar 1992). LIR thus provides a place for both concepts and the relation between them.

6.5.2 Contingency and Necessity: Bohmian Determinism

The absence, in the philosophical, scientific and logical literature of today, of any *language* of antagonism or of contradiction, and the prevalence of logics that are not *intended* to apply to real existence, suggest that the discussion of chance and necessity will remain problematical.

For Aristotle, the only modality of change in the universe was the possible, capable of evolving toward the necessary or contingent. In LIR, each logical value of a process or process element is a *probability* that is more or less necessary and more or less contingent. In addition to the two inverse probable processes of evolution toward non-contradiction (identity and diversity) or logical transcendence, there is a third probable process that evolves towards contradiction or immanence, the symmetrical reciprocal inhibition of chance and necessity. If we look back at this point at some of the entities in the category of T-states, things that I have characterized as emergent included middles, ideas, works of art, innovations of all kinds, all seem to have components of both chance and necessity. To my knowledge, no one has provided a place in *logic* for such events, as logical values. Accordingly, in LIR terms, one could perhaps best say that the universe overall is a-deterministic, an included middle T-state with local domains of determinism and indeterminism.

At the level of theory, it would seem to be impossible to decide, for systems showing unpredictability, non-computability or randomness, between a model of the system being governed by underlying genuinely statistical, indeterminate laws of nature or by deterministic ones resulting in chaotic behavior. In the first case, apparent randomness is real randomness, in the second it isn't. As discussed below in relation to realism, one aspect of the world is the existence of reality and appearance, and I suggest a dialectical relation between them, as between other dualities.

The question of determinism was brought into focus by Bohm's proposal of a theory of quantum mechanics that postulated that all particles have at all times a definite position and velocity, whether or not one is able to determine them. The Schrödinger wave equation that describes the evolution of a physical system is taken to be perfectly deterministic. Bohm reinforced this by a guidance equation that determines, on the basis of the particles' wave function plus the positions and velocities, what their future states will be. The result is a fully deterministic theory that confirms the Copenhagen interpretation of quantum mechanics, that is, that the particle and wave descriptions of quanta are complementary, but the interpretation of complementarity as I will show in the next chapter is complex, and the simplistic Copenhagen view has been largely superseded. Hoefer states (2005) the resulting dilemma as follows: if there is ever a "Final Theory" of the quantum structure of the world, it will not only be difficult to decide whether it is deterministic or not, but there seem to be today equivalent deterministic and indeterministic theories.

The only way out of the dilemma is to assume that quantum phenomena are and are not deterministic, sometimes primarily one and sometimes primarily the other. Both theories apply in reality, and the states and relations involved in individual processes are always partly determined and partly non-determined. This view is consistent with the relational version of quantum mechanics to be discussed in the next chapter.

6.6 REALISM AND EXPERIENCE

Metaphysics is a complex construct of concepts or claims about reality and the concepts or foundations of those claims about reality. I began the analysis of the existential aspect of LIR in Chapter 3 with a discussion of what it means for something to exist, for something to *be*, and I concluded that it is not possible to answer the question with a logic of bivalent linguistic elements.

The further question for the metaphysician is: “What does it mean for something to be real?” Science is, of course, what is supposed to tell us about reality, and in this section I will try to disentangle the various concepts of the relation between science, experience and reality that have been designated as realisms and empiricisms. Readers familiar with this field will have noted that I have already used the non-standard term ‘scientific-structural’ realism. This term anticipates the way in which I see that current views on scientific and structural realism can be usefully combined in LIR. I have also included a discussion of the conflict between realist and anti-realist positions in semantic realism.

Finally, is there not an infinite regress lurking as one considers the possible iterations of metaphysics of metaphysics? In my view, the origin of the concept of infinite regress, here as elsewhere, can be found in various types of challenge to a realism grounded in experience. In fact, LIR explicates the phenomenon, as indicated above, that in the reality of human experience, regresses stop as and when no further information is added, that is, after the first few iterations.[15]

6.6.1 Generic Realism

The two most general aspects of realism as a philosophical doctrine are that objects, processes, etc. exist (existence claim) and that their properties are independent (independence claim) of anyone’s beliefs, linguistic practices, conceptual schemes and so on (Miller 2002).

Realists are open to challenges by anti-realists who reject the existence dimension of realism about a particular entity and either claim that such entities do not exist, or they exist but do not instantiate any of the properties ascribed to them. Examples of the first are the debates about the existence of ‘Platonic’ entities such as numbers, and of the second questions about the existence of moral facts and requirements. Examples of the challenges by those who reject the independence dimension of realism claim that distinctive objects exist, with distinctive properties, but none of these are instantiated independently of people’s beliefs, linguistic practices, and conceptual schemes and so on. This latter is the view of classical idealism that all macroscopic objects are in some sense mental. Some of these arguments are clearly at a ‘higher’ level of reality or complexity in the sense of being second-order: states-of-affairs exist but do not have a causal role in *explanation* of the various aspects of our experience.

My purpose is not to comment on the merits of individual arguments – it would be another impossible task in the scope of this book. I also would remind

[15] Cf. Priest’s contradictions at the iterative limits of thought (Priest 2002).

the reader of what I said in Chapter 3 regarding existence or being, namely, that it would be well if both realists and anti-realists were clear on what they mean by existence. I will return to the LIR view of being in Section 7.6 on being and becoming. What is of interest here is that arguments made on both realist and anti-realist sides appeal to more or less far-fetched examples, linguistic or otherwise, none of which appear to be totally convincing. For me, this is an example of the fundamental, inevitable conflict in existence as well as its descriptions. Realist and anti-realist positions actualize and potentialize one another, but anti-realist arguments are at another level of mental reality at which the meaning, understanding or metaphors involved are closer to the T-state of contradiction, as they are based in part on the inherent paradoxes in language, and it is difficult to 'identify' them.

In my LIR conception, all physical processes, including mental or neuropsychic, are first of all real *qua* the energy involved in their instantiation. The logic of/in reality proposes a dialectical relation between 'reality' and its appearance to a conscious observer. It is the totality of this picture that I consider realism; reality and appearance are both real. What is *not* real then is not in the sense of lacking any character of dynamic opposition, that is, non-spatio-temporal phenomena such as abstract entities of all kinds.

My position also implies that the metaphysical issue of realism is not a semantic issue about the nature of truth. If it were, any question about anything would turn out to be 'really' a semantic issue. I discuss relevant aspects of semantic realism in Section 6.6.5 below.

6.6.2 Scientific Realism

In the discussion of LIR as a formal system in Chapter 3, I discussed two types of realism that are defined formally: logical realism and natural realism. As one moves toward science and experience, many new issues arise about the meaning of realism in science that as usual have given rise to endless debate. As with the various logics introduced in Chapter 1, all current theories of realism in science refer to on-going problems and limits of application, some of which LIR can address. The motivation of the next two sections is thus to show the utility of the logical aspects of my metaphysics in interpreting intuitions and insights available from the latest work in the philosophy of science.

In doing experimental or theoretical scientific research, scientists are involved on a daily basis in the inconsistencies and antagonisms in reality, both epistemological and ontological. Examples are the tension between their partial knowledge and ignorance, as well as the frustrating intractability of matter – the 'refusal' of a chemical compound to crystallize from solution. It is not surprising that these complex processes are perceived and conceptualized in an equally complex fashion. Faced by the diversity of the world as uncovered by science, philosophers tend to reject its metaphysical importance in the name of a perhaps laudable but dangerous strategy of simplification, dangerous if it confers a lower ontological value or significance to diversity as such.

Scientific realism is the stance that best captures the general validity which the activity of science has acquired, but its acceptation of entities that are not directly observable has led to its refusal by some philosophers. This is in my mind another instance of the dynamic opposition that *is* observable in all phenomena, physical and mental. Realism must, in my theory, always be accompanied by anti-realism, and both will alternately predominate as more or less valid in specific cases. Structural realism describes a group of relatively recent approaches whose objective is to respond to anti-realist and other challenges to scientific realism. I will show that LIR also supports and explicates aspects of some forms of structural realism that are relevant to science at the microphysical and macrophysical levels (this chapter) and at the cosmological level (Chapter 7).

I have given below a brief description of the varieties of realism on the market most pertinent to my proposal of LIR as *logic* of and in reality. In a sense, all have been developed as attempts to answer the question "Is science reliable?" The answers given have tended to focus on the microphysical or quantum domain, in view of its 'wealth' of unobservable entities of which only the intrinsic properties (see Chapter 3) are accessible to measurement. Like Ladyman and Ross (2007), I wish to support a program of a principled unification of science, in which the special sciences (those other than fundamental physics) exemplify the principles or patterns of physics while also involving emergent ones of their own. As I will point out in Section 7.5 on quantum physics, quantum phenomena such as quantum entanglement and quantum coherence cannot be operative at the mental level, but this does not mean that the patterns of interaction at the two levels can not and do not follow a similar logic.

The most important contribution that I see LIR as making is to provide a *non*-mathematical element of structure to the various forms of scientific and structural realism. What I will show, in the sense of the core thesis of LIR, is that LIR and the PDO apply to both the entities described by scientific theories and the theories themselves (or more generally the epistemic and ontic aspects of theories) in primarily in the *first* and *third* of the three relevant levels or domains: the quantum level; the 'inert' macrophysical level; and the biological and mental level. It is for me rather odd to note how often examples used to illustrate philosophical positions about reality and science are taken from the *second* domain.[16]

Scientific realism is the conception that, subject to the recognition that scientific methods are fallible as suggested above and that most scientific knowledge is accordingly approximate, one is justified in accepting the findings of scientists, validated by consensus, as representations of reality, that is, that

[16] The fluttering in the wind of a crumpled thousand-dollar bill has been used to discuss issues about fundamentalism in laws of nature. Others often used are simple, reversible 'to-all-intents-and purposes' physical changes of phase. I see LIR and the PDO as making accessible for analysis, that is, to science, more dynamic and interesting cases, for example, where appearance and reality are involved as in the psychology of lying or cheating.

the unobservable entities postulated by the theories in fact exist. Constructive empiricism argues that the best current scientific theories do not require such belief, and the success of modern science can be understood without it. It is such philosophical challenges to scientific realism that convert it to a philosophical position, as well summarized in Boyd (2002). I can discuss only a few of these challenges, and the realist response to them here, but one notion stands out as clearly supported by and supporting my logic of/in reality, that of approximate truth. As we saw in Chapter 2, truth in LIR is the truth of reality, which cannot be absolute. It is accordingly *unscientific* as well as metaphysically false to require that science generate absolute truth. LIR describes, in a way that makes it appear less accidental, the relation between the actual experimental methodology used to obtain knowledge of unobservable phenomena and the theory involving prior knowledge of other unobservables upon which the methodology depends. The non-actual entity that is intended as the consequence of the experiment has a potential existence, not yet proven but present as a non-localized process in the mind of the experimenter. Entity realism (ER) is another form of scientific realism. ER consists of the thesis that science does provide knowledge of a mind-independent reality, but it does not accept the strongest scientific realist claim that science provides, or can provide, *complete* knowledge of unobservables and their properties. This is, obviously, not a claim that LIR makes either.

This characterization of science, however, opens scientific realism to the criticism that the changes in theories that *have* occurred imply that further changes *will* occur and that, accordingly, currently existing theories either cannot be considered reliable. In my view, scientific realism cannot be questioned due to the existence of predictively successful scientific theories that later turn out to be false. A theory that is false is 'true' in the sense of actual and real, and its (inevitably) approximate truth is can be carrier of a contribution to scientific methodology. In any case, the errors made tend to be about the nature of the phenomena involved rather than their relations, to which experiment provides access. Nevertheless, it is useful to show how LIR treats the responses to the challenges to scientific realism that are defined as structural realism or structuralism and talk directly to the problem of theory change. I will look now at forms of structural realism that, in my view, do and do not capture the dynamic properties of reality and structure and hence the growth of scientific knowledge as a natural process.

6.6.3 Structural Realism

Structural realism essentially states (1) that science provides knowledge of the relations that the constituents of scientific theories engage in, but does not necessarily tell us anything else about its objects of study; and (2) that those relations are constituted by the *mathematical* structures, based on set or group theory, that purport to describe the relations. SR was thus developed to compensate perceived inadequacies of naïve scientific realism to respond to the problems of unobservables. Another way of saying this is that full-blown scientific realism has no basis for saying that the *nature* of things is described by the metaphysical and physical content of our best theories.

The epistemic form of structural realism (ESR) holds that the objects of our scientific theories (e.g., electrons) are epistemologically inaccessible. We believe what these theories tell us about the relations entered into by unobservable objects, but all we know are the structural elements (structures) of our theories. A version of ESR defended by Morganti (2004) is that there *could be* something more beyond structures rather than there *is surely* something, but we cannot know it. This requires, however, reliance on a classical, individual-based ontology and intuitive categories that I believe are *dépassées*.

The definition of structure in mathematical terms and the resulting structure/nature distinction begs the question of whether structure-as-equations captures all or most of the properties of the entities involved, since "nothing can be known of nature" whether there must be, in addition, meaning assigned to a non-mathematical nature-of-structure (McArthur 2006). Is the latter another unknowable metaphysical principle that SR correctly questions? LIR cuts the debate by establishing the role of Dynamic Opposition as defining, at least in part, a physical/metaphysical characteristic of the real structure (nature) of unobservable entities.

The ontic structural realism (OSR) of Ladyman and his colleagues is a complete current response to anti-realist challenges to scientific realism, since it insures that there are adequate metaphysical components that are lacking in epistemological versions of structural realism. The original motivation for the definition by French and Ladyman of OSR was to permit a metaphysics of quantum particles as both individuals and non-individuals. An initial version of this theory metaphysical structural realism (MSR) appeared to totally eliminate the reality of entities. As put by French, "the idea is that it is not just that all we *know* are the structures, but that all that there *is* are the structures". The latest version of OSR, which morphs to Information-Theoretic Structural Realism (ITSR) answers a number of the justified criticisms made of MSR. Thus "that relata constructed as abstractions from relations doesn't imply that there are no relata, rather the opposite. A core aspect of the claim that relations are logically prior to relata is that the relata of a given relation always turn out to be relational structures themselves on further analysis".

6.6.4 The LIR Extension: Scientific Structural Realism (SSR)

The conception of structures in LIR as real processes permits a convergence to what I define as a scientific structural realism (SSR). The ontological structure of reality of LIR established in Chapter 5 supports a non-naïve and above all non-absolute scientific realism, so that a theory of scientific structural realism is possible that includes the best of both worlds.

The LIR view of realism in science adds the following clarifications, some of which are in OSR in other terms:

- LIR supports a causal theory of reference, according to which the relation between a term and its referent requires a chain of causal relations between uses of the term and instances of its referent. All elements stand in such chains of chains of causal relations to what constitutes them, which must be some form of definition by an opposing element. This permits moving away from so-called descriptive formal ontological conceptions of reference and provides another crucial component to a realist approach to scientific knowledge.
- By removing the total separation between internal and external, and subjective and objective viewpoints, the LIR causal conception of perceptual knowledge treats discoveries both as empirical and philosophically and epistemically relevant explanations, *without* making an external object mind- or experience-dependent.
- Some philosophical challenges raised against scientific realism rest on intuitions[17] that beg the question against empiricist anti-realism, which states that there could be no evidence that rationally distinguishes between two empirically equivalent scientific theories. Such an approach implies the existence of two such theories, and pending their appearance, inconsistent with the LIR view of identity, I consider this objection void of content. Anti-realists tend to use arguments based on counterfactuals and highly unlikely states of affairs that carry strong anti-scientific sub-texts. They are examples in themselves of dynamic opposition.
- LIR provides a basis, accordingly, for realist theories to accept a connection between natural kinds and the conceptual machinery of the sciences. Extra-linguistic and mind-independently existing natural kinds, in my view, are metaphysically fitted for explanation and induction. Any version of something like an *objective idealism* is not required. LIR, in contrast to standard naturalism and metaphysical materialism, provides the physically grounded dialectical

[17] It is essential for the understanding of the philosophical positions in this book that no concept used familiarly in an idealist program, such as intuition as usually conceived, is supported. Intuitions are real, dynamic processes, standing in a relation of dynamic opposition to 'identity'-elements of concrete knowledge. Intuitions are therefore subject to the same standard of scientific inquiry as any other phenomenon. On the other hand, nothing here should be considered an attempt to *prove* that idealist positions are impossible. To the extent that someone takes *both* positions on an issue at some time or other, as did Dummett himself, they can be seen as dynamic opposites, a realist view potentializing an anti-realist one and *vice versa*.

> basis for such a connection. LIR thus opposes and argues against anti-realism in philosophy and science. LIR accepts as reproducible, quasi-scientific evidence that people do defend one position or the other and makes the reasonable assumption that 'psychological factors' of some sort must be at work. But it thus says something further and perhaps more interesting and important about these two opposed positions: they are *inevitable*.

An area of overlap between OSR and LIR is Ladyman's definition of a "pattern" as a carrier of information about the real world. A pattern is real iff it is projectible (has an information-carrying possibility that can be, in principle, computed) and encodes information about a structure of events or entities *S* which is more efficient than the bit-map encoding of *S*. More simply: "A pattern is a relation between data." Ladyman's position is that what exist are just real patterns. There are no 'things' or hard relata, individual objects as currently understood. It is the real patterns that behave like objects, events or processes and the structures of the relations between them are to be understood as mathematical models.

But then Lupasco's question "What is a structure?" still appears, as if the only answer to it were a set of equations! The indirect answer of Ladyman and Ross is in terms of science as describing modal structures including unobservable instances of properties. What is not of serious ontological account are unobservable *types* of properties. Thus seeing phenomena not as the 'result' of the existence of things, but their (temporary) stability as part of the world's modal structure, necessity *and* contingency, is something that is acceptable in the LIR framework, provided that the dynamic relation of necessity and contingency is also accepted. There is information carried by LIR processes from one state (of actualization and potentialization) to another, describable by some sort of probability-like non-Kolmogorovian inequalities, although it may not be easily 'computable'.

The theories of mathematical structural realists like McArthur, and ontic realists like Ladyman and his colleagues might thus benefit from something like my view of structures as dynamic entities. In LIR, these are the sets of processual relations themselves rather than sets of equations semantically equal to a theory. As Ladyman points out, the structuralist faces a challenge in articulating his views to contemporary philosophers schooled in modern logic and set theory, which retains the classical framework of individual objects represented by variables subject to predication or membership respectively. "*In lieu of a more appropriate framework for structuralist metaphysics, one has to resort to treating the logical variables and constants as mere placeholders which are used for the definition and description of the relevant relations even though it is the latter that bear all the ontological weight* (emphasis mine)." This is where I see a major contribution of the LIR approach. The mutual exclusivity of the logical variables and the description of the relevant relations is lifted: the relations are the logical variables in different states of actualization and potentialization, without the need for any kind of intermediate entity.

Concepts of partial structures, partial relations and quasi-truth were developed by the Brazilian school as the basis for their descriptions of quantum reality, given that the classic concepts of set, kind, individual and truth are inadequate. These were the basis for a definition of quantum entities as separable non-individuals. However, Bueno says at one point (Bueno 1999): "…, the partialness modeled by the partial structures approach is not understood as an intrinsic, ontological 'partialness' in the world (as an aspect about which an empiricist will be glad to remain agnostic. We are concerned here with an 'epistemic', not an 'ontological' partialness."

As I have tried to argue, LIR is about ontological partialness and approximation, without scare quotes. It confirms, as a principle, the non-absolutism of any real entity, process or theoretical, that can undergo change. If the category of Non-Separability is valid for dynamically interactive phenomena, then LIR provides an interpretation of such ontological partialness: in addition to separable non-individuals, there are also non-separable individuals and this physical individuality persists up to the highest levels of reality. The question of where the transition takes place, and individuality starts, has not been answered satisfactorily, but it may not be until the advent of *individuation* through language and memory in human beings.[18] In these terms, lower level creatures such as social insects and fish and birds that form interacting schools and flocks should be considered as consisting of non-separable non-individuals.

Like Ladyman and Ross, LIR recognizes the difference between individuality and indistinguishability for quantum particles, following Krause. Ontological verificationism (see Chapter 2) avoids reliance on the kind of non-existent pseudo-structures that are usually invoked or inserted to try to explain phenomena to which I also object. My addition to this theory is that *indistinguishability* as well as individuality is, logically, also partly present at higher levels, due to the continued instantiation of residual potentialities from the particle, molecule, etc. levels: things are and are not fully individual, are and are not the same.

Looking at entities at all levels of reality as processes and their relations is accordingly a view that is common to both LIR and OSR in the Ladyman and Ross interpretation. There is a similar pragmatic description of two domains of application of the theories, which I have referred to as those to binary logic (non-causal) and LIR (causal) respectively apply. Thus, these authors say:

> The metaphysics suggested by process views is effectively one in which the entire universe is a graph of real processes, where the edges are uninterrupted processes and the vertices the interactions between them. Thus process views, if correct, would make putatively causal claims by scientists subject to a critical test. Those that pick out real processes could be causal; those that don't can't.

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[18] Borgès talks about the "pre-eminence of the species and the almost perfect nullity of individuals". He quotes Schopenhauer as saying that the cat playing in his room is the *same* cat as the one that played in Egypt five hundred years ago (Borgès 1951).

LIR adds the critical detail of the operation of the PDO on the logical elements of the real processes, better, of the processes involving real spatio-temporal entities, which naturalizes this position, respecting the principles of both the primacy of physics constraint and naturalistic or physical closure.

I will conclude this overview with a brief reference to the neo-Kantian challenge to scientific realism in Kuhn's concept of scientific revolution. The theory dependence of scientific methods referred to above raised the possibility for Kuhn of incommensurability between competing scientific theories or paradigms. Transitions between theories, e.g. from Newtonian mechanics to relativity theory, in this view, instantiate *separability*, a form of epistemic cut (see Chapter 8), because they two theories refer to different entities despite having the same name (mass). Without going into other rebuttals of Kuhn, I will simply say that the metaphysics of LIR provides for a fundamental vagueness in nature. Any semantic conception such as that of Kuhn according to which the most basic laws in a theory or paradigm are *exactly* true is excluded as anti-realist. If my position implies that there is no epistemic cut between science and metaphysics, I have suggested some rationale for it. Based on my view of explanation in Chapter 5, I can say that LIR is a form of realism that treats experimental discovery, as for example, the components of perception indicated in Chapter 5 as empirically reliable *and* as a naturalistic philosophical explanation of why our beliefs based on perceptions represent knowledge about objects that are independent of those perceptions. Accordingly, the change to a new theory can preserve structural properties allowing a certain ontological continuity accompanying a conceptual revolution (Cao 1997). This ontological *synthesis* is a dialectical picture of growth and progress in science that reconciles essential continuity with discontinuous appearance in the history of science, a process that, again, is a logical one in LIR.

6.6.5 Semantic Realism

In semantic realism, every meaningful sentence is viewed as totally determinate, in the sense that, following the principle of bivalence, it is determinately true or false, despite the fact that there may be no method of ascertaining which. However, I feel it could just as easily be considered totally *indeterminate* or instantiating complete indeterminacy, in the sense that there is no method not to *prove*, but to *choose* between the two alternatives for the semantic case. Binary logic is adequate to describe this domain. In the dynamic process logic I propose, to the extent that real alternatives are involved, one or the other is predominantly actualized, and indeterminacy is maximized for the same reason. However, as they approach contradiction in a T-state of maximum energy and contradiction, in which each is actualized and potentialized to the same degree, that state maximizes determinacy; it is "as determined as you can get". Of course, there are many sentences that, even in a classical sense, are not true or false. It turns out, I believe, that the semantic functions of such sentences are dependent on context in a manner that implies a dynamic relation between them.

The logic of/in reality is a realist theory, grounded in experience as well as physics, in experience *as physics*. It is logic *in* reality and it *is* experience. In other words, it is resolutely opposed to a Kantian program of seeking to transcend experience as being ultimately misleading. Let us see what the further implications are for semantic realism, and if the fundamental postulate adds value to a discussion of realism, non- or anti-realism and semantic realism. In particular, are there particular semantic challenges to realism that LIR undercuts?

A quick answer is yes. LIR provides a phenomenological sense to the idea that an object perceived as external to the perceiver is not totally 'independent', but both internal and external in that these aspects are alternately and reciprocally actualized and potentialized. Thus, there is no need to require that the 'external' physical reality, either in the sense that objects exist or their properties are instantiated, has been 'created' by anyone's linguistic practices, semantic schemes or whatever. As discussed by Miller, Dummett suggests some domains in which it may be appropriate to reject the independence dimension of realism *via* the rejection of semantic realism about them. A semantic realist, in this conception, is someone who has a notion of the truth necessary to understand a sentence that is bivalent or recognition-transcendent. It may be true or false even though we will not be able to determine which, and it is accordingly determinately *either* true or false. This is an example of the 'higher-level' T-state referred to above. His two further claims are essentially (1) that language does not give us the means to make a metaphysical characterization of realism; and (2) the literal content of realism consists in the content of semantic realism.

It should be clear that truth has nothing to do with realism *per se*. This was the problem noted in Chapter 2 in the discussion of truth-makers. Realism says nothing semantic about the world beyond making the negative point that our semantic capacities do not constitute the world. Miller quotes Devitt to the effect, also, that the literal content of realism about the external world is not given by semantic realism, since semantic realism is consistent with an *idealist* metaphysics of the external world. My scientific structural realism requires the objective independent existence of common-sense physical entities. Semantic realism concerns *statements* about physical entities but says nothing about the nature of the reality that makes these statements true or false.

There are some additional non- or anti-realist semantic challenges to realism, based on the difficulties of representation (the Representation Problem: Khlentzos 2004). One can formulate this as an aporia: if the world is resolutely mind-independent, how do we get to know about it? Wouldn't a truly mind-independent world make any representation of it in thought or language unreliable or even impossible? A mechanism is needed for any representation (mental symbol) to be reliable in the sense of providing a correlation between it and its worldly referent, the mind-independent state of affairs. This assumes, of course, that such a representative entity is required.

The answers provided by LIR revolve around the word independent. I suggest in effect that antagonistic aspects of reality are ‘imported’ in perception and are subject to similar interactions in the brain, including the semantic ones that will be involved in communication and other activity. But is the mere existence of such dynamic correlations a guarantee of their reliability? As usual in LIR, the answer can only be “Not completely”.

A direct realist response to this anti-realist challenge points to the prevalence in our linguistic practices of realist-inspired beliefs to which we give expression in what we say and do. The anti-realists’ counterargument is that reality is fundamentally indeterminate and reasoning follows a correspondingly intuitionist logic. Khlentzos suggests, in terms that are directly relevant to the thesis of this book, that “the overwhelming acceptance of classical logic by mathematicians and scientists and their rejection of intuitionist logic for the purposes of mainstream science provides very good evidence for the coherence and usefulness of a distinctively realist understanding of truth.” Wait a minute. There are important domains of science and mathematics for which intuitionist logic, despite its limitations as discussed, is highly useful. Classical logic *has* been useful and still is for many objectives of science, despite its incapacity to resolve certain problems. Third, the citation places the emphasis, incorrectly in my opinion, on ‘truth’ as opposed to the reality that grounds it, as discussed in Chapter 2. This choice may be a disservice to physical/metaphysical realism.

In my view, that the considerations of LIR support a naturalistic story against semantic externalism to describe “how creatures like us came to develop the linguistic dispositions we did” so that a link can be made between, for example, the use of a name “Big Bang” and the event of that name that, in some theories, occurred some time ago. The correspondences for semantic and non-semantic mental operations are a consequence of a contradictorial reading of internal and external, and suggest that many of the semantic challenges to realism can be met accordingly.

The metaphysics and ontology of LIR are very general, and the question may be asked as to whether its key principle, the PDO, is scientific or constitutes some form of a natural law. In the next section, I provide an answer to this question, as well as comments on the on-going debate on the nature of laws of nature themselves. This will again illustrate some of the key aspects of the application of LIR to philosophical problems.

6.7 THE PRINCIPLE OF DYNAMIC OPPOSITION AND LAWS OF NATURE

LIR is a theory that is strongly realist, as I have shown, while providing an epistemological interpretation of a contradictory anti-realism. It includes as a fundamental structural feature the dualities of nature and the inherent antagonism of the terms of those dualities. I have referred to this feature as a PDO, but this leaves open the questions of whether this represents simply a coherent phenomenological observation, a law of nature, or a more authoritative scientific principle, a fundamental physical theory, on a par, say, with symmetry. There are several candidates for an appropriate description, none of which, I am afraid, exactly fit the principle of LIR. Another closely related question show the term constitutive is to be understood, in view of its Kantian and neo-Kantian background. In Chapter 4, I defined a constitutive principle simply as one that establishes the relation to an object of experience.

6.7.1 Dynamic Opposition: Constitutive and Regulative

At this stage of development of the theory, let me first say what the PDO is not:

- It is not constitutive in Reichenbach's sense of coordinating a pre-existing mathematical (or logical) formalism with the physical part of a scientific theory.
- It is not constitutive in the sense of involving a Kantian *a priori* that is isolated from experimental evidence, something prior to experience that is a condition of the possibility of the existence of that experience.

Dynamic opposition is constitutive in LIR in the sense of establishing the critical relation of interactive coordination inherent in phenomena. Lupasco introduced dynamic opposition as a logical rule on: (1) phenomenological grounds, intuition and introspection; and (2) within the increasing body of quantum mechanical knowledge, increasing its nomological scope in the process. In fact, it developed in parallel with the evolution of the Pauli Exclusion Principle from phenomenological rule to scientific principle (Massimi 2005). This principle is the scientific justification for the LIR position that the movement toward diversity, heterogenization, is as fundamental as that toward identity, governed by the 2nd Law of Thermodynamics, to which there are no known exceptions.[19] In this, however, the PDO accomplishes what might be considered a open-ended Kantian *regulative* function, giving a kind of systematic unity to knowledge in general, not only quantum mechanical.

My conclusion is that it is best to consider the PDO as *sui generis*, constitutive and regulative. In looking for models of dynamic opposition, it is essential not to refer to systems that involve the principles of standard logics that *a priori* exclude interaction between terms. I have already claimed, in the previous

[19] There are, of course, imaginable exceptions, but they constitute an alternative description of non-existent, fictional entities.

chapter, that the PDO is a metaphysical structural principle. However, is PDO a scientific principle and, accordingly, one that should not be ignored either in the philosophy or practice of science?

6.7.2 Dynamic Opposition as a Scientific Principle: Linking Physics and Statistics

I referred in my discussion of probabilistic causation to the difficulty of combining statistical and non-statistical considerations into a world which nevertheless seems to be grounded by the physical constants, indicated in Chapter 4, for both of them. Sklar calls it the "curious interworking of full laws (i.e., those of the dynamics of quantum entities) and statistical generalizations in the explanatory scheme."

If this distinction is maintained, however, then again the problem is displaced to decide what grounds the additional statistical assumptions other than the fundamental dynamics and/or whether additional fundamental postulates are necessary to include *them* into physics. I note in passing that if such a concept would hold, it could mean the end of accident and contingency as valid metaphysical terms (except for the famous unresolved question of the indeterminacy of radioactive decay).

The LIR position is that the PDO is just such a postulate. The locus of the intervention of statistical fluctuations (which in my view still follow, at a microscale, deterministic rules) at both microscopic and macroscopic levels is the transition from potentiality to actuality and *vice versa* that is involved in all change, but the formalization of this linkage as a scientific principle in its own right remains to be made. This will require a directed, appropriately designed experimental effort to test its assumptions without, as in this book, relying on data developed for other purposes. But the concept of a scientific principle is also open to interpretation. If causation can be viewed as a physical process, as in LIR, then it belongs as in Cassirer's conception to a new type of physical statement in which both measurements and laws or principles are interwoven (Laudisa 2006).[20]

Massimi proposed that a scientific principle is best understood in the context of Cassirer's reinterpretations of the Kantian *a priori* and principle of systematicity in regulative terms. A scientific principle fulfills a regulative task of systematizing and conferring order on empirical knowledge, *while being an integral part of that knowledge* (emphasis mine). This could serve as an alternate definition of Logic in Reality!

In my view, it is otiose to try to argue whether entities bearing properties and in relation with other entities are ontologically prior to laws of nature or not,

[20] As quoted by Laudisa, Cassirer talked about an "ultimate common element of all possible forms of scientific knowledge, never perfectly achieved." That the PDO might be such an element I leave as an open-ended possibility in the spirit of Cassirer's inquiry.

that is, whether objective reality is attained because there is conformity to law, and not *vice versa*. On the other hand, my categorial definition of different domains of reality according to whether the PDO is functionally instantiated in them or not suggests something fundamental about dynamic opposition that might deserve the *appellation controlée* of a law of nature.

6.7.3 Dynamic Opposition as a Law of Nature

A law of nature is defined as a general relation that holds between properties of physical entities or systems or between the physical quantities that result from measurements made on those entities. Laws are supposed to have universal validity and a high degree of accuracy and consistency, thus providing a description that aids in conceptual understanding of phenomena. Implicit in the notion of a law of nature is that such laws govern the behavior of all the entities in the universe.

The position of Hume and his followers is that there are no necessary relations or connections in nature – connections, powers or dispositions (see Section 6.3.4) – that could collectively be called modal properties. Accordingly, there are no laws of nature. In contrast, the metaphysics of the logic of/in reality are fundamentally anti-Humean: in LIR, necessary connections, including those of cause and effect are such that there are no such things as distinct existences of events linked only by contiguity.

Most realists believe that laws of nature and real modal features *do* exist, but they are divided on their content and role in explanation. For example, does the concept of a law of nature add explanatory value beyond that of the modal properties themselves? The debate about the laws of nature is whether the description of an aspect of the universe as a law implies that it is more than the equations and/or descriptions of properties of certain natural kinds that it contains. If so, it should be possible to state in what that consists. If there is 'nothing more to it', then one can ask if there is still some value in describing some phenomenon as law-like as opposed to those that is not, generally designated as accidents.

Another form of this division is that between fundamental and less fundamental laws, in other words, should the designation change of something as a law or not according to level of reality? Realists are also divided on other issues, in particular whether laws are necessary and contingent, and what the meaning of a contingent law might be. There is the related question of what should be the proper domain of application of a certain non-fundamental laws, given that there are domains in which they clearly fail or are incomplete. Finally, is there any cognitive and heuristic advantage in defining something, such as the PDO of LIR, as a law of nature?

6.7.4 Metaphysical Positions

The problem of the *metaphysical* character of laws of nature can be approached by reference to the LIR treatment of identity and diversity as non-separable categorial features, based on the discussion in Section 4.4.1.2. Standard logic is a logic of identities, and laws of nature express those identities as being dependent on necessary connections between distinct states. The opposite, antagonistic position, as noted, is the one of Hume that no such connections exist or need to be postulated to explain the observed regularities in nature. Mumford (2005) describes this position as 'Humean lawlessness'.

Currently, it is nomological realists who think that there are metaphysically real laws of nature, and that these laws correspond to the relations between entities. This approach displaces the problem, however, to whether these relations are necessary or contingent. The further argument is over whether the necessity is metaphysical, grounded in the real features of the world; analytical necessity, grounded in meaning of propositions; or classical logical necessity, grounded in form (syntax).

Roberts (2005) differentiates between two forms of laws of nature, as follows:

(1) P is a law relative to a theory T iff P is implied by T and plays a role R within T.
(2) P is a law of nature iff it is a law relative to some true theory.

In this metatheoretic account, the definition (2) of a law of nature is tautological, unless there is a theory-independent understanding of the operator "It is a law that _". Roberts says that there is a better way to define a fundamental physical law than as a law posited by a fundamental physical theory: (1) certain theories contain propositions that play a special role within those theories that are, or can be designated as the *fundamental laws* of that theory; and (2) a theory all (or most?) of whose propositions are laws of it is a *fundamental physical theory*.

Roberts suggests a new form that a philosophical theory of fundamental laws of nature defined by (1) might take. He states that correlations on which measurability depends are guaranteed not by meaning-constitutive principles, but by laws of nature. This in turn depends, however, on the proposal that what it is to be a law of a theory is to play an indispensable role in showing that the theoretical quantities posited by that theory are indeed measurable. But such laws, in turn, seem to be difficult to differentiate from principles, since if laws can be principles from which one can derive systems of differential equations, they are "well equipped" to guarantee the measurability of theoretical quantities.

My two-level approach permits the application here of the between-level epistemic dynamics that I have proposed. Elements are part of laws, and laws are parts of theories, and *vice versa*. It is not necessary to take a dogmatic position on whether LIR is law or theory from a specific point of view. Mumford refers to three general stances taken about the existence of laws: *primitivism*, that states that they correspond to a distinct non-reducible category; *eliminativism* that rejects laws as a separate category entirely; and *reductionism*, that says that there are laws but they, or the phenomena they describe, can be accounted for by other things that are not laws. My view is that something that is expressed by the phrase 'natural law' exists, and exists within the sub-category of Non-Separability, and is accordingly reducible to the underlying dualistic interactions of the universe. As a general stance, LIR is *both* reductionist and eliminativist. The modal, nomological connections of the world are inherent in the properties connected and these features are really in the world without it being laws that ground them. The job left for laws is to function as a heuristic device to *call attention* to the interaction between theories and their elements.

I thus have a further approach to the current debate on whether the laws of nature that obtain in "our universe", the one which we are able to exist according to the weak anthropic principle (Chapter 1), are a selection from an (infinite) set of laws that permit many different universes (the multiverse). LIR supports the view expressed by Davies (2007) that it is not necessary to appeal to "something" outside our universe to explain the "fine tuning" of the laws of physics. The PDO inherent in what there is "inside" provides some of the missing explanations of the operations of those laws, without going outside of *them*.

If the above line of reasoning is accepted, then it makes little difference whether the PDO and its related logic and ontology do or do not constitute a corpus of natural laws. For example, what anomic constraints[21] have in common is the extent to which they replace laws as sources of understanding or provide other epistemic or pragmatic outputs, but the benefits are not linked to generality, the formal unifying and explanatory property expected from laws. The notions of LIR are more substantial, realist and causal, as well as general, and the simplest conclusion is that they can be seen as both law-like and not.

I believe this discussion of laws of nature from the LIR standpoint constitutes an example of the second objective of this study: it is to show how theories themselves can benefit from the contradictorial approach by the explicit reference to the presence in them of the interaction between their constitutive concepts and their contradictions.

6.7.5 Laws of Nature in Use

Much effort has been made to give substance to the notion of laws of nature by using behavior under counterfactual suppositions or conditionals to

[21] *Non*-lawlike aspects of real processes (see below Cat 2005).

make a sharp distinction between laws and accidental truths. The concept of an accident has a long history in philosophy, but it is best defined for my purposes as a phenomenon whose causes appear to be essentially indeterminate. The argument, roughly, states that laws of nature hold under any counterfactual supposition that is logically consistent with every logical consequence of the laws. Laws can be defined as a stable set of truths; truths have a kind of necessity; and an accidental truth (the truth of an accident) has no such sense of necessity (Lange 2005).

However, once this definition is made, it should be clear that one is in the domain of binary logic.[22] The notion of propositional truth that is used is incompatible with the LIR description of reality. Counterfactual suppositions are epistemological devices without direct implications for physical processes, and the discussion of whether counterfactuals or laws are ontologically prior is a question within classical ontology. From the point of view of real phenomena, there are no accidents defined as undetermined events; arguments that depend on a definition of laws of nature as totally distinguished from accidental regularities cannot be maintained.

From the LIR standpoint, laws can be interpreted as governing or characterizing both A – models of real systems, equivalent to a semantic view of theories; and B – the real systems themselves. I thus have a two-level framework A and B to analyze in the sense of Section 5.2. If inconsistency in nature is constitutive, a relation must be established between such inconsistency and the basic concept that laws should not have exceptions. For this discussion, the definition of a model is a conceptual structure that mediates the application of abstract theory to phenomena or data, or simply provides their understanding by way of representation or explanation. There is no absolute requirement that that any theory cannot be *lawful* and restricted, consistent and inconsistent, since it does not have be fully both at the same time. The structure of the LIR approach accommodates the idea that laws can apply more or less completely to models, given that the models, in their similarity to the underlying phenomena, will also instantiate the categorial features of LIR (Cat 2005).[23]

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[22] As a consequence, the concept that there are laws of *logic* as logic is generally understood is trivially true: the 'law of the excluded middle' guarantees the truth of propositions of the form *either* p *or* not-p.

[23] Where, for example, Hooke's law of elasticity describes a deformation accurately, the material is in a region in which internal structural properties of the atoms or molecules have determined the elastic constant, but the macroscopic behavior is governed by the law and its simple, non-antagonistic dynamics. The 'language' of energy and dynamic opposition of LIR is thus well adapted to discussions, for example, of the strength of materials as a measure of resistance to fracture, resistance being, in this view, a potentiality dependent on the microstructure of the material, that is, on the integral of its residual potentialities at the interface between molecules. A crack is not a boundary condition, but the structural site at which macroscopic mechanical potential energy Um is transformed into crack surface energy Us. The crack as a site of physical activity is best described as an *opposition* (Cat's word) between Um and Us; as Um decreases, Us increases.

It is also clear from this discussion that for valid analysis, some distinction must be made *within* the general category of laws of nature. The issues are not the same for a 'law of gravity' or 'law of thermodynamics' which have no known exceptions, and a law such as Hooke's Law governing the elastic deformation of solids where there exists a very specific event domain, namely fracture, at and in which it no longer applies. The domain of application of some laws of nature, and the corresponding understanding of phenomena, that is, the explanatory power of the relevant theories, can be illuminated by looking at the ensemble of representational elements and processes that lie outside the content of the law proper. Cat (2005) calls these elements anomic and they include boundary conditions, state descriptions, structures, constraints, limits and mechanisms. This 'law-eccentric' knowledge is central, in his view, to both modeling the world and intervening in it.

With such content for the anomic elements, one may well wonder what role is left for the laws of nature themselves, as in the metaphysical viewpoint. As it turns out, it is exactly in this intermediate or boundary domain, the 'join' of the lawful and so-called extra-lawful, that the conflicts and dichotomies have been looked at exclusively from the point of view of classical logic. Most if not all of the issues raised in Chapter 5 and the present one seem to be involved, including continuity, the domain of application of differential calculus and the discontinuity of the boundary.

An additional problem is the difference in forms of symmetry breaking, explicit and spontaneous. Explicit symmetry breaking involves a clearly 'external' factor meaning in LIR terms one free of any prior interaction. As mentioned, spontaneous symmetry breaking (SSB) involves asymmetries in the states of systems that are not present in the prior equations of state. They, and the resulting emergence of new properties, can be described as a change in the order of a system due to instability under small internal statistical perturbations. Phenomena exhibiting such behavior at the macroscopic level include turbulence, phase changes of all kinds, superconductivity and onset of ferromagnetism. Are such changes captured by a law, or by a structural description of the state of the system? If one defines laws as applying before symmetry breaking, with a unifying character, and some other model as that from which asymmetrical states derive, then it is obvious that the latter is what bears the explanatory role.

In LIR terms, for any process to go forward, some form of symmetry breaking is required to get out of the state of a 'frozen' dialectic at a temporary limit of non-contradiction (of identity or diversity) but it is misleading to call it spontaneous. The LIR category of Process implies the dynamic interaction between actual and potential states that captures the phenomenon, 'before and after'. LIR thus has a law-like content that provides a causal interpretation of the critical value of a property. It is a mechanism in the sense that it describes the interaction of the different entities involved with their respective cause (and effect) aspects that increase the explanatory power of the concept of symmetry breaking. It is not the laws alone that are bearers of scientific knowledge, but structures and mechanisms also, as shown in the discussion of scientific-structural realism.

The difference between boundary conditions and constraints is that the former are time dependent and the second not, a property that will reappear in connection with my analysis of the basis for evolution.[24] In LIR, time is not fundamental in the first place, and the relation between a regime of boundary conditions and one of constraints can be explained in terms of the ternary/binary distinction. This is my basis for saying that a simple physical change of phase, with no internal representation, belongs in the category of Separability. Each case of boundaries and physical limits raises its own conceptual considerations, but LIR adds the generalization that no such limits can be considered absolute over an appropriately long time scale. LIR essentially fits a definition of bridge principles or correspondence rules that connect or coordinate abstract theoretical terms to or with more concrete terms to which the abstract theory is to be applied. LIR provides the basis for a incorporating an appropriate function for laws, models and the kind of philosophical Gestaltic switch that must be made depending on which level of description is the center of attention. What might be considered as *just* an epistemological shift between, say, two levels of explanation, cannot be properly interpreted unless the shift or switch is seen as a dynamic process, in the category of Process, in that the levels or elements are connected following the axioms of LIR.

I will now turn from the various theoretical aspects of the logic of and in reality developed above to their applications in some selected areas of philosophy and science. Before this, however, I will make one reference to a philosopher that I and others consider a major precursor of Lupasco, namely Hegel.

6.8 FRIEDRICH HEGEL: IDEALISM AND/OR CONTRADICTION?

I have not sought in this book to refer, except in passing, to the major precursors of the logic of/in reality. Nevertheless, because of the parallels to Hegel's dialectics, logic and ontology that may suggest themselves to the reader, it is useful to show in some detail how LIR should be differentiated from Hegel's system. Lupasco considered that his system included and extended that of Hegel. However, one cannot consider Lupasco a Hegelian or neo-Hegelian without specifying the fundamental difference between Hegel's idealism and Lupasco's realism. I share this realism and have tried to support it in previous sections in this chapter.

Both Hegel and Lupasco started from a vision of the contradictorial or antagonistic nature of reality; developed elaborate logical systems that dealt with contradiction and went far beyond formal propositional logic; and applied these

[24] At the cosmological level, the difference between a central law and an auxiliary constraint vanishes since in the effective quantum field representation of the universe, the wave function of the universe is described by the Wheeler-DeWitt equation in which time is absent.

notions to the individual and society, consciousness, art, history, ethics, and politics.

To give a rough idea of the complex relationship between Hegel and LIR, I will look at the logic; the source and locus; and the consequences of contradiction in the two systems. Hegel incorporated contradiction in logic and rejected the idea of a classical 'formal' logic that claimed to be a study of the form of thought in abstraction from content.[25] This is similar to the LIR view, also in the sense that thoughts and concepts reflect the universe in some way, but the dynamics involved are very different. Hegel proposed three axioms to describe reality that differ from our first reformulation of the classic axioms: A is A; A is non-A; non-A is A after all, or else they are all together. They imply a primarily diachronic sequence of A, non-A, and A as thesis, anti-thesis, and synthesis, whereas I have suggested both a synchronic and diachronic existence of A, non-A and T-state as an included third term, with the understanding that 'inclusion' refers to its location between the first two terms but at another level of reality or complexity.

Hegel's contradictions had their origin in the manifestations of Spirit as Idea or Concept, and, governed by Absolute Necessity as their Internal Teleology, they struggle to return to it in an ascending dialectic *via* the vehicle of human-consciousness-in-history being finally in a position to understand the process. At first sight, Hegel seems to have accepted contradiction as fundamental, until one realizes that, although the most ontologically significant relation is one of opposition between two things that mutually define each other, what is essential is their inner identity. In fact, if an element is in contradiction with itself as its negation, it disappears. This argument suits only Hegel's ontological conclusion that finite things disappear or die because they are failed attempts to 'embody the infinite' and makes it clear that Hegel lacked a physical/metaphysical basis for life, form and diversity of equal ontological value.

Hegel's logic is still Aristotelian in my view, integrated into a "metaphysical dialectic" (Lupasco 1986), in which the contradictory duality he introduced was continually abolished by successively purer and broader syntheses of antithetical terms, finally reaching the *Aufhebung*. Priest translates this as sublation, a dialectical transition in which a lower stage is both annulled and preserved in a higher one, and *Versöhnung*, reconciliation, because the new unity does not abolish the distinction. Here, one can see Hegel's picture as both synchronic and diachronic, in that the three terms are, at least sometimes, present at the same time. Nevertheless, contradiction is inherent even in the supreme identity of absolute spirit (*Geist*), since it is both embodied and opposed to its embodiment. This is nothing more than the philosophical expression of macrophysical becoming, governed by the 2nd Law of Thermodynamics. The subsequent dialectics of Marx and Engels simply transposes, to the social level of reality, the same Hegelian drive toward a synthesis involving the suppression of, in contrast to Hegel, *all*

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[25] In a paper for publication, "What is formal logic?", Jean-Yves Béziau shows, from the standpoint of contemporary logic, that the notion of 'formal' is neither essential nor useful to characterize it.

contradiction. One may, rather, take Hegel's idea that every phenomenon is a 'fragment' of *Geist* that reflects the latter's properties to foreshadow the contradictorial, dynamic view of energy, provided the difference in their role and behavior is not overlooked. For example, Hegel's description of the part-whole relation is close to that of LIR:

> …parts and whole are not identical, each only exists in opposition to the other and in order for each to exist for itself, each must as it were reduce the other to satellite status, dependent on itself. They are related essentially: each is only itself in relation to another that is its negation. … the contradictions in it (reality) that we see by looking at part and whole show that it is in movement, that it is constantly going over from unity to multiplicity and back again. But this relation of exteriorization is that of force (energy) and its manifestation. It is the whole seen dynamically as inner force that produces external reality as its manifestation.

It is easy to see "satellite status" as the result of potentialization. All this picture would require further to fit the logic of reality is the more complete picture of energy as the 'inner force' that grounds the contradiction.

Lupasco's system, however, involves *two* dialectics, ascending and descending (*diverging*) toward the non-contradictions of identity and diversity and a *third* dialectics *converging* toward contradiction. As above, the source of contradiction is inherent in energy and is the only existent reality. To say that material-energetic reality was the result or emanation of some other necessity as the foundation of the real amounts to tautology or mysticism, and Hegel's "obscure logical descriptions remained without a future for logic and science". As Lupasco expressed it, Hegel's system was "only half of a dialectics" (Lupasco 1947). The affirmative value of identification always transcends the negative value of diversification. In LIR, contradiction is established at the basic physical level.

As pointed out by Taylor (1975), Hegel's thesis depends on a premise of ontological necessity that in turn depends on the contradiction of the finite. Hegel established or expounded his ontological structure at 'high' levels, but his project required demonstration of his ontology at the lowest level of simply determinate beings, and his attempted proof of contradiction failed. I suggest that the realism of LIR successfully answers this major objection to the coherence of Hegel's system, without requiring a commitment to his basic thesis, the idealist part of his doctrine.

The Hegelian picture of the world has on-going relevance as the basis of a relevant philosophical vision of "embodied subjectivity, of thought and freedom emerging from the stream of life, finding expression in the forms of social existence, and discovering themselves in relation to nature and history." In my view, as exemplified throughout this book, Lupasco's view of contradiction founded a dynamics, whereas Hegel's did not, precisely because his system is *not* metaphysically and physically grounded at the "lowest level of simply determinate beings" that is, microphysical entities. Lupasco (1987b) showed that there is no *deductive* necessity in Hegel for thesis generating anti-thesis, let alone any subsequent fusion.[26] My view is that LIR can be considered as Hegel *naturalized*, since a physical basis in reality for Hegelian change has been defined.

Some comments about dialectical logic may be appropriate here. As discussed also by Priest (1989), Hegel distinguished between dialectics and formal logic – which was for him the Aristotelian logic of his day. The law of non-contradiction holds in formal logic, but it is applicable without modification only in the limited domain of the static and changeless. In what is generally understood as a dialectical logic, which LIR superficially resembles, the law of non-contradiction fails. The subsequent developments of formal logic, starting with Frege and Russell, have forced Hegel's conception of contradiction to be rejected or interpreted non-literally. Neo-Hegelians have attempted to conserve *this* principle of contradiction by emphasizing the factor of time: A is not identical to A, because time has passed in which changes have occurred; contradictions take place one after the other, etc. Articles purporting to describe dialectical logics still appear. In one example, a relation is proposed with non-linear dynamics in which dialectical logic is enhanced by mathematical logic. These and other moves, however, do not address, any more than Hegel did, the question of what drives the change from thesis to antithesis to synthesis, that is, how any term cannot 'stand on its own' but 'goes over' into its opposite or contradiction. Russell demonstrated, before Lupasco, that Hegel's logic could be deconstructed because it still presupposed traditional Aristotelian logic, but not for this more important reason.

Piaget, also, did not go beyond the standard Hegelian form of Marxist dialectical materialism. This correctly accords a central role to conflict and contradiction in the transformation of social realities. However (Priest 1989), Marxist dialectics fail to give an adequate account of the true contradictions involved in society: an inconsistent or paraconsistent logic is necessary for such an account, albeit in my view not sufficient. A logic of the LIR form seems required to characterize the emergence of new structures from real contradictions.

6.9 THE LIR APPROACH TO PHILOSOPHY

At several points in the previous discussion, I have referred to the difficulties associated with philosophical arguments of various kinds and suggested that LIR could make specific contributions to resolving them. The purpose of this

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[26] Lupasco rejected Hegel's dynamic relation between being and becoming, since he wanted to limit contradiction to the domain of becoming, which drastically limits the value of Lupasco's thesis. In fact, Lupasco's universe consists of almost nothing but Becoming as functional contradiction, the alternation of the actualization of a phenomenon, with the potentialization of its contradiction, and the actualization of the former, plus emergent T-states. Contradiction is absent only in affect or affectivity, which has no energetic aspects and is the only constituent of being. This metaphysical position is incompatible with the non-naïve realism of LIR.

section is to provide a characterization of some general aspects of philosophy and philosophical structures and what the application of the principles of LIR might accomplish. My criticism of philosophical arguments is that they often depend on some form of absolute separability of opposing or dichotomous terms. This takes place *via* the importation as noted, explicit or implicit, of principles of binary logic exemplified in the standard notions of time, space and causality.

My catch-all definition of philosophy is that of a set of disciplines – logic, ontology, metaphysics, epistemology – and their use *via* reasoning and analysis to arrive at a viewpoint about what it is for human beings to be alive and think. This definition has the following consequences:

1. The relations between the disciplines are themselves extremely complex, but, again pragmatically, domains can be identified in which one or the other is the preferred form of description. In turn, this can assist the characterization of the additional key relation, namely, between philosophy and science as differently constituted modes of inquiry.
2. Philosophical statements must be assumed to say *something* meaningful about the underlying reality, physical or mental, and it is accordingly legitimate to ask if they do so successfully or not.
3. If, on the other hand, the statements are claimed to be (nothing but) metaphors, it is legitimate to ask what the reality is like to which the metaphors refer.

The key terms of my (very limited) analysis of philosophy in the LIR system are *experience*, *separability*, and *immanence and transcendence.*

- **Experience**

The logic of/in reality is a logic of experience, as well as of physics, that gives equivalent ontological value to both physical and mental phenomena. It is a philosophical position that places experience within philosophy without, however, equating it with Humean empiricism. Lupasco said that "experience is logic and logic is experience", and logic, experience and method were synonyms (Lupasco 1947). This position conflicts with the statement attributed to Wittgenstein (Ambrose 2001) to the effect that

> I am going to exclude from our discussion questions which are answered by experience. Philosophical problems are not solved by experience, for what we talk about in philosophy are not facts but things for which facts are useful.

In addition to Heidegger and Sartre, a few lesser-known, European philosophers accepted the philosophical relevance of experience, e.g., Piaget, Bachelard and Gonseth. The system of Gonseth, for example, has the advantage of providing a smooth connection to science (Pouget 2004) through mutual reinforcement of theoretical (logical in the standard sense), experimental and intuitive perspectives. Its 'open methodology' refers to openness to experience.

The interactions implied in Gonseth's approach can be well described in Lupascian terms, and contrast with the Deleuzian view below.

Wittgenstein claims in the *Tractatus* that logic does not deal with the world, but with the possible. But such a dualism is now untenable (Peruzzi 1994). The development of the categorial approach to modalities clarifies how the possible pervades or intertwines with the real. LIR theory emphasizes the role of potentialities, starting at the level of basic physics, and provides an interpretation of 'intertwining'.

- **Separability**

As I have shown, most philosophical arguments seem to depend on some form of absolute separability of dichotomous terms. This takes place *via* the importation, explicit or implicit, of principles of binary logic exemplified in the use of standard notions of time, space and causality.

Derrida's philosophical concept of '*différance*'[27] is one that rather supports the principles of LIR. He questions the structure of binary oppositions (in the LIR view, the lack of recognition of how they interact), and says that *différance* "invites us to undo the need for balanced equations, to see if each term in an opposition is not after all an accomplice of the other. At the point where the concept of *différance* intervenes, all of the conceptual oppositions of metaphysics, to the extent that they have for ultimate reference the presence of a present …(signifier/signified; diachrony/synchrony; space/time; passivity/activity, etc.) become non-pertinent. A new definition for dialectics is necessary" (Derrida 1974).[28] LIR takes this intuition and provides a new 'structure' of the oppositions in question and what it might mean to "be an accomplice".[29]

Deleuze is a contemporary philosopher, on the other hand, who considered philosophy as a constructivism (Deleuze and Guattari 1991), implying an intuitionist logic that depends on the maintenance of the law of absolute non-contradiction. Accordingly, all the concepts he uses are to be placed in the sub-category of Separability.

My claim is thus that despite, or rather because of the fact that the various philosophical disciplines (disciplines within philosophy) overlap, the application of the PDO and its consequent ontology defines domains in philosophy that are characterized by whether binary logic or the ternary logic of/in reality primarily apply. Thus, aspects of LIR may still be considered within the multiple traditions of analytical philosophy, as a logical system into which physical processes, as well as propositional ones, may be translated.

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[27] The neologism *différance*, with an 'a' in the third syllable, differs from the word for difference in French which is spelled *différence*. *Différance* is a kind of dynamism in the LIR sense.

[28] Derrida's concept of 'supplementarity' can be seen as a kind of emergent third term.

[29] Priest (2002) also shows that the notion of *différance* instantiates both the inexpressibility of all linguistic expressions and its own expression and that this real contradiction is inherent in Derrida's system.

Philosophers may also wish to note that the paradox of analysis does not arise in LIR, since by Axiom **LIR1**, *analysandum* A and *analysans* C in the form ‘A is C’ can not have exactly the same meaning due to identity. A is and is not C, and this gives substance to the concept that the statement can be informative if C has a “different or more richly articulated sense than A”. Finally, LIR opposes what Dummett has proposed as the fundamental axiom of analytical philosophy, namely, that “the only route to the analysis of thought goes through the analysis of language”. The LIR analysis of ‘thought’ goes through the analysis of the energetic processes at hand.

- **Immanence and Transcendence**

I discussed immanence and transcendence earlier in this chapter in relation to causation and determinism and proposed a contradictorial relation between them. The absence of such a relation in the work of Deleuze further illustrates my thesis.

Deleuze has probed deeply into the relation between real events and philosophical concepts and ‘events’, especially, immanence, transcendence, life and meaning. His work is significant for this study because of the *way* in which he rejected dialectics (Lardreau 2006), although he accepted a reciprocal relation between his most important terms – Immanence and Life.[30]

The best way of summarizing his system is to see it as a structure of abstract relations between terms which define two domains – ‘philosophy’ and ‘science’. Deleuze’s philosophy includes transcendental structures of several kinds: two levels of idealized structures: a pre-philosophic chaos and a plane of immanence (in which language games operate), which ‘cuts’ through the chaos (Bento Prado 2003); the transcendental field; the metaphysical surface and the plane of immanence. Examples of separability in ‘philosophy’ are to be found in Deleuze’s construction of meaning as a metaphysical surface, or a ‘line’, a middle between extremes (Badiou 2006), that are the loci of the separation of different aspects of phenomena, propositions and things (Deleuze 1969).

The plane of immanence provides a field in which concepts and meanings are produced, circulate collide, etc. Life is transcendental, but the plane of immanence is *a* life; “it is not immanence *in* life, but immanence which is not *in* anything.” If it were immanence in life it would lose its character as being which possesses in itself the reason for its being, as opposed to a being whose existence depends on that of another. A critical task for this philosophy is to retain

[30] Life is simply a more affirmative and better-specified concept than Immanence. Life rather than Immanence opposes Transcendence not only as a general concept, but as the form in which (or by which) Transcendence is specified, namely Dialectics. Term-to-term oppositions remain an essential part of philosophy – Negation-Transcendence *vs*. Affirmation – Immanence, and Dialectics, placed in opposition to Life, in opposition to an integral ‘immanentism’. Transcendence is thus specified by Dialectics, but its relation to Immanence is not Dialectics. These are not dynamic relations in the LIR sense, in which the relations between non-absolute elements constitute the ‘dialectics’, and there is no difference between opposition and dialectics.

a property – the infinite – that is allegedly ‘lost’ in science.[31] The objective of philosophy is not to recognize objects; it is the task of science to convert the objects of the plane of immanence into determined states-of-affairs.

The philosophy of Deleuze illustrates the results of an application of the concepts of immanence and transcendence that does not define or include any dynamic dialectical relation between them. The domain of Deleuze’s philosophy is a realm, governed by binary logic, of undetermined, idealized entities, Humean in its lack of effective interactions. In the domain of reality to which LIR applies, the existence of all beings depends and is defined by that of others. Infinities and infinitesimals do not exist, but are replaced by transfinite values, and immanent and transcendent aspects of phenomena are alternately actualized and potentialized.

My interim conclusion, that will be valid for my use of the term ‘philosophical’ in the remainder of this book, is that LIR can discuss philosophical problems in physical, dynamical terms that do not require recourse to any imaginary, abstract structures to separate or define aspects of reality. Any such aspects that are considered ‘virtual’ or ‘possible’ in Deleuze are so ‘in philosophy’ but ‘in reality’ are instantiated as potentialities.

The practice of philosophy as an activity that is ‘chaotic’, not subject to formal rules (Wittgenstein) brings it close to a form of artistic creation; its language-games are from this point of view exactly that, games, *Glasperlenspiele*, and do not necessarily have anything to tell us about reality or real behavior. Games as they are usually understood are binary phenomena, with winners and losers. Only infinite or transfinite games, in which the objective is to keep the game going, seem to me to involve dynamic real relationships, to which the rules of LIR might be applicable.

The example of Deleuze should not be taken to mean that I believe all philosophical characterizations involve imaginary structures or processes. As a counterexample, I suggest Jankélévitch’s view of irony as being capable of transforming apparently conformist attitudes into a ‘higher synthesis’, that is, something with additional real meaning. This is a real emergent process in LIR terms. The opposite of this ‘ironic conformism’ is ‘conformist extremism’ that moves back, ‘through superficial and mechanical anti-theses’ toward the non-contradictory thesis from which it started out (Jankélévitch 1964).

The LIR view of philosophy expressed here ultimately combines, as in the conception of D. W. Smith (2004), phenomenological and ontological standpoints, in particular in relation to the most complex philosophical questions of life and mind. It differs from that of Smith in its picture of ontology, as I have shown above, but it is also a systematic approach to the structures of all real phenomena, including mind.

[31] I discussed the concepts of infinity *vs*. transfinity in Section 2.3.1. As stated by the Argentine poet Jorge Luis Borgès: “Infinity is the concept that corrupts and alters all others”.

6.9.1 The Philosophy of Mind

The existence of a phenomenon in the universe capable of reflecting on its own existence and referring to it symbolically is only one of the innumerable ways in which the human mind has been described. The philosophy of mind can be considered as the sum of all theories that attempt to explain both its physical or quasi-physical aspects – biological, neural, causal, computational – and its psychological components – intellectual, emotional, social, and the relations between mind and the objects, internal and external, physical and linguistic, that are processed by it. Dealing with the concept of mind also requires dealing with the related concepts of consciousness and intentionality, the unique character of mental phenomena, considered by some as parallel and by others as equivalent to that of mind. Consciousness in turn is accompanied by, or may be equivalent to, its self-referential properties, self-consciousness. The problem is thus enormous, and only this start on an LIR theory of consciousness and mind will be made in this book.

The central problem for a philosophy of mind is to show how physical tokens, the neuro-physiological processes occurring in the brain, can give rise to mental tokens that retain the properties of intentionality, "aboutness", individuality and some level of causal powers or functionality. The weak point in some current views (Esfeld 2006) is that physical and mental tokens must be identical (identity theories of mind (ITM)). The LIR principle of opposition at all levels of perception, mental processing and action gives the logical and scientific basis for saying that something is the same *and* different, here physical and mental tokens, in dynamic opposition at the same time. It has now been shown that the energy required for the brain's responses to controlled stimuli is extremely small compared to the on-going amount of energy that the brain normally and continually expends. LIR thus supports the idea that a "balance of opposing forces" (Raichle 2006) that has a high energy cost is a necessary element of brain function.

At this stage, I thus simply state as a postulate that *no* theory of mind, philosophical or metaphysical, that is based on entities, physical and mental in the category of Separability, can provide adequate explanations of mental phenomena. Philosophers of mind may, however, already see that a revision is possible of Brentano's basic thesis of intentionality as involving a *separation* of mental and physical. If there is a philosophical attitude endorsed by LIR, it is, certainly, one of looking for what links, rather than what separates, aspects of phenomena.

My additional claim, which should be obvious, is that the complexity of mental phenomena and their relations of partial self-reference exclude the application of the principles of classical logic except to the most reductionist, mechanistic models of brain function. That the principle of bivalence continues to be used or implied in discussions of intentionality is simply a measure, for me, of the extent of the problem.

6.9.2 The Naturalization of Phenomenology

I have claimed that the PDO and the categorial features of the logic of/in reality are instantiated, also, at the mental level. The dualism of LIR does not involve ‘flirting’ with a classical, indefensible dualism of body and mind, one neurological and the other mental. However, why should the sole presence of a dynamic, interactive dualism, a non-reductive physics involving potentialities as well as actualities, insure preservation of the specific qualities of human thought, that is, provide an adequate explanation for its operation? A successful scientific theory of human cognition should account for its phenomenality, the fact that things have appearances, but appearances can, also, be shared. The ultimate objective is to bridge the explanatory gap between a phenomenological mind (consciousness) and brain and to naturalize phenomenology, bringing subjective conscious experience within the purview of natural science. The following remarks indicate some of the directions the LIR discussion might take.

Any view of consciousness and mind must account for both external events as they are cognized – phenomenological data – and their internal processing. However, phenomenology cannot be taken into cognitive science as such without substantial modification. To be scientific, phenomenology thus requires some form of ‘naturalization’, but there are some inherent limitations in both cognitive science and other current approaches. Most of these theories involve a kind of realism and objectivism that either eliminates all subjective, ‘irrational’ dimensions of the phenomena under study as ‘unscientific’ or assign them to a second-rate logical category.

As one example, Smith’s strategy for the naturalization of phenomenology is to extend the concept of the natural world to the processes of intentionality, viewed as a physical phenomenon. However, his ‘Unionism’ is subject to the condition that the unity of the mental and physical is to be understood as the product of a categorical constitution and not as a factual reality. Naturalization in this way is alleged to avoid “reduction to causal or computational processes along the lines envisioned by current cognitive science,” but it is difficult to see how intentionality defined in this way would not be epiphenomenal.

LIR challenges the structure of both cognitive science and Smith’s critique of it as embodying classical concepts of cause and separability, e.g., between internal and external. Like standard cognitive science, LIR can propose a “close and explicit relationship between brain mechanisms, their existence within an organism, and a surrounding world with which there is an unceasing coupling” (Petitot et al. 1999), but the basis for such coupling, as in my critique of Maturana in Chapter 8, needs to be spelled out.

In the next chapter, I return to issues in physical science, with the recognition, however, that these very much include the structure of the phenomenological world.

References

Ambrose, Alice, trans. 2001. *Wittgenstein's Lectures*. Amherst, MA: Prometheus Books.

Arntzenius, Frank. 1999. Notes to Reichenbach's Common Cause Principle. In *The Stanford Encyclopedia of Philosophy*, ed. Edward N. Zalta. http://plato.stanford.edu/archives/entries/Rpcc/notes.html/.

Badiou, Alain. 2006. *De la vie comme nom de l'être*. *Philosophie* 89: 78–93.

Bell, John L. 1998. *A Primer of Infinitesimal Calculus*. Cambridge: Cambridge University Press.

Bell, John L. 2006. Abstract and Variable Sets in Category Theory. In *What Is Category Theory?* Monza, Italy: Polimetrica International Scientific Publishers.

Bento Prado de Almeida. 2003. Plane of Immanence and Life. In *Introduction to Deleuze's Philosophy*, ed. J. Khalfa. London: Continuum Editions.

Bird, Alexander. 2006. Potency and Modality. *SYNTHESE* 149: 491–508.

Borgès, Jorge-Luis. 1951. *Histoire de l'infamie. Histoire de l'éternité*. Paris: Éditions du Rocher.

Boyd, Richard. 2002. Scientific Realism. *The Stanford Encyclopedia of Philosophy (Summer2002 Edition)*, ed. Edward N. Zalta. http://plato.stanford.edu/archives/spr2002/entries/scientific-realism/

Bueno, Otavio. 1999. Empiricism, Conservativeness and Quasi-Truth. *Philosophy of Science* 66: 474–485.

Cao, Tian Yu. 1997. *Conceptual Developments of 20th Century Field Theories*. Cambridge: Cambridge University Press.

Carvalho, Tadeu. 2006. Thesis, State University of Campinas, Brazil.

Cat, Jordi. 2005. Modeling Cracks and Cracking Models. *SYNTHESE* 146: 447–487.

Davies, Paul. 2007. Why is the Universe Right for Life? *Public Science Symposium*. Montreal, Canada: McGill University, January 25.

Debrun, Michel. 2000. A Idéia de Auto-organização. In *Auto-organizaçao: estudos interdisciplinares*, eds. M. Debrun and O. Pessoa Junior. Campinas, Brazil: University of Campinas, Center for Logic, Epistemology and the History of Science 30: 13.

Deleuze, Gilles. 1969. *Logique du Sens*. Paris: Les Éditions de Minuit.

Deleuze, Gilles and Felix Guattari Felix. 1991. *Qu'est-ce que la philosophie?* Paris: Les Éditions de Minuit.

Derrida, Jacques. 1974. *Of Grammatology*. Baltimore, MD/London: Johns Hopkins University Press.

Drewery, Alice. 2005. Essentialism and the Necessity of the Laws of Nature. *SYNTHESE* 144: 381–396.

Emmeche, Claus. 2003. Causal Processes, Semiosis, and Consciousness. In *Process Theories: Cross-disciplinary Studies in Dynamic Categories*, ed. J. Seibt. Dordrecht, The Netherlands: Kluwer.

Esfeld, Michael. 2006. From Being Ontologically Serious to Serious Ontology. In *John Heil. Symposium on His Ontological Point of View*, ed. M. Esfeld. Frankfurt (Main)/Germany: Ontos-Verlag.

Heil, John. 2005. Dispositions. *SYNTHESE* 144: 343–356.

Hitchcock, Christopher. 2002. Probabilistic Causation. In *The Stanford Encyclopedia of Philosophy (Fall 2002 Edition)*, ed. Edward N. Zalta. http://plato.stanford.edu/archives/fall2002/entries/causation-probabilistic/.

Hoefer, Carl. 2005. Causal Determinism. In *The Stanford Encyclopedia of Philosophy (Summer 2005 Edition)*, ed. Edward N. Zalta. http://plato.stanford.edu/archives/sum2005/entires/determinism-causal/.

Jankélévitch, Victor. 1964. *L'Ironie*. France: Flammarion, Champs.

Khlentzos, Drew. 2004. Semantic Challenges to Realism. In *The Stanford Encyclopedia of Philosophy (Winter 2004 Edition)*, ed. Edward N. Zalta. http://plato.stanford.edu/archives/win2004/entries/realism-sem-challenge/.

Ladyman, James and Don Ross. 2007. Every Thing Must Go. Metaphysics Naturalized. Oxford: Oxford University Press.

Lange, Marc. 2005. Laws and Their Stability. *SYNTHESE* 144: 415–432.

Lardreau, Guy. 2006. *L'histoire de la philosophie comme exercice différé.* In *Gilles Deleuze; Immanence et Vie*. Paris: Presses Universitaires de France, Quadrige

Laudisa, Federico. 2006. *Le principe de causalité entre empirisme logique et néokantisme*. *Philosophie* 89: 78–93.

Longo, Giuseppe. 1999. The Mathematical Continuum. In *Naturalizing Phenomenology. Issues in Contemporary Phenomenology and Cognitive Science*, eds. J. Petitot et al. Stanford, CA: Stanford University Press.

Lowe, E. J. 2002. *A Survey of Metaphysics*. Oxford: Oxford University Press.

Lucas, John R. 1961. Minds, Machines and Gödel. *Philosophy* XXXVI: 112–127.

Lucas, John R.. 1990. Paper Read to the Brighton Turing Conference, April 6, 1990, in Brighton, England. http://users.ox.ac.uk/~jrlucas/Godel/brighton.html.

Lupasco, Stéphane. 1947. *Logique et Contradiction.* Paris: Presses Universitaires de France.

Lupasco, Stéphane. 1967. *Qu'est-ce qu'une structure?* Paris: Christian Bourgois.

Lupasco, Stéphane. 1986. *L'énergie et la matière vivante.* Monaco: Éditions du Rocher (originally published in Paris: Julliard, 1962).

Lupasco, Stéphane. 1987a. *L'énergie et la matière psychique.* Paris: Editions le Rocher (riginally published in Paris: Julliard, 1974).

Lupasco, Stéphane. 1987b. *Le principe d'antagonisme et la logique de l'énergie.* Paris: Editions du Rocher (originally published in Paris: Éditions Hermann, 1951).

Massimi, Michela. 2005. *Pauli's Exclusion Principle. The Origin and Validation of a Scientific Principle.* Cambridge: Cambridge University Press E-book. http://www.cambridge.org/9780521839112.

McArthur, Daniel. 2006. *Journal for General Philosophy of Science* 37: 209–224.

Menzel, Christopher. 2003. Actualism. In *The Stanford Encyclopedia of Philosophy (Spring 2003 Edition)*, ed. Edward N. Zalta. http://plato.stanford.edu/archives/spr2003/entries/ actualism/.

Miller, Alexander. 2002. Realism. In *The Stanford Encyclopedia of Philosophy (Winter 2002 Edition)*, ed. Edward N. Zalta. http://plato.stanford.edu/archives/win2002/entries/realism/.

Morganti, Matteo. 2004. On the Preferability of Epistemic Structural Realism. *SYNTHESE* 142: 81–107.

Mumford, Stephen. 2005. Laws and Lawlessness. *SYNTHESE* 144: 397–413.

Peirce, Charles Sanders. 1955. Philosophy and the Sciences: A Classification. In *Philosophical Writings of Peirce*, ed. J. Buchler. New York: Dover Publications (originally published as MS *Minute Logic II.*1.203 (1902). Vol. 1 of *Collected Papers of Charles Sanders Peirce*, eds. C. Hartshorne and P. Weiss (Cambridge, MA: Harvard University Press, 1931)).

Penrose, Roger. 2005. *The Road to Reality.* New York: Knopf.

Peruzzi, Alberto. 1994. Prolegomena to a Theory of Kinds. In *The Logical Foundations of Cognition*, eds. J. Macnamara and G. E. Reyes. New York: Oxford University Press.

Petitot-Cocorda, Jean. 1992. *Physique du Sens.* Paris: CNRS Éditions.

Petitot, Jean et al. (eds). 1999. *Naturalizing Phenomenology. Issues in Contemporary Phenomenology and Cognitive Science*. Stanford: Stanford University Press.

Poli, Roberto. 2004. Process Semantics. In *After Whitehead: Rescher on Process Metaphysics*, ed. M. Weber. Frankfurt, Germany: Ontos-Verlag.

Pouget, Pierre-Marie. 2004. *Les Ambitions Légitimes de la Philosophie.* Pailly, Switzerland: Editions du Madrier.

Priest, Graham. 1989. Dialectic and Dialetheic. *Science & Society* 53: 388–415.
Priest, Graham. 1995. *Beyond the Limits of Thought*. Oxford: Clarendon.
Priest, Graham. 2002. *Beyond the Limits of Thought*. Oxford: Clarendon Press.
Raichle, Marcus E. 2006. The Brain's Dark Energy. *SCIENCE* 314: 1249–1250.
Roberts, John T. 2005. Measurability and Physical Laws. *SYNTHESE* 144: 433–447.
Salthe, Stanley N. 2004. The Spontaneous Origin of New Levels in a Scalar Hierarchy. *Entropy* 6: 327–343.
Schaffer, Jonathan. 2003. The Metaphysics of Causation. In *The Stanford Encyclopedia of Philosophy (Winter 2003 Edition)*, ed. Edward N. Zalta. http://plato.stanford.edu/archives/win2003/entries/causation-metaphysics/.
Schaffer, Jonathan. 2006. *Le trou noir de la causalité. PHILOSOPHIE* 89: 40–52.
Shoemaker, Sydney. 1982. Causality and Properties. In *Identity, Cause and Mind*. Cambridge: Cambridge University Press.
Sklar, Lawrence. 1992. *Philosophy of Physics*. Boulder, CO/San Francisco, CA: Westview.
Smith, David Woodruff. 2004. *Mind World*. Cambridge: Cambridge University Press.
Sober, Elliott and Larry Shapiro. 2007. Epiphenomenalism – The Do's and the Don'ts. In *Studies in Causality: Historical and Contemporary*, eds. G. Wolters and P. Machamer. Pittsburgh, PA: University of Pittsburgh Press, pp. 235–264.
Taylor, Charles. 1975. *Hegel*. Cambridge: Cambridge University Press.
Van Inwagen, Peter. 2002. *Metaphysics*. Boulder, CO: Westview.
Varela, Francisco J. 1999. The Specious Present. In *Naturalizing Phenomenology. Issues in Contemporary Phenomenology and Cognitive Science*, eds. J. Petitot et al. Stanford, CA: Stanford University Press.
Weiner, Matthew and Nuel Belnap. 2006. How Causal Probabilities Might Fit into our Objectively Indeterministic World. *SYNTHESE* 149: 1–36.
Woodward, James. 2001. Causation and Manipulability. In *Stanford Encyclopedia of Philosophy (Fall 2001 Edition)*, ed. Edward N. Zalta. http://plato.stanford.edu/archives/fall2001/entries/causation-mani/.

7 LIR AND PHYSICAL SCIENCE: TIME, SPACE AND COSMOLOGY

Abstract The question of the nature of time and space, which determines how one looks at both phenomena and theories of reality, will be explored in this chapter. The LIR view of time and space is compared with current views in general relativity, and the problems of 'subjective' and 'objective' time and of an independent 'background' space-time are discussed. The mode of description of space-time and of the relation of simultaneity and succession in the LIR framework is quite novel, and is applied to issues in both science and philosophy, e.g., to the metaphysics of being and becoming. Quantum mechanics, including the operation of the widely discussed concept of Bohr complementarity, are interpreted in LIR terms. Like relational quantum mechanics, the scientific structural realism of LIR places the emphasis on relations rather than states, while maintaining the role of both. Recent developments aimed at the unification of quantum theory and gravity within general relativity tend to confirm the role of relations as in the LIR framework. The principle of self-duality in these theories may be reflected in the LIR principle of dynamic opposition. A new cosmological theory, the cyclic model of the universe, is examined from the LIR standpoint.

7.1 TIME AND SPACE: PRELIMINARY REMARKS

Classical notions of time and space and of simultaneity and succession still underlie reasoning in almost all of fields of thought and everyday human behavior. To begin to put the LIR theory in perspective, I first will summarize a view of time and space that might be held by a reasonably well-read person[1]:

> (a) Space and time are not independent, but are related by the laws of general and special relativity, such that one should refer to the world as a four-dimensional continuum of three spatial dimensions and one temporal dimension.

[1] I realize that this is a caricature.

(b) Time and energy are also related, in the sense that times closer to the Big Bang correspond to higher energies.

(c) At the quantum level, there are additional dimensions, but they are hidden at the macroscopic level; correlations between states of quantum particles over arbitrary distances are possible (non-separability); and quantum entanglement between states of particles provides a novel basis for information storage and encrypted exchange.

The differences between quantum and macroscopic properties do not seem to have consequences at the phenomenological level. When I am on a trip 3,000 km from my wife, we are not connected in any physical sense, with the exception of the (negligible) gravitational force between us. The clock time to which we refer is the same; we are not traveling at relativistic speeds.

Problems remain, however, since the indicated unification of the notions of space and time in a four-dimensional physical structure is epistemically contradictory to their diversity in phenomenological experience. In addition, even within human experience, there is the possibility, given more than one individual consciousness, of two estimates of 'the' time. I will address in what follows a few of the multitude of issues that are involved in both. For example, the phenomenological problem is one origin of anti-realist views that time, among other things, is what I imagine it to be. The question then becomes, if the solipsist position (only I am real) is rejected, what can account for the consensus between most people on the common measures of time and space? Proving clearly that solipsism is false, in that it violates some fundamental physical principle, has also been difficult.

Another way of stating the problem of time is that given its very real appearance and its probably different but non-perceivable reality that (one assumes) is present in the quantum phenomena that constitute us, and the universe we inhabit, what is the relation between them? Further, is there some assumption we have made in the model presented by general relativity (GR) whose origin is in classical logic that falsifies the debate? I will assume for purposes of discussion that the PDO is accepted and that the axioms of LIR are applicable at all levels of reality, including that of the universe itself.

I will organize my analysis as follows: Section 7.2 will present the LIR conceptions of time, space and space-time derived from the fundamental postulate and axioms of LIR plus its minimum definition of existence as the existence of two 'things' and an oppositional relation between them. Section 7.3 is a review of some concepts of time in philosophy that could now be reinterpreted. Section 7.4 will look at their implications for the philosophy of being and becoming. Section 7.5 introduces the essential correspondences between LIR and quantum mechanics, especially relational quantum mechanics and complementarity. Section 7.6 revisits the entire foundation of the logic of/in reality. It establishes the correspondence of its principles with current realistic formulations of general relativity, which includes a metaphysics of relations that also is an integral part of LIR theory. Finally, I propose that a recent model of the (currently) expanding universe also can be interpreted in LIR terms. This strategy, I hope, will convince the reader that the principle of dynamic opposition and the axioms of LIR are concepts relevant to the understanding of dynamic phenomena at all levels of reality, including that of the universe itself.

7.2 THE LIR THEORY OF SPACE-TIME

7.2.1 The LIR Categories of Time

I have proposed a category of Process to describe aspects of change or becoming, applicable to real events instantiating the category of Energy (or its quantum field equivalent). We have also seen that the entities of these categories fit the axioms of Conditional Contradiction and Asymptoticity, which require not only reciprocal actualization and potentialization, but that no actualization or potentialization can be complete and absolute.

In LIR, time, space and space-time, as these terms are commonly understood are *not* categories themselves. Rather, they are concepts of dynamisms (Chapter 3) that fit the category of Dynamic Opposition. This leads me to a first theorem of time:

Theorem 7.1: The actualization or potentialization of a logical event is not a function of time, A_t or P_t, but time that is a function of the dynamics of actualization and potentialization, t_A or t_P.

If an actualization of an element or its opposite is rigorous and absolute, there is no more time; the logical element is fixed and immutable. Process as such is impossible. If the consequent potentialization is, accordingly, infinite, the element disappears along with the temporality. The notion of time enters into the concepts of wear, change and transformation, all of which require modification of identity. Complete actualization or potentialization would be equivalent to an end of time, in the heat death of the universe, for example, the absolute homogenization of energy at the lowest level. Time is only possible due to the existence of contradictory dualities whose energetic antagonism is both the source and necessary condition of partial, non-infinite actualizations and potentializations. Time is thus, like the dynamisms that generate it, neither finite nor infinite but transfinite. Again, reversing Kant, time is not a condition of phenomena, but conditioned by phenomena, due to their logical dynamic structure. The first ‘object’ to instantiate both a time and a space would be, of course, the singularity of the Big Bang, or its latest non-absolute replacement.[2] To repeat, time, like space, as will be discussed, results from the development of a process that actualizes itself, the necessary consequence of the dynamic structure of an energetic world.

This implies that

Theorem 7.2: Objects and events do not exist or take place in time, but are the sources of, or 'unroll' (*déroulent*) their own time.

Classical logic is non-temporal, since its rigorous non-contradiction, pure identity and relations and implications are totally fixed, incompatible with time and change. Together with much else, time is relegated to the domain of the psychological and irrational. Temporal logics are modal logics that introduce operators for discussing *propositions* whose truth is different in an apparent, past, present and future, but these logics do not provide a model for the dynamics of change as such. Smooth Infinitesimal Analysis, which is based on standard logic, captures only temporal aspects of phenomena that are amenable to description by differential equations, but neither the realities of phenomenological time, nor physical realities that are discontinuous or both continuous and discontinuous.

Varela's theory of biological and subjective time, that of Varela, for example, that links time with affect, tend tends to support the LIR view. Standard views of the experience and perception of time (Le Poidevin 2000), blocked in a classical logical framework, do not. As an alternative to the classical philosophical notion of time based on a classic logic of identity and homogeneity, time in the empirical philosophy of Bergson is a heterogeneous duration, psychological, biological, vital, etc. However, it was defined as being outside logic, involving another classical *distinguo* that was simply opposite to that of Kant – what is heterogeneous in Bergson is logical; what is homogeneous is not.

According to LIR,[3] there are three kinds of time: a positive time corresponding to the identifying actualizations of positive ortho-deduction, physico-chemical causality; a negative time inverse to the former of differentiating actualizations, associated with the processes of living matter. The two involve both continuities and discontinuities, like any dialectic process, and their dialectic results in the emergence of a third time, t_T, at the mid-point, corresponding to a minimum of non-contradiction and a maximum of tendency to contradiction, as we have seen elsewhere. This is the time of quantum and neuropsychical entities, which could provide a logical basis for the phenomenological 'nowness' of Varela (1999). In any event, it would be fair to say that the LIR scheme provides a more

[2] See below, Section 7.6.4, on a cyclic model of the universe.

[3] See Lupasco (1987).

thorough description of the relation between 'passivity and activity' and 'invariance and change' than that suggested by the term 'mixture' (see below, Section 7.4.2).[4]

The work of Carlo Rovelli on quantum gravity includes a discussion of the way in which a variable 't' for time can be eliminated from the equations of basic physics. Not only is neither time nor space absolute, but "time does not exist". Equations describe rather the way in which two effectively observable quantities, a beating pulse and an oscillating pendulum, evolve with respect to one another (Rovelli 2006).

One asks not how many beats or oscillations per second, but how many beats per oscillation. There is no reason, in my view, not to extend this concept to other pairs of entities that are in direct interaction.

7.2.2 The LIR Categories of Space

The logic presented here, in which all is process and energy, dynamically contradictorial, is a logic *par excellence* of the *a posteriori*. Therefore, if space is a logical phenomenon, it is *a posteriori*, like time, not a Kantian condition of phenomenal actualizations but conditioned by them. Simultaneity requires space; if events do and do not succeed one another, a required notion of space can develop. The moment two elements exist at once, simultaneously, they imply, simply because they don't coalesce, a space, a location with a distance between them.

By the fundamental postulates of the logic of energetic phenomena, the generation of a transfinite series of dualities of dualities (systems of systems) necessarily generates the logical space for them, which Lupasco called configurations or logical forms. Lupasco identified this space with the configuration space of quantum physics.

The link between space and time is achieved as follows (Lupasco 1987):

> In every actualization, and precisely because there exists an antagonistic actualization relative to a contradictory potentialization and never the possibility of an absolute actualization, a contradictional conjunction (of some sort) essentially and irreducibly accompanies the development of the process of actualization and potentialization. In other words, there is always a simultaneity of an element or event that is more or less actualized and of an element or event more or less potentialized.

This contradictional conjunction is present during the unfolding of any actualization in such a way that one can say that the logical temporality that is generated by energy is always tied to a logical spatiality that is generated similarly. The space of the expanding universe is the space of a dynamism that actualizes or potentializes itself. This concept is thus based on the structure of energy itself and

[4] Rovelli suggests that fundamental science is in a state of confusion and that existing ideas may not help, "or maybe something is missing and we need a new idea". The PDO is my candidate for the "something that is missing" in science, philosophy and logic.

its logical aspects. There are both spaces and times, which are *proper to* individual phenomena, functions of their actualization.

Thus

Theorem 7.3: Objects and events do not exist or take place in space, but are the sources of, or ‘unroll’ (*déroulent*) their own space.

Objects are not in space, but space is in objects; objects are not localized, but localize, create localizations. It is in this admittedly informal way that such a space has the same characteristics as a configuration space, that is, it is a function of the number of its elements and of their degrees of freedom; it is what links the elements, their relations, that permits their co-existence in a system and their simultaneity. There is no spatial location outside of what is inside it. Logical space and logical time constitute a space-time proper to each system, a configuration space-time. Time cannot be separated from space, and only space-time exists.

I thus construct three (kinds of) space in an analogous manner to that of the three times: a positive space of the physical world and its matter, of homogenizing causality, of particles following Bose-Einstein statistics and that of the set M of the Axiom of Choice of Zermelo-Frankel set theory (cf. Appendix 2), a space that could be called photonic space; a negative or heterogenizing space of biological configurations, particles following Fermi-Dirac statistics, the sets N of choice, or electronic space; the third is the space of interactive quantum phenomena and of esthetic and psychological phenomena as well as of the sub-sets P of the Axiom of Choice.

Let us now look at the relation between simultaneity and succession.

7.2.3 Simultaneity and Succession

Simultaneity as characterized above is a contradictional *conjunction* that requires the presence of elements that are both identical and diverse; otherwise, the simultaneity would tend to disappear. Simultaneity is spatializing in that it defines or is the locus of the ‘three spaces’ referred to above and is, accordingly, an energetic operation, not a static given. An energetic simultaneity is thus a ‘simultaneization’. It *implies* a passage from a degree of potentialization to a degree of actualization, of a certain quantity of potential energy to a certain quantity of actualized energy, therefore movement, succession and time: “No space without passage from succession to simultaneity and thus without time, and no time without passage from simultaneity to succession, no time without space.” One consequence is that simultaneity in LIR is similar to that in current relativity theory. In

LIR, simultaneity[5] can not be considered absolute within one frame of reference, although not for exactly the same reasons.

Thus, succession is considered as a contradictional *disjunction* or *exclusion*, opposed to the simultaneity or conjunction. It also involves identity and diversity of elements at the same time, but succession involves an actualization of a series of identities and potentialization of a series of diversities, something like a choice between contradictory elements or events. Succession in time is a dialectical series of metaphysical 'choices' by a system. Succession is also, in this picture, the passage from a certain potential state to an actual state, and inversely. There could be no succession possible, in energetic phenomena, if there were no potential of succession, of dynamic 'successionizations' and an actualization of this potential. There is actualization of a succession – which is essentially actualization itself – because there is a potentialization of the contradictory succession. Every succession implies this dialectic.

The conclusion is the following: logical space, in the sense of simultaneity or conjunction is dynamically opposed (in a contradictional relation) to logical time as succession or disjunction. The simultaneity of elements in space is based on their succession of time, and *vice versa*. Neither of the contradictional relations being processes ever going to absolute completion, each will always have an irreducible residue of the other; there will always be some space in time, some time in space. This picture is sufficiently novel to warrant a further formulation of the basic points.

For succession to exist, temporality, there must also be simultaneity, spatiality, in which and by means of which succession can operate and develop. Inversely, for there to be space and contradictional conjunction, that which what constitutes disjunction and entails succession and temporality and coexists with space must be potentialized. Since these processes never go to completion, there is always some space in time, some time in space. Spaces and times develop dialectically, following the scheme of ortho-deductions, moving toward, but not reaching, the ideal non-contradictory limits of identity or diversity, or, alternatively, toward a limit of maximum contradiction.

The dialectic of the three energetic times and three energetic spaces defined in Sections 7.2.1 and 7.2.2 and their interaction by contradiction and antagonism constitute space-times or time-spaces. To the spatialization or homogenizing simultaneization of positive space is linked a temporalization or heterogenizing successionization, contradictory and antagonist, a negative time, potentialized by the actualization of that positive space, such that it tends to disappear asymptotically.

[5] The relativization of the neo-classical concept of simultaneity (or of a plane of simultaneity) to a frame of reference results in paradoxes in assigning times, or rather, temporal sequences, positive, negative or zero for different observers, a concept whose metaphysical significance, is by no means understood. In the context of relativity theory, there is no *a priori* definition of the simultaneity of two distant events, and it becomes subject to an arbitrary or conventional choice, called a convention of simultaneity and synchronization (Petit and Wolf 2005). The sense of simultaneity (and succession) in LIR is in my opinion metaphysically richer.

It is this idealized negation of diversity that gives rise to the intuitive notion of an infinite homogeneous time that contains nothing in itself and embraces everything.

When both simultaneity and succession, that is, what define the structure of time and space, are both semi-actualized and semi-potentialized, one has (Lupasco 1986b) a semi-actualized negative time and a semi-actualized positive space together with a semi-potentialized positive time and a semi-potentialized negative space. This can be defined as the microphysical and mental space-time (T-state). The complicated interactions involved result in the impression, subjective and objective at the same time, that when one observes or observes oneself, there is and is not a psychological time and there is and is not a psychological space in which a person exists and thinks.

The consequence of this picture is that the standard view of synchronicity and diachronicity as well-defined, separate properties does not hold. Subsequent references to processes being synchronic or diachronic (as in the following section), should be understood accordingly.

Perhaps the most important conclusion from the LIR view of space-time is that it is not primitive; in other words, there is no background space-time manifold which is required for the description of entities as there is in theories of quantum physics, strings and quantum gravity. What I have not yet given an LIR interpretation for so far are fundamental questions that remain as to the presence, persistence and spatio-temporal location of the objects, including relations and processes, whose dynamics I have characterized. To do this, I will look in Section 7.6 on Cosmology at current developments in relativity theory, in order to take into account the role of the gravitational field. I agree with the often made point that metaphysical issues must not be conflated with a literal interpretation of physical theory, but I feel the two cannot be maintained as totally independent, and LIR offers some metaphysical options that may be useful.

7.2.3.1 Synchronic and Diachronic Logic

In the period 1950–1970, Suszko developed a concept of a distinction between synchronic and diachronic logic that should be positioned relative to the LIR theory of time. A synchronic logic consists of a language, axioms, a consequence operation and interpretations (models) as usual (cf. Chapter 1). A diachronic logic purports to be a formal representation of evolutionary and revolutionary changes in scientific theories and of human knowledge in general. It thus would appear to occupy much of the conceptual space of LIR.[6]

As it turns out, however, Suszko's approach to change was strictly formal. He constructed a framework for abstract notions of the epistemological properties of the human subject within which diachronic logic gives only very general information about the development of knowledge. This logic *could not*

[6] I am grateful to Professor Jean-Yves Béziau for bringing the work of the Polish logician Roman Suszko to my attention.

consider non-formal or what he called pragmatic (and I call dynamic) aspects of knowledge. The 'diachronicity' in this logic is limited to a difference in the way a "subject with semantic notions concerning itself can talk about its earlier and future stages". The Suszko program, accordingly, remains for me within the domain of binary logic.

7.3 SOME ALTERNATIVE VIEWS OF TIME

This section will give the opportunity of comparing the LIR theory of time and space with a number of few familiar ideas, all of which refer to problems associated with phenomenological time. This will enable the fundamental difference in my point of view to become further apparent. The consequence is that application of the PDO in this field may be both desirable and feasible.

7.3.1 Time in Philosophy

It is impossible to even summarize here what has been written since antiquity on the subject of time as an aporia. In any event, the few prior intuitions of a more complex structure of time can be subsumed under the concept of 'both at once', and the medieval *coincidentia oppositorum*.

A standard philosophical view of time is that it is 'paradoxical' (Levinas 1998). What more, however, do we now know than before? In my view, we know little more than the commonsense concept of a flow. This is in a sense going backwards from Heraclitus, since the latter said all *things* flow, not time.

Also pertinent are the ideas of Derrida (1993), whose concepts of deconstruction have influenced much of current philosophy.[7] Derrida begins with the Aristotelian definition of time as an exoteric aporia, both entity and non-entity. He criticizes the philosophical tradition from Kant to Hegel, suggesting with Heidegger that the Hegelian dialectic is a 're-edition' of the Aristotelian exoteric aporia, and remains a 'vulgar concept of time'. Derrida then asks if this exoteric aporia is irreducible and calls for an "*experience* other than that consisting in opposing, from both sides of an indivisible line, another concept, a non-vulgar concept, to the so-called vulgar concept." Finally, Derrida asks (all these points are formulated as questions) if (such) an experience can surpass an aporia, or else, "putting the experience of the aporia to a test, "And is it an issue here of an *either/or*? Can one speak – and if so in what sense – of an *experience of the aporia?* An experience *of the aporia as such?* Or vice versa: is an experience possible that would not be an

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[7] I have followed here the English translation of his *Apories*.

experience of the aporia?" This is a kind of 'philosophy of experience' that can be related to the discussion of LIR and experience in Section 6.9.[8]

Although Derrida makes his analysis here primarily with reference to concepts of time and death, it is clear that he intends it to apply to other phenomena – "the interminable list of the so-called quasi-concepts that are so many aporetic sites or dislocations; the double bind, the 'non-dialectizable contradiction', etc." As with regard to other issues in this book, my objective is not to arrive at some final conclusion about time in philosophy, but simply to point to some alternative ways of talking about time that make sense from a metaphysical, logical standpoint.

7.3.2 Time in Phenomenology

One original contribution to the phenomenology and philosophy of *time* is that of Varela (1999) who says, "The familiar account of time inherited from our modern Western cultural background is inadequate". However, he also states that: "The experience of temporality addresses head-on the fundamental fact that we exist within a transparent web of time." Husserl's view of subjective time was that of a paradoxical appearance of 'double intentionality', a mixture of passivity and activity, of invariance and change. Temporality is constituted through complementarity between spatial and dynamical ingredients, affect, and trajectories in a phase space landscape.[9] A dynamical 'mutual bootstrap' principle applies such that the trajectories provide the "conditions for an embodied coupling, since through their coupling they shape their dynamical landscape. Metaphorically, the walker and the path are intrinsically linked." Varela refers to his neuro-phenomenological hypothesis that states:

> Phenomenological accounts of the structure of experience and their counterparts in cognitive science relate to each other through reciprocal constraints.

Given two accounts – a process of external emergence with well-defined neurobiological attributes and a phenomenological description that stays close to our lived experience – Varela asks for a 'circulation' between them, that is, their mutual or reciprocal constraints, "*including both the potential bridges and contradictions between them*" (emphasis mine).

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[8] My approach, here as elsewhere, provides a dynamic link between the terms of an aporia, and thus both corrects and amplifies the line of historical argument on time that Derrida developed. I suggest that one should see the Derridean experience as an emergent included middle between the either/or terms of the aporia.

[9] I notice that while the concept of time is given substantial development, the standard concept of space (including phase space) seems perfectly adequate to the author and does not receive additional comment.

A number of questions can be asked here, in relation to the development that follows:

- Does a web of time exist, or is this a metaphor?
- How can 'passivity and activity' be mixed?
- Is 'embodied coupling' real or also metaphorical?
- From where might 'contradictions' come and what is their significance?

From the LIR standpoint, such views fail by postulating an independent subjective temporal flow within which entities and their relations are located. According to Grush,[10] Husserl had the better intuition that it is the relations themselves that constitute the flow of subjective time. The LIR system, that takes words like coupling, contradiction and constraint seriously and asks that their content be defined, is no more (and no less) in my view than well-intentioned criticism.

A concept of time being deployed by objects or systems might thus be generally employed as a rule rather than an exception. A significant example is that of biological time, such as circadian rhythms, as a function of biological processes. The primary area of application of what I have described in Section 7.2.2 as the *three* contradictorially-related forms of space-time is that of subjective time as a function of human cognition. However, further development of this application must await a detailed discussion of the LIR view of the origin of consciousness and knowledge which is outside the scope of this book.

7.4 BEING AND BECOMING IN MODERN PHYSICS

A review article with the title "Being and Becoming in Modern Physics" (Savitt 2002) confirms the point in Chapter 3: it contains no definition of what it is to be. The problem is addressed essentially as that of a definition of time: "Does time flow or lapse or pass? Are the future or the past as real as the present?" Nevertheless, the controversy that already existed between Heraclitus and Parmenides and their respective followers is a good place to start the discussion. The three 'rival' metaphysical views of time are

- Presentism = "Nowism" > Only the present is real (Heraclitus).
- Possibilism = "The Tree Model" > Past and present are real.

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[10] Grush (2006). The discussion here of content/vehicle confusion in theories and the need for a 'middle-level' theoretical framework that can bridge, without reliance on metaphor, the temporal profiles of the content carried by a representation with the vehicle – the material substrate of the representation. LIR is a candidate for such a theory.

- Eternalism = "The Block Universe" > Past, present and future are equally real (Parmenides).

Of the above, the possibilist view is the easiest to accept intuitively, and it accounts most easily for the asymmetries between past and future.

7.4.1 Tensers Versus Detensers

An on-going debate in the standard philosophy of time revolves around whether or not time is tensed or tenseless. For the tenser, events only truly exist in the present, and they posses properties of pastness, presentness and futureness. This is the classical 'presentism' view. The tenseless theorist denies that events possess those transient properties and instead stand in the unchanging relations of earlier than, simultaneous with, and later than, one another ('eternalism').

Q. Smith (1986) defends the tensed theory by showing that the early 20th century criticism of it by McTaggart, to the effect that the idea that presentness, pastness and futurity are attributes of events entails a vicious infinite regress and a consequent contradiction, fails to hold. McTaggart argued that time is unreal because the concept is self-contradictory: the idea that presentness, pastness and futurity are attributes of events entails a vicious infinite regress and a consequent contradiction. Smith adopts a number of strategies, which will not be reproduced here, to show that McTaggart's assumptions (e.g. of hierarchies of levels of predications and inherences[11]) are not valid. Further, that "the infinite regress of genuine and necessary temporal predications is a *regress* of *analysandum* and *analysans*[12] (benign regress), not of contradictions and attempted resolutions, and consequently lacks the viciousness that McTaggart attributed to it.

Although suggested by the "facts of immediate experience and science", it is not logically necessary, as assumed by McTaggart, that events occupy moments. However, without a logic of dynamic opposition, this is an abstract statement that simply denies the commonsense intuition. More importantly, the regress, albeit benign, is still an infinite one. The ontological character of pastness, presentness and futurity, involving an infinite number of inherences is maintained. Smith believes that detenser theories of time are mistaken, that the indicated properties are "essential and mind-independent elements of time", but, interestingly, if these theories were correct, there *would of course be no regressive position*, and thus there is no reason why (infinite) benign regresses cannot exist in reality. "The concept of such a regress is not self-contradictory and hence is able to have real instances." Elsewhere, he claims to have shown that the notion of an actual infinity is not self-contradictory and is applicable to reality.

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[11] These inherences can be understood as something like potentialities in LIR.

[12] An *analysans* is a sentence that makes explicit something implicit in the *analysandum*.

McKinney (2003) cuts through the debate between tensers and detensers by showing that they have no shared semantic or metaphysical starting point (e.g., *re* existence), and the resulting confusion traps both sides in question begging arguments. The tenseless view could be supported if it were clear that two different languages are being used, and that of the tensers does not represent reality, in that logical connections among sentences in ordinary language do not represent ontological connections between facts in the world. However, the tenseless view has failed until recently to provide a satisfactory account of becoming.

In the conception of space-time in general relativity discussed in Section 7.6, eternalism is related to *perdurantism* (Lusanna and Pauri 2006), in which objects are taken as persisting and being temporally extended and made of different temporal parts at different times. Presentism is more like *endurantism*, in which objects (including people), persist by being wholly present at each moment of their history. As might have been predicted by an application of LIR principles, it would appear that the term 'wholly' and accordingly a simple endurantist view cannot be defended, and aspects of an extension of the object in time, including maintenance of the tenseless, observer-dependent relations of "earlier than", "simultaneous with" and "later than" are required for a complete picture. The attributes of "past", "present" and "future" are tensed in the sense that their meaning is dependent on a temporal perspective of an observer.

The question remains as to whether the metaphysics of LIR provides any insight into the key problem of the arrow of time, that is, whether fundamental *physics*, and not an obsolescent concept of abstract time, is tensed or tenseless. My answer would be no more than a restatement of the conditions of the existence of the actual world. The (relatively) modest of objective of my logical approach is to suggest some insights into unstudied aspects of change or process, categorial concepts that require time-asymmetry. It is certainly not known with certainty at this time whether the dynamical structures in the universe reflect a fundamentally tensed reality or whether eternalism – the 'block' universe – is the in part a correct description. The answer may depend on further advances in cosmology, along the lines of the cyclic model proposed by Steinhardt, discussed below in Section 7.7.1. Even for events playing themselves out at ordinary macroscopic levels, the elimination of absolute spontaneity and succession, and the relativization of times to *both* tendencies toward decreasing and increasing entropy provides both identity and diversity as described above provide an alternate way of thinking about phenomena and their interrelationships.

7.4.2 Being and Becoming Revisited

The deepest problem in the metaphysics of time, or in metaphysics *tout court*, has thus been how to understand *any* passage or becoming and its relation to existence. From my standpoint, the difficulties in the various pictures of becoming and its relation to being arise due to neglect of the dynamic, contradictory, antagonistic aspects of the terms used: simultaneity, passage, space-time, etc. Passage as usually defined without antagonism *is* self-contradictory and absurd, because it excludes an interactive contradictory relation between time and space. Passage is both objective and subjective (in both the broad sense, as the locus of actualization and in the usual sense). Savitt cites Carnap's statement that "all that occurs objectively can be described in science" and then argues that passage (becoming) reflects something perspectival or subjective and *so is implicit in physics or rightly omitted by it* (emphasis mine). From the LIR perspective, it (becoming, the perspectival or subjective) is indeed implicit in physics and should not and does not need, for this reason, to be omitted from it.

Temporal becoming, in a view derived from Broad and Gödel, does not need to resemble motion nor qualitative change; there can be, it is claimed, an *absolute* becoming that is just the successive happening of (simultaneity sets of) events. One is here quite close to the relative becoming of LIR, except that the latter provides a dynamic for the 'happening', and assigns a meaning to 'just', by the oppositional categorial linking of simultaneity and succession, as indicated above.

Having made this proposal, and if eternalism in the detenser sense is not valid, what then is *being* in LIR? I made a start on a discussion of being in Chapter 3, where I said that being and non-being were terms 'of art' that describe in some way the totality of the universe, related to what I have defined as the real in Chapter 1. I would also suggest that being and becoming, *as concepts*, clearly stand in the dialectic relationship to one another defined in Chapter 5: as one thinks of the world as being, the world as becoming is potentialized and *vice versa* in the usual way.

A more standard philosophical discussion of being is that of Heidegger. Heidegger provides some perhaps unexpected (and certainly unintended) support of a dynamic view of contradiction in reality when he describes 'being' as both wholly indeterminate and at the same time highly determinate. "From the standpoint of the usual logic we have here an obvious contradiction: …determinate, wholly indeterminate being. *If we decline to delude ourselves* (emphasis mine), ... *we find ourselves standing in the very middle of this contradiction. And this stand of ours is more real than just about anything else we call real; it is more real than dogs and cats, automobiles and newspapers.*" As in LIR, it is contradictions that are fundamental to reality, being characterized by its contradictorial relation with non-being, as well as with becoming. Jacquette is correct in saying that Heidegger based his conception on human experience, but it is not a criticism to say, as I do, that it is more fundamental than Heidegger thought! Heidegger saw that the constraints on thought imposed by classical or traditional logic ("a court of justice, established for all eternity": Heidegger 1959), of which the principle of non-contradiction was the cornerstone, were unacceptable, and his idea finds confirmation in LIR.[13]

[13] Aerts differentiates between a process view of reality that includes being and becoming, and a geometrical view, that discusses only being, and shows that there is no contradiction between them. One is dealing, of course, with two views of being – the physical and the metaphysical, but the distinction may be losing force: in the latter, being seems also to mean the normal physical

I will cite a few of Savitt's further statements and quotations, recognizing that they do not all represent his own point of view and my rebuttals:

1. "Motion is one sort of change, change of spatial position with respect to time. The motion of time, then, must be change of time with respect to … What?"
LIR: … with respect to space.

2. "In order for a thing to change it must evidently persist at least from t_1 to t_2, but the events usually supposed in discussions of passage are instantaneous events, which have no duration at all."
LIR: Absolute instantaneity and its problems are excluded axiomatically.

3. "Future facts that do depend on human choice or quantum measurement, should they be facts now, would seem to constrain human choice or quantum measurement in ways that many philosophers find undesirable. It is easy to convince oneself, then, that future facts of these two sorts cannot really be part of existing."
LIR: They can be, if they are looked at as current potentialities. It is not necessary to separate the real (actual) from the potential *via* a metaphysically distinguished present.

4. "If some distinction can be made between categorical and non-categorial existence statements (that is, events exist in the categorical sense, but particular events can be past, present or future), then eternalism is not a straightforward consequence of adopting the space-time treatment of special relativity.
LIR: The dynamic concept of simultaneity and succession is in line with this, and eternalism can be rejected.

The approach of Stein, cited by Savitt, seems realistic. Stein assumes a two-place relation R such that Rxy means that y has already become or is definite with respect to x, and this can be developed into a 'genuine relation of becoming'. Interestingly, Stein wanted to tie his definitions of temporal concepts to intrinsic geometric structure. This opened his relation R to criticisms that Savitt shows are unjustified. The atemporal Minkowski diagram (light cone) represents the evolution of systems along their world lines. Such diagrams do not require 'animation', an artificially attributed 'motion'. In Stein's geometric picture, the transience or passage is in what it depicts. LIR is compatible with these intuitions and could be designated, in this context, as an *adequately relativized possibilism*.

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contents of the universe, without 'time', but the NEO categorization of them as Process and Energy is needed to adequately characterize both being, becoming and their relation (Aerts 1996).

What I mean by adequately relativized possibilism is the following: the thought experiments offered in support of the relativity of simultaneity all seem to involve cosmological, relativistic distances (by analogy with relativistic speeds). They perhaps describe phenomena occurring at some kind of limiting state, in which the contradictorial relationships between time and space, simultaneity and succession might well be altered. Axiom **LIR5** excludes such classical-type limits. The concept of the relativity of simultaneity as "the point of departure for our metaphysical questions rather than the answer to any" cannot be supported. My view of simultaneity and succession does not require frame-of-reference arguments.

Further to this is the question of the relativization of *existence* to a frame, "a difficult notion to understand or accept". Savitt quotes Gödel to the effect that "The concept of existence … cannot be relativized without destroying its meaning completely." And then asks

> Is the concept of existence, then, like the concept of truth, which, when relativized (as true-for-me, true-for-you), comes to something more like belief than truth? Or is it like simultaneity, about which thoughtful persons a century or so ago might have made pronouncements much like Gödel's? This difficult and fundamental question has by no means been resolved.

I suggest answers to both points: 'truth' is more like belief looked at in its dynamic aspects that also apply to existence. Second, simultaneity in LIR has an interpretation that is not *relativized* as in the original or current standard theory but *related* functionally to its conjugate – succession.

"Being and Becoming" is also a section title in a paper by Aerts (1996), who says that:

> Although we know from Einstein's analysis of the concept of relativity that we cannot retain the classical view on reality, as being the collection of all simultaneously happening events, there has not been proposed a real relativistic equivalence for reality in a serious way.

From the LIR point of view, one is dealing here exclusively with becoming, not being. The introduction of time as a fourth geometrical dimension, and the proposal of the space-time continuum as the "real scenery of reality" was incomplete. In this interpretation, there is no change – it is the eternalist picture criticized above. Aerts and others, as we have seen, showed that this result is a consequence of an incorrect view of reality, and that one can accommodate both a four-dimensional space-time continuum and change, combining process and geometric insights.

In an Einsteinian interpretation of reality, the possibility of relativistic time travel enables one's presence 'tomorrow' at an existing location to be, in Aerts' terminology, a 'happening', a determining part of his real, present experience "an actuality and not just a potentiality". The advantage of my approach, as compared to that of Aerts and the standard geometric views, is, as in the previous discussion of simultaneity, that no appeal to travel in a relativistic space-time is required to confirm the current existence of reasonably stable future entities and events involving oneself by reference to a hypothetical ability of directly observing them.

Aerts elsewhere (1999) describes a 'creation-discovery' view of change: things make their place instead of having a place. Contrary to the 'space-contains-reality' hypothesis, reality is not contained within space. "Space is a momentary crystallization of a theater for reality where the motions and interactions of the macroscopic material and energetic entities take place." Quantum entities 'take place' outside this space within a space that "is not the three-dimensional Euclidean space." The theory describes reality as a kind of pre-geometry, where the geometrical structure of the material universe arises as a consequence of interactions that collapse into the time-space context (Aerts and Aerts 2004).

It is intriguing to consider that this 'space' is what I have described as T-state space-time. The realism of LIR implies this kind of connection between the systems of systems that constitute all human personal realities and provides the account of 'reality' that is independent of them. However, without the aspect of dynamic opposition, one has no basis for the proposed model, which resembles other systems of thought in which geometry is emphasized at the expense of dynamics. In other words, scientific theories that purport to be realist but minimize or ignore dynamic opposition as fundamental must be seen as idealist in the same sense as the binary logic from which they derive.[14] I will return to this issue below in Section 7.6.

Hawley (2006) has asked whether science can guide metaphysics, since she is concerned that traditional metaphysicians are more or less, rather less than more, justified in questioning some of the metaphysical claims made by, or inherent in, current science. The most pertinent example revolves around the nature of time and presentism, which as noted above is the belief that only present objects and events exist. LIR talks directly against naïve presentism by supporting non-absolute concepts of simultaneity and succession as applicable to space-time. The present is not an absolute, but it does not have to be frame-dependent as in special relativity. There is epistemological ignorance of the now-ness of distant events, but the potential event that we will not know about for ten years exists in the present nonetheless in a contradictorial manner, as a potentiality.

My position in this book is that the overwhelming direction of flow of concepts between science and metaphysics should be from the former to the latter. However, by augmenting the doctrine of scientific realism with a, in my view, neglected element of science with a strong metaphysical character, namely, the dynamic opposition of fundamental physical dualities, including their non-actual but real aspects of potentiality, I claim that I have accomplished two things: I have decreased the dependence of structural realism on non-intuitive, mathematical structures, that is, by introducing the more accessible concept of process structures as the basic furniture of our world, and I have given traditional metaphysicians a

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[14] It is 'logical' therefore, that in the 'hidden variables' quantum theory of Aerts, the concept of superposition of states in quantum entities is "no longer seen as a general principle which is always satisfied".

basis for principled avoidance of either reductionism or anti-realism as preferred strategies for talking about existence. To the extent that LIR provides a non-circular picture of being and non-being, and being and becoming, and at the same time supports the principled extension of quantum mechanics to macroscopic phenomena, it supports the convergence of metaphysics and physics without reduction of one to the other.

7.5 QUANTUM MECHANICS

The advent of quantum mechanics in the 20th century resulted in a 'revolution' in science and philosophy, and basic ideas of what constitutes objective reality, as opposed to our subjective experience of it, became problematic as a consequence. This revolution is ongoing, and there is yet no agreement on the implications of quantum mechanics for the other major problems of existence – the origin of life and individual, first-person consciousness. In this book, *I have suggested that an equally revolutionary change of perspective is required to see the relation between such concepts as subjectivity and objectivity themselves*. LIR, in my view, facilitates the inclusion of philosophical and metaphysical principles in science and *vice versa*, and should have a place in their mutual development. This idea is echoed in Sklar's suggestion that "Physics and philosophy (including metaphysics) are two highly interdependent ways of seeking to understand the world and our place as knowers of it (Sklar 1992)."

Sklar suggests a different an approach that "looks for the resolution of the problems (inherent in the quantum view of the world) in a modification of our traditional thought concerning some of the most pervasive and general modes we have for describing the world", in my terms, logic. He asks whether a revision of our standard logic itself could help us make sense of quantum phenomena. Instead of logic being immutable and independent of experimental knowledge, perhaps it (logic) is just as much an empirical matter as chemistry and geometry is now taken to be. However, quantum logic *per se* does not resolve all dilemmas about quantum paradoxes, indicating not that quantum mechanics and quantum logic cannot provide a complete description of the world, but that something was and may still be missing from this logic as well.

By this time it is clear that an explanation of the experimentally demonstrable quantum features of the world will (still) require a radical rethinking of our metaphysical picture of it. At the latter level, the one of greatest generality, the definition of some principle that is missing or has been ignored would have major consequences for the future of 'reason' in the broadest possible sense. As indicated in this book, there may exist aspects of physics that are already accessible that could fit this description.

There is a hint of this in the usual description of the possibility (1) of salt dissolving in water that depends on (2) a piece of salt having an actual constitution of ions. If the structure of space depends only on the collection of all possible spatial relations, what is the underlying reality that grounds this structure in the same way that the structure of salt is grounded? I have outlined a structure of reality in Chapter 5 that offers a possible answer to the second phrase about salt: the process requires the *potential* energy of solution, something that is still a 'substance' in the classical sense, but is not burdened with the necessity of being actual and localized.

Cao (1997) takes another ontological approach to modern physics with regard to the development of field theories. Like Sklar, Cao sees the synergy – 'mutual penetration' – between physics and metaphysics, considering that physics has also provided us with a direct access to metaphysical reality. Cao describes another debate, over the nature of energy, and makes an important suggestion, close to the thesis of this book: "What if energy is taken as substance *with the new feature of being always active, always changing its form while keeping its quantity constant* (emphasis mine)? Then energeticism would seem to be a precursor of James's functionalism and Whitehead's ontology of process." The principles presented in this book show the validity of this intuitive view of the 1st Law of Thermodynamics as well.

Cao's theory is also of interest to me for two other reasons: he retains both the currently less used S-matrix theory (SMT) as well as Quantum Field Theory (QFT) and suggests that their interplay, which has been neglected, may turn out to be useful in furthering understanding. This is an example of an interaction between *theories* where the principles of LIR and NEO can be applied. In addition, in SMT, as in Ontic Structural Realism processes and relations rather than entities are individuals constitute the basic ontology rather than; in QFT, fields or particles are the basic entities. The second reason is his concept that the growth of scientific knowledge is not unilinear but dialectical. Convergence to some form of fixed truth is incompatible with the latter, while a concept of scientific structural realism, compatible with the LIR view, is strengthened (see Chapter 6).

7.5.1 Two Complementary Logics of Complementarity

It has by now been amply documented that the Copenhagen interpretation of Quantum Mechanics (QM) is a reduction of the original profound insights of Bohr as to the real nature of quantum phenomena and their description, a reduction of which Bohr was aware (Faye 2002). Part of the problem was and is due to the absence, in both scientific and non-scientific language, of the necessary terms for dealing with the contradictory aspects of quantum particles (Nicolescu 2002). I claim that if one goes over the requirements that Bohr himself set for a proper theory from the standpoint of the logic of/in reality, one can provide an interpretation that satisfies these requirements.

Bohr's principle of complementarity as a fundamental aspect of quantum objects is one of the major advances in thought of the 20th century. Bohr asked physicists, essentially, to accept A and non-A, wave and particle characteristics of a quantum particle, and its space-time description (kinematic) and causal (dynamic) descriptions at the same time. More accurately, the *explanandum* was that A or non-A was observed depending on what theoretical or experimental questions were being asked. But what could this mean? In the absence of a firm definition by Bohr, the complementarity principle came to be discussed as something like a simple juxtaposition. Apart from providing no explanation or description of how one aspect insured the continuous existence of the other, this picture does not seem adequate where A and non-A appear to have such a drastically different character in both cases.

Bohr's early work indicates that he viewed complementarity as primarily an epistemological principle:

> The very nature of quantum theory forces us to regard space-time co-ordination and causality, the union of which characterizes classical theories, as complementary but exclusive features of the description, symbolizing the idealization of observation and definition respectively.

> The term 'complementarity, which is already coming in to use, may perhaps be more suited also to remind us of the fact that it is the combination of features which are united in the classical mode of description but appear separated in quantum theory that ultimately allows us to consider the latter as a natural generalization of the classical physical theories.

Later, Bohr seems to have moved toward a more ontological interpret-tation: phenomena or information were mentioned as being complementary, rather than descriptions.

> The phenomenon by which in the atomic domain objects exhibit the properties of both particles and waves that in classical, macroscopic physics are mutually exclusive categories.

If the fundamental nature of dynamic antagonism is accepted, a real contradictorial relation in quantum phenomena is neither physically nor logically unacceptable, and it can have both epistemological and ontological aspects. It is not physically unacceptable because wave and particle properties are not fully instantiated at the same time, until the measurement of one potentializes the other. It is not logically unacceptable for exactly the same reason. Two answers can be given to the objection that this formulation simply restates the result of experiment: (1) if the particle aspects are actualized, the wave aspects must be present as potential, and *vice versa*, otherwise it is difficult to explain how they could reappear; (2) it is not in the LIR view that there is any problem with the observed duality of quantum entities in the first place.

If one assumes, for the sake of argument, a principle of non-contradictory complementarity, one comes up against the limitation to the precision of measurement of the Planck constant, the constitutive 'contradiction' in nature (Lupasco 1987). This means that one or the other aspect can only be partially and never completely actualized, and the other subject to an indeterminacy that can be represented by its potentialization. Contradictory processes, identification and diversification, or attraction and repulsion, go toward the limits in both directions of actual non-contradictions and a potential non-contradiction (actual contradiction), but they, like contradiction, are only relative, due to the nature of energy. At the macroscopic level, classical physics, infinitesimal differential calculus and mathe-matics based on rigorous non-contradiction and continuity work (very) well. It is clear that the laws governing the macrophysical level of reality approach the laws of classical physics, but only statistically and probabilistically. To this extent, rea-lity always retains or conserves a contradictory foundation.

Some of Bohr's own requirements for an adequate theory, as summarized by Faye, are the following (his numbering):

> 6. The concepts of classical physics are the exact specifications of the common categories of pre-scientific experience (commonsense) notions of position, change of position, cause and effect that are part of everyday language.
> 7. 'Classical concepts', if not classical physics, are a precondition for understanding and communication regarding the results of experiments.
> 11. In a quantum mechanical description, experimental objects and measuring devices are not totally separated, but parts of the measuring device may be treated as parts of the object.
> 14. Quantum phenomena are complementary in the sense that their manifesttations depend on mutually exclusive measurements, but that the information gained exhausts all possible objective knowledge of the object.

Bohr believed that kinematic and dynamic properties, represented by conjugate variables, could be ascribed to quantum objects only in relation to actual experiment, whereas classical physics in his opinion was idealist in assuming that the physical world has such properties independent of their actual observation. One is thus back to an *anti*-realist semantic interpretation of QM in terms of truth conditions of sentences about quantum objects. For this study, what is important in Bohr's later view is that when justified by experimental outcomes, kinetic and dynamic variables have ontological implications for the reality of quantum entities, and the Heisenberg uncertainty relation is not merely an epistemological one of limitations on our knowledge of the system. It is phenomena and information that are complementary, rather than only descriptions (although they may also be complementary as theories, cf. Chapter 5). Bohr believed quantum entities were real, although QM does not give a 'picture' of this reality.[15]

The LIR system is applicable to the above points. For example, as discussed earlier in this book, the concept of conflict or dynamic opposition, now actual and now potential, is also an integral part of human experience and inheritance, and thus classical in the desirable sense of point 7 above.

Béziau states that "there is no principle of complementarity, and complementarity is just a word for some philosophical ideas, for an insight that Bohr was

[15] The LIR dynamic model does not add directly to this picture, but is a way to conceptualize moving from one picture to another.

never able to formulate in a clear way." It is correct to say that the common understanding of complementarity is too vague to be of metaphysical value. Béziau develops a paraconsistent approach that sees the different sets of experiments on quantum phenomena as different viewpoints that can exist without being trivial in a Jakowski-style logic of discussion (Béziau 2001). However, I also feel that Bohr, toward the end of his life, had developed a coherent philosophy to the point where it accepted a concept, which is the fundamental concept of LIR, of the complementarity of opposites[16] in an ontological sense.

Returning to physics, it seems clear that Bohr was seeking a way to justify point 11 above regarding the separability of measurement object and measurement device. This can only be done, in my view, by modifying the concept of parts and whole along the lines of my discussion of scientific structural realism and non-separability.

Bohr was apparently suspicious of the ability of various modifications of classical logic, as it was understood in the mid-20th century, to assist in the definition of quantum physics, although the failure of non-commutativity and non-distributivity of quantum variables, which suggest non-Boolean algebra and logics, were well known. It was only in the 1980s, with the advent of paraconsistent logics, that the first major new approach to the formal explanation of the principle of complementarity became possible.

Da Costa and Krause (2004, 2006) present an interpretation of complementtarity as a general principle of *incompatibility* in the sense that the logical combination of complementary aspects into a single description requires a non-classical logic. Although complementary propositions are acceptable, their conjunction seems not to be valid. 'Mutually exclusive' or 'complementary' refer to incompatible sentences or propositions whose conjunction lead to a contradiction in classical logic. These authors develop a notion of *C*-theories (complementarity theories) whose underlying logic is paraconsistent. They say specifically, however, that their system is not intended to be a condensed account of all Bohr's ideas, in particular, the potential extension of complementarity to other, macroscopic domains. This interpretation does not mean that contradictory propositions are always contradictory, and hence this group of logics is termed paraclassical: the expression, "x is a particle entails that x is not a wave" does not indicate strict contradiction. In *LIR* terms, that x demonstrates particle properties entails that wave properties are potentialized.

In my view, this underlying logic for *C*-theories is very largely adequate for discussing the epistemological requirements of quantum theory. However, the above discussion indicates that Bohr was also in part a realist, and made an

[16] Bohr chose the Taoist yin-yang symbol for his coat of arms when he was awarded, in 1947, the Danish Order of the Elephant as well as the Nobel Prize. The Latin motto reads: "Opposites are Complementary", suggesting that Bohr believed complementarity as metaphysical antagonism to be the most fundamental principle of existence as a whole. The Tao involves, however, not only *Yin* and *Yang* but their conjunction, which one might see as an emergent included middle T-state.

implied ontological commitment to the real existence of the phenomena. (That some-one is both realist and anti-realist is perfectly acceptable in the LIR framework, provided one avoids the requirement of 'both-at-once'.) Perhaps responding in part to this, da Costa and Krause have extended the concept of a *C*-theory by de-fining 'complementarity theories with meaning principles', termed C_{mp} – theories. The purpose of this extension is to accommodate complementarity as a meta-theoretical principle of science, keeping it a kind of meaning principle due to its resemblance to the idea of the existence of contradictions in paraconsistent logic. This might make it unsuitable for acceptance in the polite company of classical logic, but it helps in understanding and accepting incompatible information. In fact, da Costa and Krause show how complementarity can be seen from perspec-tives, as "standing for both a general regulative meaning principle and also as a (strict) law that can be internalized in the language of the theory proper". In other words, the concept of complementary propositions can also be put within a certain object language without making the entire theory trivial. The underlying logic of complementary propositions in C_{mp} – theory is the paraclassical logic mentioned above.

The vision expressed by these theories is congenial to LIR. It suggests an opening to new types of logic, perhaps such as LIR, which offer new perspectives for treating domains of science from different perspectives with new logical apparatuses. Da Costa and Krause, following Englert, suggest that complement-tarity may be more general and more fundamental to quantum mechanics than the Heisenberg uncertainty principle. Further, that their logic could be modified to treat even more general kinds of incompatibility, 'physical incompatibility', incur-porating physically incompatible postulates, such as human behavior.

The concept of something like complementarity as extendable to physical phenomena is, of course, the core thesis of my logic of/in reality! The major difference is not only that I designate a PDO as my metaphysical and metalogi-cal principle, but that it includes *ab origine* the physical basis for change and emergence that are required a description of reality above the quantum level. In my view, the PDO has been ignored or rejected from a formal logical standpoint based on absolute non-contradiction and limitation to propositions and their mathematical equivalents. The paraconsistent logic and metalogic of complement-tarity of da Costa and Krause are thus steps in the right direction, that is, toward a logical description of real phenomena, but in my opinion they do not go far enough.

The application of the PDO and the categories of NEO to each critical feature of the quantum and non-quantum world, at the level of *both* reality and descriptions of reality, resolve some of the paradoxes resulting from standard interpretations. The necessary concepts are the non-separability of individuality and non-individuality; part and whole; subjectivity and objectivity in relation to the experiment-experimenter pair; and of object and meta-levels of theories. LIR grounds the commitment to the reality of quantum entities that is necessary for the ontological view of complementarity.

On this basis I propose LIR as a preferred ontological logic of comple-mentarity, and an '*LIRC*' as a theory of complementarity in which the PDO plays the role of 'meaning principle'. One can then see the two types of theory of complementarity, *LIRC* and C_{mp}, as themselves complementary: the latter (on which much more in-depth work has been done), explicates an object level and a meta-level of statements about quantum phenomena, and the latter the corresponding levels of the phenomena themselves.

In conclusion, if the LIR PDO has a basis in physics, it should be taken into account in science and philosophy, including the philosophy of mind, either as an extension of complementarity or an as alternate description of 'complementary' phenomena. The argument is more complicated than in the case of complementarity based on paraclassical logic, but no less deserving of serious consideration.

7.5.2 Relational Quantum Mechanics

Relational Quantum Mechanics (Laudisa and Rovelli 2002) is an interpretation of quantum phenomena that discards the notions of the absolute state of a system, the absolute value of its physical quantities, or an absolute event. The theory describes only the way systems affect one another in the course of physical interactions. State and physical quantities always refer to the interaction, or the relation, between two systems. Nevertheless, the theory is assumed to be complete. The physical content of quantum theory is understood as expressing the ontology of the net of relations connecting different physical systems. In my opinion, this formulation has the strongest possible affinities with the principles of LIR, both from the point of view of the impossibility of absolute values or isolated events, and, what amounts to the same thing, the primacy of relations in a processual framework. Elements and events are not the 'material' terms of a relation, but are themselves always relations. Further, RQM leads to the idea that from the formal ontological standpoint, relations could be seen as a formal sub-category of Process.[17]

In standard QM, there is a core conceptual difficulty in reconciling the possibility of quantum superposition with the fact that the observed world is characterized by uniquely determined events. According to the theory, an observed quantity can be at the same time determined and not determined. An event may have happened and at the same time may not have happened. RQM offers a way out of the dilemma. QM becomes a theory about the physical description of observing and observable systems relative to other systems. This is a 'complete' description of the world that can be considered a kind of included middle between its observing and observable parts, the measured system S and the measuring system O. Rather than worrying about where to put a von Neumann

[17] In Whitehead (1978) the "concrete facts of relatedness" are classed as Prehensions among the categories of existence, while the "world as process" is the first category of explanation. One does not need to argue about the hierarchy here; what is important is the existence of a conceptual relation between relation and process.

'boundary' between the two, one focuses on their dynamic relationship. The comparison of accounts of different observers does not lead to contradiction because *the comparison itself is a physical process that must be understood in the context of quantum mechanics*.

The statistical features of correlations make their implications similar to those of relations. The relevant physics of a system *S* is entirely contained within the internal external correlations of its subsystems (which I believe are, always, what leads to '*S*'). It is to the correlations that physical reality may be ascribed, and not to the quantities that are the terms of the correlations. This can be compared with Lupasco's statement that "everything is determined by the relation, everything is relational, everything that exists, exists in relation to …" (Lupasco 1967).

This approach avoids the ontological multiplication of realities of the Everett 'many worlds' hypothesis that has had a certain attraction for some people. In the relational point of view, such epistemological abstractions are avoided, since physical quantities are uniquely determined, once two systems are given. It seems natural to suggest that it is a logic involving three and no more than three terms, which is appropriate for relational quantum mechanics. Relational interpretations can be given to aspects of special and general relativity, providing a more precise definition of time, and are consistent with the known observation that there is no absolute localization in space-time.

The relational approach weakens the notions of the state of a system, event, and the idea that a system, at a certain time, may have just a certain property. (In my view, that was what had to happen, namely, that the 'hold' of definitions of processes based on binary logic has to be weakened for progress to be made.) Laudisa and Rovelli say that despite wide diversity in the authors they cite, "there is a common idea underlying all RQM approaches, and the convergence is remarkable." The authors conclude by saying:

> This way of thinking the world has certainly heavy philosophical implications. The claim of the relational interpretations is that it is nature itself that is forcing us to this way of thinking. If we want to understand nature, our task is not to frame nature into our philosophical prejudices, but rather to learn how to adjust our philosophical prejudices to what we learn from nature.

Amen. I have tried to show here something of the nature and origin of those prejudices, in terms of the operation of the prevailing logic of identity and non-contradiction, and suggested how they might be overcome.

7.5.3 Quantum Physics and Consciousness

As an introduction to an eventual discussion of an LIR theory of consciousness, I wish here to discuss just one approach that has attracted much attention. Confronted by the indeterminate and determinate aspects of consciousness, as well as the intuition we have of its being something fundamental in the universe, many people have sought to link it, and them, to quantum phenomena *directly*. One representation considered applicable might be a quantum wave function for the entire neural network that would be a superposition of the wave functions of its parts. Stapp and Penrose believe that it is the shared global character of conscious thought and quantum reality that makes the latter essential to the existence of the former. However, up till now, there has been no alternative to seeing, in the uncertainty of mental processes, the operation of the *same* physical principles as at the quantum level, views defended by Stapp and Hameroff. Thus, quantum mechanics would be applicable directly to beliefs, judgments, ideas, etc., which could be seen as quantum phenomena, despite excellent biophysical evidence that thermal noise results in total quantum decoherence (loss of information). In LIR terms, the relation between quantum and mental phenomena is the operation at both levels of the PDO in the isomorphic laws governing them.

Penrose's search for a missing science of consciousness, for a scientific understanding of consciousness, published in 1994, has by far not terminated. His intuition is one that I wholly share: there is an essential scientific ingredient missing needed to incorporate central issues of human mentality within a coherent scientific world-view (Penrose 1994). A picture of the universe requires an extension that does not only involve completion of the zoo of fundamental particles and their interactions, although it should be compatible with it. I have mentioned earlier the questions posed by the existence of quantum non-locality, but Penrose is in agreement that the strange world at the quantum level is real and permits real objects to be constructed from it. After showing that the simplistic approach based on activity at the microtubule level in the brain is inadequate, Penrose describes the missing physics as a "highly subtle non-computational (but undoubtedly still mathematical) physical scheme, an 'objective reduction' (OR). But what might be the source and nature of the 'OR effects' that could be "harnessed to conjure up the shadowy phenomenon we refer to as consciousness?"

As I claimed in connection with the naturalization of phenomenology, there is no reason to assume that consciousness as an emergent phenomenon requires different categories than other natural phenomena with the single exception of human individuation (the 'harder' problem), not of the behavioral aspects of consciousness.[18] This is not necessary in LIR, since the latter are described in terms of the contradictorial but physical process relations between the appropriate elements or entities. The burden of proof should be on idealists to show the basis of intentionality as being somehow outside physics, chemistry and cause-effect. This is not necessary in LIR, since the latter are defined in terms of the interactive processes between the appropriate elements or entities.

Penrose states that the way quantum mechanics operates is a (mathematical) mystery that appears to be the kind needed to accommodate mentality within physical reality, and that deeper theories will make the place of mind in the

[18] The 'hardest' problem remaining at this time is that of human individuation, why I am 'me' and not someone else, not the behavioral aspects of consciousness.

world less 'incongruous'. Most importantly for my LIR theory, Penrose says that *neither* a computational physics *nor* such physics augmented by randomness can be adequate. Rather:

> Every one of our conscious brains is woven from subtle physical ingredients that somehow enable us to take advantage of the profound organization of our mathematically underpinned universe …

The most important words in this citation: conscious, subtle, physical, somehow and profound organization all require explanation. As far as mathematical is concerned, Penrose' conception is that of a Gödelian mathematics, and suggest that the 'underpinning' is as much logical as mathematical, along the lines of the basic concepts of completeness and determinacy in Gödel's theorems.

The Gödel theorems and logic – as written – do not apply to physical or mental emergent phenomena, but LIR views the principle involved, the duality of consistency and completeness, axiomatically, as another instantiation of the fundamental duality of the universe. The current logical and ontological development undertaken in LIR provides a bridge between the PDO in the real world and Gödelian dualism. The relation between consistency (absence of internal contradiction) and completeness, in logic, language and mathematics, is between two abstract entities. For any application in physics or other science, what must be recognized is that an *isomorphic* relation of opposition or dynamic interaction can exist in the physical domain between real elements, processes, etc., with emergence of new phenomena as a consequence in certain cases.

In the next section, I will suggest further how the LIR interpretation of time and space modifies the metaphysical implications of theories about the universe.

7.6 TOWARD A LOGICAL COSMOLOGY

The logical conception of existence that I have proposed requires that the contradictorial physical and metaphysical relations for which I have developed a categorial ontology are justified by the basic physics of the world. All of the LIR concepts in hand of reality – being, continuity and determinism and their opposites – should be related to a description of the universe itself. As noted above, modern cosmology has developed in parallel with quantum mechanics, and the problems of reconciling a theory that applies to quantum objects and General Relativity that applies to large-scale gravitational phenomena are still very active topics of research. One can perhaps see the elements involved, the small and the large, as antagonistic in their characteristics of their extensity and intensity, the former as discussed in relation to limits exemplify action, discontinuity, and subjectivity, while the latter exemplify continuity, invariance, and mathematical extensity. However, much more is needed. In this section, I will discuss the relevance of some recent cosmological theories to the principle of dynamic opposition of LIR, and *vice versa*.

7.6.1 Space-Time in General Relativity

In Section 4.4.1 on the self-duality of the quantum field, I speculated on the relation of that duality to other dualities in physics and their correspondence with the picture of dynamic duality given in LIR. In this final section on physics, I will provide an interpretation of the other major component of existence, the phenomenon of universal gravity or the gravitational field.

One way of characterizing early 20th century cosmology is to say that it has been a cosmology of *identity* and non-contradiction, with major effort devoted by Einstein and others to a search for invariants. In special relativity, an absolute Newtonian time and space was replaced with a new invariant (the universal interval *s*). This approach gave a relative reality to time from which everything that depended on the observer was eliminated. The principles of Special Relativity (SR), pushed to its limits, essentially eliminated energy and dynamics from existence. General Relativity (GR) was introduced to handle the extension of relativity to non-uniform movement and microphysical phenomena, quantum and wave mechanics. For GR, Einstein proposed as the most general invariant the total curvature of the universe. This required a non-Euclidean geometry, from which all heterogeneity of its space-time points at a microscopic level was eliminated by the notion of bodies in continual acceleration (due to the curvature). In other words, through the requirement of general covariance (changes of position with respect to a frame of reference), these space-time points lost what in my view was critical, namely, the really and dialectically necessary component of *partial* individuation.

Two cosmologies were proposed to explain the relation between matter and space-time: the universe of Einstein, in which the geometric structure of the universe was determined by its total material mass. Finite, curved space-time was reduced to matter and absolute time, the absolute time "of the universe" was considered a sort of subjective noumenon with which no interaction could be possible.[19] In the Eddington-De Sitter model, there was no causal relation between the curvature and the total mass; matter was responsible only for local irregularities.[20] In the De Sitter model, a discontinuous intensity takes the position that

[19] In work on new foundations for geometry and computation, Michael Leyton has criticized theories, from Euclid to Einstein, that maximize invariances on the ground that they are 'memory-less'. Leyton proposes the grounding of geometry on a concept of maximization of memory storage, that is, on shape. Leyton shows that certain shapes, described in a highly technical manner, contain a high amount of memory storage that can be organized in a hierarchy, called a *Process-Grammar*. Unfortunately, the dynamics of process seem to be missing in this otherwise wide-ranging rule system for inferring history from shape (Leyton 2005).

[20] Lupasco cites the strangely significant statement by Eddington: "*That which is* is an envelope that floats in the infinity of *that which is not*": two terms with the same ontological value, each defined by the other that opposes or negates it, and existence as a whole defined by both at once. This rather resembles the being and non-being of LIR.

extensity occupies as an external objectivity in the Einsteinian universe.[21] Both Einstein and Eddington seem to have avoided any *antagonistic* dualism, one throwing into the subject what the other threw into the object, and *vice versa*; for both one is appearance, the other reality.

Lemaître was the first to formulate clearly, in 1927, that the universe is in a phase of expansion, in which, accordingly, the matter of the Einsteinian model of the universe[22] that is becoming rarified, approaching the universe of De Sitter of pure geometric form. The Lemaître model reconciled the opposition between the first two models: there is a dual tendency to expansion and contraction, suggesting that a basic antagonism exists in the universe between the constitutive properties of this expansion and contraction. In the light of current cosmological work, the Lupasco picture of the universe of Lemaître is of interest: the dynamic opposition excluded in the other two models is maintained, and can be a source in principle of instability and becoming. I will now try to describe how this is done.

7.6.2 The Dual Role of the Metric Field

As discussed above, Special Relativity (SR) describes an absolute chrono-geometrical structure of a four-dimensional Minkowski universe with a Euclidean geometry in which is embedded a frame-relative, observer-dependent space-time. ‘Distant’ simultaneity is defined by convention. General Relativity (GR) is necessary to handle the universal nature of gravitational interaction and aspects of physics at high energies. However, this theory removes all physical objectivity from space-time, and is in direct conflict with the ‘apparently real’ objectivity of the phenomenological world. There is, accordingly, a need for some kind of frame- and observer-independent description which would ground both the reality of both experience and scientific knowledge. The debate revolves over how to assign physical meaning to the *metric field* which is the central concept in GR. The metric field is a term for the mathematical (tensor) description of the geometrical and gravitational structure of the universe as a four- (3 + 1) dimensional space-time manifold – the background for, but also possibly a participant in the manifesta-tions of physical events.

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[21] Eddington was credited by Lupasco for having seen how much *his* view of the constitution of the universe was a creation of his mentality, a “universe in his image”. Eddington never seems to have wondered explicitly about the equally ‘logical’ opposite view, nor that there might be something very fundamental indicated by this conflict.

[22] Coherent interpretations of the phenomenon of time and the nature of space-time are being currently sought in terms a synthesis of gravity and quantum field theory. The theory of Yilmaz (Alley 1995), for example, corrects certain oversimplifications made by Einstein, and suggests solutions to a number of problems, in particular, the absence of a basis for Newtonian interactions in General Relativity, a need recognized by Einstein himself.

The solution proposed by Lusanna and Pauri (2005) starts by seeing the metric field as split into two parts: an ontic part corresponding to the autonomous degrees of freedom of the gravitational field in the absence of matter, and an epistemic part to the information encoded in the metric that must be specified in order to get empirical access to the ontic part, which refers to the appearance of gravitational phenomena.

A physical individuation of point-events is derived in terms of the ontic part of the gravitational field. The identity of point-events is conferred upon them by a complex relational structure in which they are holistically enmeshed. This relational structure includes all the elements of a so-called complete gauge fixing, supported by a definite solution of Einstein's equations (a definite Einstein "universe"). The characterization of such space-time points includes the fundamental intrinsic properties instantiated at those points including mass, charge, spin and perhaps others. However, it also gives a physical meaning to the coordinate indexing of such which makes point-events as ontologically equivalent to the existence of the gravitational field as an extended entity.

Summarizing, this view holds that space-time point-events do exist as individuals however, their properties can be viewed both as extrinsic and relational, being conferred on them in a holistic way by the whole structure of the metric field and the extrinsic curvature on a simultaneity hyper-surface (see below), and, at the same time as intrinsic, being coincident with the autonomous degrees of freedom of the gravitational field. "In this way both the metric field and the point-events maintain their own manner of existence, so that the structural texture of space-time in this model does not force us to abandon an entity realist stance about both the metric field and its points". This theory supports LIR since for the above description of time and space no background of *dimensionless* points (like those of differential calculus) needs to be postulated in addition to, or apart from, either the causally effective quantum field or the gravitational field and their self-duality.

Here, the thesis according to which metrical relations can exist *totally* without their constituents (point-events as relata, some of which may be relations; this point remains open) does not hold. LIR is consistent with this physics that provides a basis for a physical individuation of *some* point-events (entities), while insuring the required indistinguishability of quantum particles. LIR insists on a contradictional relation between identity, which implies indistinguishability, and diversity, which implies individuation.

Lusanna and Pauri (2006) propose solutions to Einstein's equations in which there is a dynamical emergence of 'instantaneous' 3-spaces, the three-dimensional instantaneous spaces in which ordinary phenomena are observed and described. In their striking metaphor, 'space-time' and the vacuum (matter/energy free) gravitational field are "two faces of the same reality". The 3-spaces are 'embedded' in an Einsteinian 4-D manifold. The appropriate theory is a new kind of structuralism, containing with elements of both the substantivalist and relationist points of view, implying a four-dimensional holism resulting from a foliation or unfolding within it of the instantaneous spaces with three spatial coordinates (3-spaces). The reality of the vacuum space-time of GR, the dynamical instantaneous 3-spaces and their dynamical individuation of point-events described by the epistemic part of the metric field is ontologically equivalent to the reality of the autonomous degrees of freedom of the gravitational field as described by the ontic part of the metric field. What this study brings out is that GR contains the potential for a differentiated description of both the four-dimensional space-time manifold implied by the existence of universal gravitation and a 'foliation' development into 'sheets' of observable 3-spaces.

In this picture, the individuation of the point-events involves their change in time. This is an attribute whose information is not wholly contained in the 3-space at a time *t*, but this is not inconsistent with the dual role of the metric field in GR. That a complex material process entity cannot be described as *wholly* present or absent is logically acceptable in LIR, and I see here a basis for the eventual formalization of the LIR conception of simultaneity and succession.

The program of Lusanna and Pauri thus establishes the mathematical basis for a reinterpretation of a 'join' region between phenomenal and non-phenomenal reality, establishing a relation that is both physical and epistemological (Smith 1997). LIR is compatible with this interpretation, which can serve as an extension of its foundation in physics as foreseen in Section 4.5.2. I wish to emphasize that I am not endorsing this theory as the last or most authoritative word on models of General Relativity; this is not a monograph of physics. The program is, however, a basis for discussion that not only addresses the complex relations between space-time in general relativity and phenomeno-logical space-time, but also discovers relations in the physics that have dialectic properties that LIR is capable of formalizing axiomatically and categorially. The usual counterarguments are available, but I submit that the alternative of seeing the two theories as mutually supporting is worthy of consideration.

From my point of view, the Lusanna and Pauri description suggests that the underlying *principle* of the metric field is one of self-duality, expressed by the properties of the gravitational field alone, which the authors describe as more ontologically diverse than any other. The critical insight is that GR is a theory that from the physical point of view is radically different. Its reference is to the space-time that evolves 'within' the gravitational field rather than to some internal mathematical groups, and it leads to a dual role of having both a unique dynamics (reality) and appearance to an observer.

Self-duality in cosmological theory refers to a type of solution to Einstein's equations,[23] for which LIR suggests a physical interpretation in terms of the same kind of opposition between inherent properties as in the quantum field. This view is supported by Majid's principle (Majid 1991) of representation-theoretic self-duality which states that a fundamental theory of physics is incomplete unless the role reversal implied by duality 'pairing' of structures is taken into account. The self-duality condition means that an evaluation function f(x) can also be read x(f) where f is an element of a dual structure. The consequence is that since all the reality elements of LIR are dual, they follow this principle, as does the notion of T-duality in string theory referred to in Chapter 4. This form of

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[23] For a general discussion see van Holten (1996).

self-duality was shown by Majid to apply to quantum theory and gravity theory, since Lie groups provide the basis for both the Riemannian (non-Euclidean) geometry needed for a representation of gravity and the quantum numbers of elementary particles in quantum theory. Also interesting from my point of view is Majid's search for an appropriate axiomatization of this principle, *via* an extension of intuitionist logic to a 'co-intuitionist' logic[24] to try to capture the duality. LIR, of course, starts from the position that duality is in any case ontologically primitive, and the relations can be expressed in contradictorial terms of alternate actuali-zation and potentialization of the elements. The necessary change to the law of the excluded middle falls out naturally.

The concept I suggested above of objects (matter/energy) being the source of space-time, or space-times should now be augmented as follows: the gravitational field exclusive of matter/energy has the physical role of individuating, physically, the points of a four-dimensional manifold. The gravitational field is constituted by gravitons or instantons, considered as quantum particles with a very high quantum number. In another metaphor of Lusanna and Pauri that I see as an expression of the self-duality of gravity, these non-linear gravitons are at the same time "both the stage and the actors within the causal play of photons, gluons, and other material (energetic) characters such as electrons and quarks".

7.6.2.1 Simultaneity: A Comparison of Dynamics

The issue of simultaneity of events offers a good opportunity for comparing its description in general relativity and *via* the logic of/in reality. In Section 7.2.3, the origin of simultaneity and succession was proposed as a matter of *logical necessity*, given some minimum assumptions about being and change. Simultaneity and succession were linked dialectically, as operations defining non-formally the space and time respectively associated with two entities, without reference to distance or proximity. However, the effect of the universal gravitational field has not been taken into account explicitly.

The account that is emerging in GR yields an image of a complex curved 'surface' (hyper-surface, which may be asymptotically 'flat') of simultaneity on which are located point-events throughout the universe. The advantage of this picture is that it corresponds to the intuition that distant events *are* simultaneous with proximal ones, despite the inevitable ignorance of the clock-time at such events. The advantage of this model over that of Special Relativity is that it is dependent on the definition of a global, non-inertial frame of reference but this is the same for all observers. All have the same sequence of before and after, and the same notion of simultaneity and perceived instantaneous 3-spaces (space not 'flowing' as time).

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[24] This is in fact a form of paraconsistent logic.

One can differentiate the descriptions by referring to the respective meanings of dynamics and dynamically: in the LIR 'metaphysical' model, dynamic in dynamic opposition refers to the real physical interactions between any entity and its opposite or negation resulting in an alternating potentiality and actuality of both. Where those are absent, as in the case of three billiard balls, there is no question about their all being on the table 'simultaneously'. In the GR model, as in some forms of structural realism, dynamic refers to a principle of change inherent in the *equations*, Einstein's or others, which describe a non-trivial evolution in 'time'. These are referred to as 'dynamic symmetries', dynamical tensor fields and so on. All of the chrono-geometrical structure of an Einsteinian universe is dynamically determined in this sense. The point-events located on the simultaneity surfaces are achronal (timeless *per se*), but are characterized by dynamically determined conventions about distant simultaneity. My conclusion is, however, that simultaneity in GR is still defined as a *convention*, with respect to such large distances. There is no explicit reference to the simultaneity or lack of it in proximal events that may be in just as much need of definition.

The major difference in the LIR and GR accounts of simultaneity is in thus in their treatment of *proximal* events involving entities of greater tangible complexity than those at the quantum or cosmological levels. Another way of saying this is that wherever the process phenomena require formalisms for their description that are dual in the LIR sense, but not self-dual as in the case of quantum and gravitational fields, the LIR picture applies. The logic I have proposed describes the contradictorial evolution of biological and cognitive processes as involving a richer structure of simultaneity and succession than provided by GR.

Having arrived at a *logical* theory of time and space, or space-time, it might be asked what possible consequences it might have, practical or theoretical. I suggest two preliminary answers: first, this logic could make more accessible, by pointing to the operation of the PDO in them, the contrasting or opposing domains of cosmological physics. It is, if one likes, a restatement of the fundamental duality of the universe into perceiving and non-perceiving domains. The mathematical and physical structures of these domains are separately describable but functionally linked as suggested by the LIR axioms of LIR, in particular, of Functional Association, Conditional Contradiction and Asymptoticity. Second, it could serve as another way of reminding people that the space and time they experience are neither eternal and absolute realities, nor the framework of *a priori* functions of sensibility, but the consequence of the existence of matter/energy itself.[25] The further role of LIR may be, given the application of the PDO 'across the board', to facilitate the application of significant aspects of the new theories at the quantum and cosmological levels of reality to the levels of intermediate biological and agentive human existence.

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[25] Lupasco's phrase was: "the continual creations of the contradictory, deductive fertility of energy."

7.6.3 Structural Realism and the Metaphysics of Relations

The reason for returning to the discussion of structural realism and the role of relations in it is to examine its physical significance, now that the significance of relations has been established for the most fundamental physical theories. Both quantum field theory and General Relativity describe the relations involved in quantum entanglement (non-separability) and space-time respectively. In the above discussion of cosmological physics, I have tried to give some sense of its evolution and suggested that the improvements that are being made in the above are due in part to the descriptions of gravity and the duality and self-duality of energy (the quantum and gravitational fields) that bring out the inherent duality in existence.

A metaphysics of relations was developed by Lupasco in his monograph on structure (1967) cited earlier: he said essentially that objects can neither appear (to us) nor exist except as a elements related to others. Everything is relational; nothing is self-sufficient. There is a 'law' of contradictory relationality, *whose terms are indefinitely relations* (emphasis mine), that governs or implies the contradictional antagonism of the homogeneous and heterogeneous, the same and the different, and so on. The two essential relations in the LIR theory are those necessary for the formation and continuing existence of a minimal physical system, as described in Appendix 2. They are: (1) the relation of antagonism or opposition, whose elements are attraction and repulsion; and (2) the relation of contradiction, whose elements are identity and diversity, homogeneity and heterogeneity. These are related to, or the expressions of, the fundamental duality in energy in which the relations are intrinsic or internal. The relational aspects of LIR were also mentioned above in connection with Relational Quantum Mechanics (RQM), where I pointed out that the relational approach weakens the notions of the state of a system, event, and the idea that a system, at a certain time, may have just a certain property. This was in part the basis for my critique of the pure logical approach to being of Jacquette in Chapter 3.

There is a striking similarity between the Lupasco view of the fundamental nature of relations and that of Ladyman and Ross outlined in Chapter 6. The later authors maintain a metaphysics of structural realism (Ontic Structural Realism, OSR) according to which there is, primitively, structure in the sense of concrete, physical relations, with objects derived from relations. LIR gives a picture of this 'derivation' in terms of a pause in the ortho-dialectic concatenation of processes (Appendix 1). The ontological commitment to relations in LIR and OSR, as well as RQM places objects and their relations on the same level within a holistic metaphysics.[26] Esfeld sees our world as one of holism, tied together by relations that do not supervene on (whose source is not) intrinsic properties. There is no ontological priority, but rather a mutual ontological dependence between space-time relations and the objects that stand in the relations, considered as

[26] Esfeld and Lam (forthcoming).

space-time 'points' or point-events as developed in the theory of Lusanna and Pauri. These point-events also define the process entities which LIR sees as populating the universe, instantiating both identity and diversity.

This view holds that when space-time point-events are the relata, they do exist as individuals. Their properties can be viewed both as extrinsic and relational, and, at the same time, as intrinsic. The concept that point-events instantiate both intrinsic and extrinsic properties at the same time fits the category of Dynamic Opposition. Whether or not relations by themselves, at this primitive level, can be described in this picture as real entities capable of entering into relations with others is not clear. At any other level, if they are involved in an energetic interaction, the LIR description is that they (the relations) are real but both actual and potential.

I referred earlier to the debate between substantivalists who consider that matter exists either distinct from or equivalent to 'space-time' and relationists who insist that all there is to fundamental physical objects is the relations in which they stand. In relationism, the physical meaning of space-time depends upon the relations between bodies; its specific reality is dependent of the entities or fields present. The above view of space-time, called point-structuralism, includes elements common to both substantivalism and relationism. Lusanna and Pauri believe their analysis may offer a *tertium quid* resolution of the debate by overcoming it (in LIR terms, a solution emerges from the dialectics as an 'included' third term: *tertium datur*). It is the kind of best-of-both-worlds scenario which LIR sees as logical *via* the principle of dynamic opposition and the category of Non-Separability of entities at all levels of reality.

In this "peculiar space-time structure", the relation/relata correspondence does not fit either of the extreme views: the totality of the physically concrete events is displayed by means of the holistic relational structure. In LIR terms, this structure is a 'structuring' since it is the source of the points which supervene on it. The points of general-relativistic space-times, unlike the points of homogeneous Newtonian space, have a rich non-point-like, holistic structure furnished by the metric field. Although physical properties are conferred to the point-events in a peculiar relational form, point-structuralism does not support the standard relationist view either. Point-events are individuals, albeit in a peculiar sense: they exist as autonomous constituents, but one cannot claim that their properties do not depend on the properties of others. Not only relations exist, but also the carriers of them, even if their intrinsic properties are also relations. This is another statement of the LIR position on individuality. It provides further support for the extension to higher levels of reality, since the relations (say, between human individuals) can readily be seen to be both dependent on and independent from the individuals themselves.

Esfeld maintains that the distribution of relations can be contingent in the same way as the distribution of intrinsic properties. Laws of nature, as in a Humean world, can be contingent instead of metaphysically necessary. The LIR version of structural realism also does not require that locally necessary relations invalidate global contingency, since it assumes the existence of domains and entities that are not linked dynamically, as well as those that are. Situations of interest in the macroscopic world, however, will generally exhibit contra-dictorially linked aspects of both necessity and contingency, as discussed earlier.

From my metaphysical standpoint, what is essential in the above is the mutual ontological dependence between relations and objects regardless of what the relations are (quantum, spatio-temporal, or interactive) and of what the objects are (single quantum systems or complex space-time point-events that are equivalent to macroscopic processes). In my view, this dependence is described logically by the axioms of LIR and its fundamental principle of dynamic oppo-sition. Stated more specifically than in Esfeld, any relation is part object and any object is part relation such that one is more instantiated at any time at the expense of the other, physically and theoretically, except at the mid-point of the interaction that, above the quantum level, is the locus of emergence. At the most fundamental level of reality or being, one would, in this theory, still never find a single object 'existing', but a minimum of two plus their relation.

7.6.4 A Cyclic Model of the Universe

One debate in cosmology, as discussed in Chapter 4 and above, revolves around the nature of the gravitational field and/or the reality of strings as fundamental entities of which the universe is constructed. One might regard the former as evidence of a general trend toward more balanced solutions in which dynamic opposition is present and the latter – string theory – as the latest version of a continuing tendency toward a cosmology of identity. The cyclic model of the universe discussed below is for me an example of the former.

Models of the universe since the original concept by Lemaître of an expanding universe have assumed an initial singularity, the Big Bang, at, or as, the origin of the universe, in which matter-energy had 'infinite' temperature and density. The weakness in this picture is the existence of the singularity, how it can possibly be explained, and, if, as some versions of this model require, the Big Bang is followed by a phase of contraction, what meaning is to be ascribed to the Big Crunch that would necessarily follow.[27]

The consensus regarding the current state of the universe is (1) that it is expanding at an increasing rate; and (2) it seems to be composed to the extent of 70% of an unknown dark energy, 25% of cold dark matter, whose nature is also unknown, and of not more than about 5% of ordinary matter-energy. I have selected the model proposed by Steinhardt and Turok (2002) as an illustration of

[27] I will not discuss here the endless speculation of how such a notion can be reconciled with the experiential notions of time and space (what 'was' before the Big Bang). These questions are applicable only to the veiled three-dimensional view of reality that is possible to us as medium-sized macroscopic objects, and, as indicated, probably badly posed.

what a theory based on categories of Energy, Process and Dynamic Opposition might look like.

In this cyclic cosmological model, the universe undergoes an endless sequence of cosmic epochs that begin with almost a 'bang' and end in almost a 'crunch'. Temperature and density at the transition remain finite. Instead of having an inflationary epoch, each cycle includes a period of slow accelerated expansion (as currently observed) followed by contraction that "produces the *homogeneity* (emphasis mine), flatness and energy needed to begin the next cycle." Steinhardt and Turok showed that the universe is infinite and flat, rather than finite and closed as in earlier oscillatory models, and no singularities are required. A negative potential energy is introduced rather than spatial curvature to cause the reversal from expansion to contraction. The authors also suggest a mechanism for the passage from the end of contraction to the restart of expansion: some small fraction of the kinetic energy is converted to matter and radiation, but both sides of the relation involved are finite at the 'bounce'. In LIR terms, a potential is available to effect the changes. Subsequently, the scalar field increases rapidly, but its motion is damped by the expansion of the universe and comes to rest prior to the next phase of expansion, in a movement that reminds one of actualization and potentialization. The universe never reaches a true ground state, but 'hovers' above it, approaching asymptotically now one side and then the other of the cosmic potential well. The serious metaphysical problem of a putative 'first cycle' is not explained in this model, but the situation is no worse than in any other. In further theoretical work, the authors show that the cyclic model gives a possible explanation for the low relative value of the cosmological constant. This picture offers, among other things, more stages of evolution of the universe in which the constants would be appropriate for life (Steinhardt and Turok 2006) than does the standard Big Bang model. This eliminates a bothersome 'epistemological singularity', since in combinations of the strong anthropic principle (see Chapter 1) with an inflationary cosmology, the fraction of space-time that is 'habitable', that is, available for life, is infinitesimally small.

It is of interest to note that serious researchers have been arrived at a cosmological description that tracks the basic principles of LIR quite closely. It is one of the key aspects of my approach that singularities, or the artificial idealized limits between opposing terms that are required by Aristotelian logic, do not in fact exist. It will be fascinating to see whether further discoveries about the nature of dark matter and energy and negative gravity, perhaps based on the cyclic model, will provide more direct illustrations of the principle of antagonism. This theory has been challenged by a proposal that the expansion of the universe is a by-product of enormous ripples in the fabric of space-time. These ripples, caused by rapid inflation after an alleged Big Bang, mimic in this second theory the properties of dark energy. One has recourse to a series of hypothetical constructions that are separate identities – the ripples, the Big Bang and a background fabric of space-time – all of which embody concepts of time, space and causality from classical logic. Despite its theoretical and mathematical complications, this theory describes static entities, the idealized products of processes in which they do not participate. Accordingly, I will hazard the prediction that based on the principles I have been talking about, the cyclic model, in which one can see the operation of a dynamic opposition, an alternating actualization and potentialization, is closer to being correct.[28]

In the next and final chapter, I will look at the application of all the logic and concepts developed so far to the biological level of reality.

References

Aerts, Diederik. 1996. Relativity Theory: What Is Reality? *Foundations of Physics* 26: 1627–1644.

Aerts, Diederik. 1999. The Stuff the World Is Made of: Physics and Reality. In *Einstein Meets Magritte: An Interdisciplinary Reflection*, eds. D. Aerts et al. Dordrecht, The Netherlands: Kluwer.

Aerts, Diederik and Sven Aerts. 2004. Towards a General Operational and Realistic Framework for Quantum Mechanics and Relativity Theory. In *Quo Vadis Quantum Mechanics? Possible Developments in Quantum Theory in the 21st Century*, eds. A. C. Elitzur, S. Dolev and N. Kolenda. Berlin: Springer Verlag.

Alley, Carroll O. 1995. The Yilmaz Theory of Gravity and Its Compatibility with Quantum Theory. In *Fundamental Problems in Quantum Theory, Annals of the New York Academy of Sciences*, eds. Daniel M. Greenberger and A. Zeilinger. New York: The New York Academy of Sciences 755: 464–475.

Béziau, Jean-Yves. 2001. The Logic of Confusion. *Proceedings of the International Conference on Artificial Intelligence*, IC-AI, in Las Vegas, Nevada.

Cao, Tian Yu. 1997. *Conceptual Developments of 20th Century Field Theories.* Cambridge: Cambridge University Press.

Da Costa, Newton C. A. and Décio Krause, Décio. 2004. Complementarity and Paraconsistency. In *Logic, Epistemology and the Unity of Science*, eds. S. Rahman, J. Symons, D. M. Gabbay and J.-P. van Bendegem. Dordrecht, The Netherlands: Kluwer 1: 557–568.

Da Costa, Newton C. A. and Décio Krause. 2006. The Logic of Complementarity. In *The Age of Alternative Logics: Assessing the Philosophy of Logic and Mathematics Today*, eds. J. van Benthem, G. Heinzmann, M. Rebuschi, and H. Visser. Dordrecht, The Netherlands: Springer.

Derrida, Jacques. 1993. *Aporias*. Stanford, CA: Stanford University Press.

Esfeld, Michael and Vincent Lam. In Press. Holism and Structural Realism. In *Worldviews, Science and Us: Studies of Analytical Metaphysics. A Selection of Topics from a Methodological Perspective,* eds. Robrecht Vanderbeeken and Erik Weber. Dordrecht: Springer.

Faye, Jan. 2002. Copenhagen Interpretation of Quantum Mechanics. In *The Stanford Encyclopedia of Philosophy (Summer 2002 Edition)*, ed. Edward N. Zalta. http://plato.stanford.edu/archives/ sum2002/entries/qm-copenhagen/.

Gingrich, Robert and Chris Adami. 2002. *Physical Review Letters*, 30 December 2002, reviewed in *SCIENCE* 299: 185.

Grush, Rick. 2006. How to, and How *Not* to, Bridge Computational Cognitive Neuroscience and Husserlian Phenomenology of Time Consciousness. *SYNTHESE* 153: 417–450.

[28] A number of recent *Gedankenexperimente* suggest additional potential real-world implications of LIR. For example, Gingrich and Adami (2002) show that particles whose spins were entangled when at rest lose spin entanglement when accelerated to relativistic speeds, their momenta become entangled to compensate, and *vice versa*. In LIR terminology, actualization of momentum entanglement potentializes spin entanglement.

Hawley, Katherine. 2006. Science as a Guide to Metaphysics? *SYNTHESE* 149: 451–470.
Heidegger, Martin. 1959. *An Introduction to Metaphysics*. New Haven, CT/London: Yale University Press.
Laudisa, Federico and Carlo Rovelli. 2002. Relational Quantum Mechanics. In *The Stanford Encyclopedia of Philosophy (Spring 2002 Edition)*, ed. Edward N. Zalta. http://plato.stanford.edu /archives/spr2002/entries/qm-relational/.
Le Poidevin, Robin. 2000. The Experience and Perception of Time. In *The Stanford Encyclopedia of Philosophy (Fall 2000 Edition)*, ed. Edward N. Zalta. http://plato.stanford.edu/archives/fall2000/entries/time-experience/.
Levinas, Emmanuel. 1998. *De l'existence à l'existant*. Paris: Libraire Philosophique J. Vrin.
Leyton, Michael. 2005. Shape as Memory Storage. *LN Artificial Intelligence* 3345: 81–103, Dordrecht, The Netherlands: Springer Verlag.
Luca, Lusanna and Massimo Pauri. 2005. General Covariance and the Objectivity of Space-Time Point-Events. arXiv:gr-qc/0503069 v2 3 Sep.
Luca, Lusanna and Massimo Pauri. 2006. Dynamical Emergence of Instantaneous 3-Spaces in a Class of Models of General Relativity. Forthcoming in *Relativity and the Dimensionality of the World*, ed. A. van der Merwe. Dordrecht, The Netherlands: Springer. arXiv:grqc/0611045 v1 7 Nov.
Lupasco, Stéphane. 1967. *Qu'est-ce qu'une structure?* Paris: Christian Bourgois.
Lupasco, Stéphane. 1986a. *L'énergie et la matière vivante*. Monaco: Éditions du Rocher (originally published in Paris: Julliard, 1962.)
Lupasco, Stéphane. 1986b. La topologie énergétique. In *Pensées hors du Rond, La Liberté de l'esprit*. Paris: Hachette. 12: 11–28.
Lupasco, Stéphane. 1987. *L'énergie et la matière psychique.* Monaco: Éditions du Rocher (originally published in Paris: Julliard, 1974).
Majid, Shahn. 1991. Principle of representation-theoretic self-duality. *Phys. Essays* 4: 395–405.
McKinney, Shawn. 2003. The Problem of Shared Semantic Beginnings in the Debate over the Philosophy of Time. In *Proceedings of the Heraclitean Society.* http://www.wmich.edu/philosophy/heraclitean/vol20/mckinney.htm/
Nicolescu, Basarab. 2002. *Nous*, *la particule et le monde*. Paris: Éditions Le Rocher (originally published in Paris: Éditions Le Mail, 1985).
Penrose, Roger. 1994. *Shadows of the Mind.* Oxford: Oxford University Press.
Petit, Gérard and Peter Wolf. 2005. Relativistic Theory for Time Comparisons: A Review. *Metrologia* 42: 138–144.
Rovelli, Carlo. 2006. *What Is Time? What Is Space?* Rome: Di Renzo Editore.
Savitt, Steven. 2002. Being and Becoming in Modern Physics. In *The Stanford Encyclopedia of Philosophy (Spring 2002 Edition)*, ed. Edward N. Zalta. http://plato.stanford.edu/archives/spr2002/entries/spacetime-bebecome/
Sklar, Lawrence. 1992. *Philosophy of Physics*. Boulder, CO/San Francisco, CA: Westview.
Smith, Quentin. 1986. The Infinite Regress of Temporal Attributions. *The Southern Journal of Philosophy* XXIV: 383.
Smith, Quentin. 1997. The Ontological Interpretation of the Wave Function of the Universe. *The Monist* 80: 160–185.
Steinhardt, Paul J. and Neil Turok. 2002. A Cyclic Model of the Universe. *SCIENCE* 296: 1436.
Steinhardt, Paul J. and Neil Turok. 2006. Why the Cosmological Constant Is Small and Positive. *SCIENCE* 312: 1180–1183.
Van Holten, J. W. 1996. Gravity, Geometry and Physics. Lectures presented at the Summer school of Theoretical Physics, September, in Saalburg, Germany.
Varela, Francisco J. 1999. The Specious Present: A Neurophenomenology of Time Consciousness. In *Naturalizing Phenomenology. Issues in Contemporary Phenomenology and Cognitive Science*, eds. J. Petitot et al. Stanford, CA: Stanford University Press.
Whitehead, Alfred North. 1978. *Process and Reality*. New York: The Free Press.

8 EMERGENCE, LIVING SYSTEMS AND CLOSURE

Abstract The final chapter uses the fundamental axiom of an emergent included middle and the LIR two-level framework as a basis for a discussion of emergence in biology. The principles of LIR permit the formulation of a physics and chemistry of living systems that includes a locus for the potentialities necessary for emergence. A categorial interpretation of the related issues of closure and downward causation is developed, using the LIR notions of time, simultaneity and succession outlined in Chapter 7. LIR is presented as a logical system that can compensate for the inability of standard logics to address general issues in biological science. The application of LIR to the major problems of the origin of life and evolution and natural selection is suggested, and the essential role of the Pauli Exclusion Principle as the physical basis for the emergence of diversity and living systems emphasized. The chapter closes with a comparison of LIR and several current semiotic, thermodynamic and contextual views.

8.1 INTRODUCTION

8.1.1 Emergence

As an introduction to the applications of LIR and NEO to theories of emergence and living systems in the final chapter of this book, let me first restate a hierarchy of levels of reality in a way that will facilitate talking about the connection between them:

- Inanimate Systems
- Living = Perceiving Systems
- Conscious Systems
- Knowing Systems

For all systems, *change* can be defined as involving a new state or position of the same entity, and *emergence* as involving the formation of a new entity. Both display the classical logical problem of the point at which an entity moves or passes from one state to another, or a new entity appears, but, as I will show, the relations defined by LIR largely avoid this problem. Further, juxtaposing the four terms of non-life, life, consciousness and knowledge is not intended to mean that one group of systems is the *cause* of the next. Rather, the former state the conditions of existence of the latter.

I have implied that the concept of emergence applies throughout reality: even evanescent virtual particles can be considered to 'emerge' from the quantum vacuum. However, the question of emergence is most relevant to explanations of phenomena at higher, more complex levels of reality. All sciences receive some new interpretations of their domains in LIR, but I begin here with a discussion of emergence in relation to life, since without life there is neither consciousness nor knowledge! Discussion of these latter topics, as previously noted, will be deferred to another occasion.

There are (at least) three conflicting views of what constitutes emergence that are relevant to my current development:

1. Emergence does not exist at all.
LIR: This view is based on a limited, classical picture of ontology.

2. Emergence is an *empty* concept: to say that a phenomenon is emergent is nothing more than a description of the processes involved.
LIR: This view does focus on what is happening without the reification of a term, but it is too reductionist.

3. Emergence can be associated with several other terms, such as biosemiosis, all of which are equivalent.
LIR: Emergence can be given a general interpretation that suggests useful distinctions with the other terms, and the intuitions of this approach receive needed further grounding and explanation using the principles of LIR.

It is curious and perhaps significant that the form of this debate is very similar to that about laws of nature outlined in Chapter 6.

In this chapter, I will refer to a number of examples from the recent literature. It is clear that my selection cannot be exhaustive, but it is in addition open to (at least) two additional, different forms of objection: the PDO does not apply to a specific subject, or its effect is negligible or trivial. In this case, I may consider revising my thesis with respect to that subject, and agree, on reflection, to reassign it to the category of separable entities. I am, of course, most interested in the applications in which I believe that Non-Separability applies. The form of objection that is relevant here is that my core thesis does not apply at all, either to theory or experiment. The objection has been made, for example, that it is incorrect to speak of logic of any kind in relation to experimental science outside, perhaps, the domain of quantum entities, or that there is no functional connection between a scientific theory and the data of that theory, between metaphysics and physics. My counter-strategy will be to show, as I have in regard to these issues earlier, that theories of biological systems (cf. Appendix 2) that do not take contradiction in the LIR sense into account lead to an impasse, if in fact, from their models, the most problematic aspects of the phenomena in question are not completely excluded. I will also include references in which intuitions are expressed of the need for something like my logic, or in which it is found in 'embryonic' form in the concept of an adequate bridging principle or theory.

8.1.2 Opposition in the Physics and Chemistry of Living Systems

The problems of trying to explain the existence of any change, but particularly of the emergence of biological systems in terms of physics and chemistry, were and are still due to the retention of classical notions of cause, time and matter-energy solely in terms of actualities. This is particularly important in regard to living systems, as I will now show.

I have discussed earlier how the Pauli Exclusion Principle for electrons establishes a basis for heterogeneity, in real as well as epistemological opposition to the 2nd Law of Thermodynamics, which is a basis for homogeneity. This principle of heterogeneity, or tendency toward heterogeneity, is what is considered, in the logic of/in reality, the basis for the existence of increasingly complex macrophysical systems, leading ultimately to those designated as living systems at a biological level of reality. The processes leading, in some as yet undefined way, to entities and their constituents at the biological level – the genome, gametes, other cells, organs, and living individuals – all involve the emergence of new forms, which I have tentatively identified as T-states, included middle elements at another level of reality or complexity. Their origin in turn is in properties of molecular and chemical substrates (under-levels) and processes that are less complex, and I have postulated that all processes, at all levels, are characterized by more or less easily identifiable aspects of dynamic opposition, instantiated in those properties. An overly simplistic model of natural selection as a consequence of the 'pressure' of the environment on the evolution of a species is an example of such opposition.

This postulate of the real, logical and dynamic opposition at the heart of energy, and consequently of its embodiment in matter and information at all more complex levels of reality, requires that it applies to fundamental particles, protons and electrons, atoms and inorganic and organic molecules and ultimately the living organisms that are constituted by them. Everything that involves this principle is a system, a process of systems of systems, etc.; therefore, everything is a system, capable of interacting with other systems in a manner that one can call antagonist. In chemistry the calcium ion, Ca^{++} is a biologically 'active' system as are the toxic thallium ion, Tl^{+} and the carbon atom with its capacity (potential) for four covalent bonds to other atoms that make possible complex molecules, an amino acid, a polypeptide, a hormone, a gene, an egg and a human being. The proposed consequence of LIR for biology and philosophy is that its principles are universal in the sense of applying to chemical elements, inorganic and organic materials, macromolecules, their dynamics, the memory they embody *via* their folding and to all other constraints that enable self-replication of living systems.

Some early proponents of emergence believed that primitive features of matter could exert a primitive form of causality, involving fundamental 'configurational forces'. This, in other terms, is the LIR thesis: the 'features' of phenomena, starting with energy, can be described as involving 'configurational forces', in which significant energy is encoded in potential form. It is in configuration space that the actual and potential states of electrons are present, and it is both these categorial features that are the carriers of the upward causation necessary for emergence. To take the example of the calcium ion, again, the combination of its size and net positive charge results in different potentialities for interactions with, say, water molecules than that of a lithium ion, Li^{+} , and their biological activity, partly as a consequence of this, is quite different, for example, at the psycho-physical level.

I note, not entirely in passing, that the reduction of chemistry to physics is no longer an issue. Every physical entity is a system, unsaturated in its potential for further interactions, the more complex chemical systems that emerge from those interactions will retain part of that unsaturation as higher-level causal properties that I designate as the residual potentialities of the system. These consist, again, in the ability to lose an electron 'completely', to form an ionic bond, say sodium to sodium chloride; to share electrons in a covalent bond, as in the unsaturated ethylene molecule; or to form electrostatic bonds such as those between water molecules and sodium chloride ions. The greater stability of the hydrated ions is the thermodynamic basis for the solubility of salt in water.

While the details of the initial production of biological macromolecules at the origin of life, as discussed below, remain unknown, the concept of opposition or antagonism provides a further entry point for analysis of these processes.

8.2 THE LIR APPROACH TO EMERGENCE

8.2.1 The Category of Emergence

In Chapter 4, I proposed a category of T-states that are the consequence of the operation of the principles of dynamic opposition and of levels of reality. Since the T-state resolves the contradiction between two antagonistic terms at another, 'higher' level of reality, it seemed reasonable to suggest that the T-state emerges from them. Accordingly, one could consider the logic of/in reality as a 'logic of emergence'. However, I need to establish the difference between processes, T-states and emergence. I propose a category of Emergent Processes as a sub-category of Process, and Emergence as the formal category corresponding to it. Emergence focuses on the process *qua* process, or rather, as is usually the case, the transfinite series of processes of processes, while the T-state is the (temporary) end-point of this ortho-dialectic series tending toward contradiction, viewed as an (id)entity.

In one anti-emergentist position (see below), emergence is reduced to a merely epistemic notion, that is, describing formal relations between *statements* about some set of properties of processes, not the inherent properties or processes themselves. As we have seen, however, the relations involved in and between processes are grounded in the inherent properties of energy, and statements about the consequences for higher levels of reality do not have an *a priori* character. Accordingly, the first concept I introduce at this point is the following:

Thesis 8.1: Emergence is a physical and a metaphysical category.

LIR provides a framework for analyzing the organizational properties of biochemical networks, ones not manifested at the level of the parts, but which result from the antagonistic interactions between the parts. Organization can be explained in terms of component properties, which depend on both the properties of the parts and on the state of the system. These have the part-whole structure suggested earlier, namely, the whole is present in the parts as potentialities, and *vice versa.* Emergence is the consequence of the overall two-level structure of interactions, horizontal and vertical (Boogerd et al. 2005).

To see what can be achieved through this concept, I will look first look first at the development of the concept of emergence and then see how the LIR principles can be applied to the three competing views outlined above. I will then discuss the related issue of closure and specific problems pertaining to the understanding of life and evolution.

8.2.2 Emergence and Dualism Under Attack

The concept of emergence is central to current theories of evolution and other developmental biological processes. It corresponds to our intuitive notions of life and growth, creativity and new human relationships. However, for much of the last one hundred fifty years or so, emergence has lacked a sound metaphysical basis and has been and still is open to attack by 'anti-emergentists'. Most of the positions taken against emergence can now be discarded as reductionist-materialist or neo-vitalist. What is 'wrong' with taking such positions is not only that they do not capture the essential processes in reality, or favor one side or the other in the debate. It is, as in the debate between realists and anti-realists, positions are taken exclusively and absolutely.

Kim (1999) has made a serious challenge to the reality of emergence. Let us assume that emergentism implies the existence of fundamentally novel properties, all of whose elements are physical, including some macrofeatures that cannot be explained or deduced as the consequence of, or in terms of complex microfeatures. Kim's challenge, in one form, is that emergentists are faced with the following dilemma: as physicalists, they are either committed to reductionism or materialism, or, if they avoid reductionism, they are committed to a dualism that cannot be distinguished in a principled manner from a vitalism of some kind, outside the laws of physics. Kim has shown, in addition, that emergence requires reflexive downward causation, a new, emergent phenomenon acting on its own constituents. As discussed by Symons (2002), Kim argues that this implies a kind of circular self-causation that is absurd. I will return to the problem of downward causation later in this chapter.

My claim is that the fundamental PDO and its related categorial features can carry the philosophical weight required for an approach to the resolution of dilemmas such as the one proposed by Kim. Very specifically, *I propose LIR as a dualism without vitalism, with the potentialities of fundamental particles governed by the laws of physics.* The consequence is equally important for the first challenge. The second challenge fails, but *LIR avoids reductionist materialism by providing a mechanism for most, if not all, of the critical non-physical and subjective aspects of life (including consciousness and mind).*

In what I consider a further attack on the irreducibility of emergence, to explain biological processes, Wilson (2000) believed that "powerful principles of complexity" would lead to algorithms conserved across many levels of organization. From these algorithms, "self-assembled, sustainable, and constantly changing yet perfectly producing organisms" will somehow be possible. "In other words, they will be living organisms." This will be true, however, only if "general organizing principles exist that allow a living organism to be reconstituted in full without recourse to brute force simulation of all its molecules and atoms." If the same principles apply to mind, behavior and ecosystems, is there a body of mathematics that will "serve as a natural language for biology, parallel to the one that works so well for physics", and show how the principles could be used in the desired models, assuming they could be found? If the essential elements of life could be captured by an algorithm, this would mean, in Lupasco's critique of similar positions (Lupasco 1973b), that "every differentiation not only flows normally from physical, identifying extensities, but they are only epi-phenomena.…

From the point of view of LIR, the Wilson approach, and others like it, amount to simply the reappearance of mechanism in modern dress. By conflating the problem of inter-and trans-disciplinary aspects of the sciences (biology, mathematics, computer science, etc.) with the concept that algorithms can capture the essential 'mechanisms' of life, all the diversities of the phenomena of life are exposed to a reductionist interpretation. The disparate elements of a living entity are no more than means toward ends that transcend and condition them, to which no autonomous power should be ascribed, which might in turn require recourse to some form of constitutive existential antagonism. LIR seeks to correct this view by eliminating the type difference between a living entity and *all* the aspects of its elements. To avoid misunderstanding, I repeat that I am not saying that a calcium ion is alive, but that it is its potentialities that contribute to its function in living systems.

8.2.3 A Peircean Perspective

In his discussion of causal processes, semiosis and consciousness Emmeche claims the advantage for contemporary biosemiotics, the application of concepts of signs to living systems, is that "it does not force on us a dualist metaphysics that separates phenomena into two distinct worlds or realms which are afterwards difficult to reconnect again". Emmeche considers that Peirce's system was an ideal combination of semiotic monism, conjoined (how?) with an ontological category theory. Peirce based his theory on the categories of Firstness (possibility), Secondness (existence) and Thirdness (reality), without the requirement for radically different ontological domains. The 'First' is a 'Sign' or 'Representamen' which is in a genuine triadic relation to a 'Second', called its 'Object' so as to be capable of determining a 'Third', its 'Interpretant' to assume the same triadic relation to its Object in which it stands itself to the same Object'. The term 'Sign' was used by Peirce to designate the irreducible relation between the three terms, irreducible in the sense that it is not decomposable into any simpler relation, such as some form of part-whole relation.

As might be guessed from my comments on dualism above, I do not fully accept this theory, which I consider insufficiently dynamic, despite the common interpretation that the relation is dynamic because it leads to 'chains of triads'. I think this because there is no energy that can be assigned to the triadic relation that would give it a basis in reality (physics). The Peircean framework, from my standpoint, is an outstanding heuristic device for keeping track of the entities involved in biological processes (Queiroz et al. 2005), but its use should not make one forget the real properties of the system.

Despite his deep and anticipatory intuitions, Peirce made no ontological commitment regarding his concepts. He wrote specifically that his ‘phaneroscopy’ (phenomenology) had nothing at all to do with the question of how far the ‘phanerons’ it studied correspond to any realities. It abstains from all speculation as to any relations between its categories and physiological facts, cerebral or other. It does not undertake, but sedulously avoids, hypothetical explanations of any sort. Peirce also said that the one intelligible theory of the universe is that of object-tive idealism. In a general way, as a Kantian, it would appear that Peirce was un-comfortable with contradiction, and rejected even Hegel‘s more dialectic cate-gories and their associated or implied dynamics. He considered a principle of continuity as “a supreme guide in framing philosophical hypotheses”, relegating heterogeneity and discontinuity to second-class status. ‘Sportings’ and pure chance are the sources of evolution and change in Peirce’s cosmogony. These positions should not be taken too seriously. Peirce was anxious to avoid being tagged as a naïve realist or nominalist. My point here is not to deconstruct Peirce but to provide a working alternative to ‘naïve’ realism and classical dualism, and I have suggested LIR as a variety of conditional dualism as such an alternative.

8.2.3.1 Virtual Logic and Organic Logic

There are two additional systems of logic that are worth mentioning, as they derive from this Peircean view of the structure of reality: the virtual logic of Kauffman and the organic or dichotomistic logic of McCrone (2007).

According to Kauffman (1997), virtual logic is “that which energizes reason” without being a (standard) logic nor the actual subject matter of the discipline in which it may be embedded. … “it is a pivot that allows us to move from one world of ideas to another.” The emphasis here is on virtuality, a wholeness with unlimited potential for becoming, with dynamic aspects capable of all possible changes. Peirce is quoted to the effect that semiosis is virtual, inclu-ding appearance (in the sense of formation) of connections between things, events, phenomena and processes seen *a priori* as signs not interacting with each other. Kauffman then says that semiosis can be a methodology for exploring nature in the sense of looking for patterns “emerging out of the tangled web of interdep-endent relationships”.

McCrone’s statement that logic is about the way things do and *must* happen is in principle congenial to LIR. Organic logic is a model of reality com-posed of a combination of monadic (Peirce’s Firstness), dyadic (Secondness) and triadic (Thirdness) elements. Processes start with vagueness, a state of pure (sic) potential, poised equally between existence and non-existence. Vagueness is the ground from which come Dichotomies, the driving forces that result from, and/or are cause of the splitting of the ground. Hierarchies, which themselves have a triadic structure, instantiate the result or the destination of Dichotomies, a triadic state of balance marking the presumably temporary outcome of the process.

It is relatively easy to translate these more philosophical than logical languages into LIR terms, since some of the underlying intuitions are similar. LIR provides a more physical and metaphysical understanding of the movement from actual to potential, as well as potential to actual, based on the dualistic structure of energy itself, without recourse to the idea of a pure or unlimited potential.

In another paper, Kauffman (2002) shows that virtual logic can be interpreted as a new logic without a law of the excluded middle. It is then capable of handling or systematizing a wide variety of problems related to imaginary values in (Boolean) mathematics and the geometrical constructions of both Peirce and Spencer-Brown ("Logic could be an encoded form of geometry.") In my view, the Kauffman discourse takes place in the domain of classical logic, in which there is no basis for giving meaning to the otherwise correct statement that the system and its observer are neither separate nor coincident. In another passage however, dealing with time series and recursion, a source is given of time series "partaking of chaos and yet resembling the patterns of biological time. Incredible worlds come into being beyond the dichotomy of True and False." The domain beyond this dichotomy is, of course, the one described in this book, and my choice of an 'incredible' world is none other than our own!

8.3 EMERGENCE IN PERSPECTIVE

It a relatively simple matter to observe the two forms of psychological process that drive people toward one or the other monism of identity or diversity as the basis of their preferred theories of reality, existence and thought. This tendency is nowhere more clearly illustrated than in the debate in science, still in progress, between mechanistic and non-mechanistic views of the origin, emergent development and functioning of living systems. Mechanistic explanations have had relative success against standard dualist or vitalist ones, but even in current theories of evolution and emergence, classical notions of part and whole, synchronicity and diachronicity and predictability and unpredictability make it difficult to devise principled counters to reductionist concepts of evolution and skeptical positions against metaphysical emergence. Systems concepts, which provide a first line of argument for it, generally also require some further grounding in physics. Finally, with the return of vitalism to education and politics in some countries, the importance of establishing a theory of evolution on a basis sounder than neo-Darwinism, unfortunately, now goes far beyond the realm of civilized scientific and philosophical debate.

The history of emergentist ideas begins with the arguments between mechanists and vitalists in the late 19th and early 20th centuries. British emergentists tried to develop a compromise position, avoiding vital substances but retaining some sense of irreducibly vital qualities (O'Connor and Wong 2002). Mill, an early exponent of emergentism, tried to distinguish between modes of conjoint action of causes leading to: (1) a total effect equivalent to the sum of the causes acting alone – homeopathy; and (2) an effect which is in no sense the sum of the effects of the individual causes, as in a chemical reaction – heteropathy. The laws and effects corresponding to the latter were called ‘emergent’. Hierarchical levels were seen within levels of heteropathy that could be governed by homeopathic laws in what appears to be a primitive model of levels of reality or strata. Mill’s account of emergence involves causal laws and interactions and is both dynamical and diachronic.

Broad developed a synchronic, non-causal, co-variational account of the relationship of emergent features to the conditions that give rise to them. Broad was interested not only in resolving the debate between mechanists and vitalists, but also in answering the question of whether biology and chemistry were reducible to physics. Broad suggested that two possible positions could be taken, one mechanist and the other emergentist. The former, in LIR terminology, is one of pure identity and homogeniety, one and only one kind of material, one uniform law of composition, one science, and so on. To anticipate, I can already note, however, that although the mechanist position will be seen to be untenable, *part* of it must be incorporated within the framework of an adequately antagonist theory of emergence. There *is* only one “kind of material”, and it is energy in different forms, the consequences of its inherent dynamic opposition, and the homogenizing tendencies in macroscopic matter are present in all phenomena.

Emergentists were physical monists too, but they recognized

> aggregates of matter of various orders, a stratification of different kinds of substances with different kinds belonging to different orders or levels. Each level is characterized by certain fundamental, irreducible properties that emerge from lower-level properties. Correspondingly, there are two types of laws: (1) ‘intraordinal’ laws, which relate events within an order … and (2) ‘trans-ordinal’ laws that characterize the emergence of higher-level properties from lower-level ones and identify them.

To recall the LIR picture, the phenomena of different levels of reality and complexity are, similarly, characterized by different, if isomorphic, laws, but the emergence at a T-state is governed by Axiom **LIR3** of the Included Middle. The unpredictability that was associated with Broad’s emergentism does not present a major problem, given the contradictorial view of determinism and indeterminism. This unpredictability is not constitutive of emergence, but rather a consequence of the metaphysical irreducibility of emergent properties.

Broad’s ontological description of emergence is, accordingly, generally compatible with the LIR view: in both, emergent laws are not totally irreducible to laws characterizing properties at lower levels of complexity (or reality), otherwise there would be no basis for the discontinuity between levels. Both concur that since emergent features have not only same-level effects, but also effects in (or on) lower levels; they accordingly accommodate the concept of downward causation. At this point, I have not made explicit an account of the relationship between the necessary physical conditions and the emergents, apart from the agreed upon, general and lawful character of emergence. Given the requisite structural conditions, does a new level invariably appear? I say yes, the universe is logical and deterministic at least to this extent.

The same criticism can be made of the proposal that emergent properties are not epiphenomenal because they pass a counterfactual test for causal efficiency. To explain the relationship between the mental and the neuro-biological, either each causes the other, or they have similar properties of some undefined kind. These views are close to standard non-reductive physicalism (NRP). Again, the theory presented in this book might at first be considered a form of NRP also, provided one excludes concepts and laws that cannot be derived from fundamental physics. LIR does not require 'natural kind' pictures[1] since it proposes something fundamental in addition, which is close to the Mill and Broad view plus synchrony, or, better, the view of time in which the actual state-of-affairs involves both synchrony and diachrony in the dynamic relationship discussed in Chapter 6.

The work of another influential British emergentist, Samuel Alexander, in its interpretation by Gillett (2006) is of interest in view of its rather extraordinary combination of what are, from an LIR standpoint, both correct and incorrect intuitions about emergence.

As shown by Gillett, Alexander was able to combine three desirable metaphysical positions: (1) Physicalism – all individuals are constituted by, or identical to, microphysical individuals and all properties are realized by, or identical to, microphysical properties; (2) Completeness of Physics – all micro-physical events are determined, insofar as they are determined, by prior micro-physical events and the laws of physics; and (3) Higher Causal Efficacy – there are higher level properties that are causally efficacious. Subject to the redefinition of individuals, properties and cause made earlier, these principles are accept-able in LIR.

The significant contribution of Alexander to a theory of emergence consists in the following statements:

SA1: A new emergent property H is at the same time new and identical to a combination of lower level properties.
SA2: The microphysical realizers are used up to produce something different from and transcending them, but they are not altered or superseded. There is transformation of these parts in building something higher, but the parts remain what they were.
SA3: Microphysical realizers are neither unconditioned nor homogeneous, such that the higher level entity H can have causal powers of its own.
SA4: A new emergent property H is jointly responsible with the lower level properties in determining its causal powers. One of the fundamental realizer properties is such that it has a conditional power whose contribution is partly determined by the higher level property it realizes.
SA5: The determinative influence of H on the lower level property is *non-causal, instantaneous, and does not involve a force, configurational or otherwise and/or the transfer of energy.*

[1] No longer needed in any case since Quine's critique of Natural Kinds (Quine 1969), especially Chapter 3 "Epistemology Naturalized".

The problem is that in order to insure that the realized property *can* influence the course of events leading to its instantiation, one requires some form of downward causation which Gillett shows, in an argument also used by Kim, apparently cannot take place diachronically without paradox, either H or the already transformed emergent property needs to exist prior to the transformation! The solution requires something like the LIR picture of synchrony and diachrony that I presented in Chapter 6 and will review further below in Section 8.6.

Acceptance of SA4 and SA5 together is equivalent to the abandonment of the Completeness of Physics. This position is not acceptable within the physiccalist metaphysics espoused in this book. I do not believe that causal influences propagate among non-physically constituted objects or events nor that non-causal influences propagate among physically constituted objects or events. I accept here the implied critique of Ladyman and Ross, in particular, the need to accept the transfer of information as an energetic one.

For my theory of emergence, I retain the desirable aspects of the Alexander framework (that is SA1–SA3), I eliminate SA5, and I add an additional phrase from Alexander himself:

> SA4-1: "Microphysical realizers are 'peculiar' in "contributing slightly different powers when realizing emergent properties than they do in other conditions."

The higher level property in my view, does not have to have an ontologically *fundamental* force, while exhibiting causal powers. The force consists of the residual potentialities brought to it from the lower levels. I see this as a description, in other words, of what takes place at the T-state, the point of maximum interaction of the low-level realizers. Without this additional principle, Gillett's interpretation does not eliminate the fatal weakness in Alexander's scheme, but rather amplifies it by recourse to non-causal determination.

The approach in this book renders superfetatory the metaphysical relation of fusion one sees from time to time. The idea is that emergent properties result from an essential interaction (i.e. fusion) between their constituent properties, an interaction that is nomologically necessary for the existence of the emergent property. The claim is that fusion is a real physical operation, not a mathematical or logical operation on predicative representations of properties. This is a kind of Hegelian synthesis (based on an underlying identity). LIR provides an alternative for the interaction that is both logical and physical, as I have tried to show, and that is applicable to situations more complex than those equivalent to mixing and changes of physical phase.

Some objections made against ontological emergence appear to be due primarily to a desire to maintain an absolute separation between 'high-level principles' and an underlying microscopic 'Theory of Everything'. Authors taking these views include Prigogine, who suggested that the ‘dissipative structures’ of non-equilibrium thermodynamics involve properties and dynamical principles irreducible to basic physics, and Laughlin and Pines:

> the generic low-energy properties (of the crystalline state) are determined by a higher organizing principle and nothing else.

The *apparent* independence of various confirmed high-level principles, and the practical impossibility of deriving them from fundamental principles in fact supports ontological emergence (against objections to it). I take this statement as a basis for a new postulate on emergence, as follows:

> **Postulate:** “All high-level principles reflect, and can be derived from, the same basic antagonistic properties of energy that constitute the fundamental principles of existence, including those of basic physics. Accordingly, the phenomena of ontological emergence can be described by the former and are explicable in terms of the latter.”

In my discussion, the word phenomena has been used as covering both ‘properties’ (or the event or states consisting in a system’s having a property), *and* systems and objects as such, seen as emergent ‘included middles’ arising from dialetheias, true and real-world contradictorial processes. Some difficulties certainly arise by the conflation of systems and ‘objects’ as they are usually thought of, that is, non-dynamic non-systems. Merricks (2001) does not take a position on what emergence is, nor on the nature of causation, for which we now have a contradictorial picture, but he does, however, assign macroscopic causal powers to it, similarly to Laughlin and Pines. Merricks also talks about relations among his basic microphysical entities, but this relation is obscure.

> The relation of physical substrate to emergent features could be a) one of causal determination or brute fact, or emergent features could necessarily appear (supervenience), or b) at best contingently appear in all systems attaining a requisite level of complexity.

With regard to (a), my view would reject the concept of brute (independent) facts as untenable by the fundamental postulates of the logic of reality and energy. As far as (b) is concerned, the fact of the appearance of emergent features is contingent, but some words in the question need explaining. ‘At best’ seems superfluous, and the word ‘all’ is inoperative. Emergent features have the *potential* for appearing; whether they will or not depends on probabilistic aspects of adjacent systems within the overall a-determinacy of the universe.

I will now discuss some general aspects of emergence beginning with physical emergence outside the specifically biological area.

8.3.1 Physical Emergence

Many physical phenomena are described as emergent: tornadoes certainly arise from complex temperature and humidity gradients. Other systems involved in non-linear dynamic interactions can exhibit new behavior relative to the behavior of their substrates. From the LIR standpoint, they are (almost) pure, actualized macrophysical processes with no form of internal representation or semantics. Examples are the dissipative, far-from-equilibrium systems described by Prigogine, other intrinsically simple structures such as the convection cells in heated liquids or certain oscillating chemical systems that have described and discussed *ad nauseam.*

It is thus correct to discuss such systems, which are identities “to all intents and purposes”, from an essentially mechanistic standpoint. Batterman considers such phenomena as emergent since they display singularities (critical points) rather than as simply resulting from the underlying causes (Batterman 2002). What is not correct in my view is to take them as models of the fine structure of emergence at other levels of reality. As noted previously, the pre-valence of T-states and emergence is not a smooth function of level of reality, but is at a minimum at the macroscopic level. Individual particles nevertheless retain all their potentialities for entry, under the right conditions, into more complex, emergent configurations.

8.3.2 Normative Emergence

The fundamental metaphysical conception of a split between two kinds of substances, the factual, non-normative world and the mental, normative and largely intensional world goes back to Descartes. In Bickhard’s succinct summary, substance metaphysics makes process problematic, emergence impossible and normativity, including representational normativity, inexplicable. I will mention some of the major arguments made (Bickhard 2003) to model causally efficient ontological emergence within a process metaphysics, deconstructing the challenges of both Kim (metaphysical) and Hume (logical). Both of these critiques are fully compatible with the LIR-NEO framework.

As discussed first in Chapter 6, Kim’s view is that all higher level phenomena are causally epiphenomenal, and causally efficacious emergence does not occur. This argument depends on the assumption that fundamental particles participate in organization, but do *not* have organization of their own. The consequence is that organization is not a locus of causal power, and the emergence assumption that new causal power can emerge in new organization would contradict the assumption that things that have no organization hold the monopoly of causal power. Bickhard’s counter is that particles as such do not exist; ‘everything’ is quantum fields; such fields are processes; processes are organized; all causal power resides in such organizations; and different organizations can have different causal powers and consequently also novel or emergent causal power.

In LIR, as we have seen, a degree of organization is ascribed to particles as particles, as well as to the quantum field (its self-duality) and hence there is no difficulty in ascribing causal powers to them. Further, in the above argument, the simple possibility of emergence being ubiquitous in new organizations of process is not an explanation of how it occurs. In my theory, the dynamic opposition inherent in the particles provides the necessary causal mechanism.

As Bickhard shows, Hume's argument is that norms cannot be derived from facts, due to the presumed empiricist origin of representational or semantic content. Thus valid derivations do not go beyond whatever is available in the premises with respect to their basic terms and that accordingly nothing fundamentally new can be introduced. This argument is proved to be unsound, and that normative emergence is possible, by reference to the linguistic concept of implicit definition. Contrary to the abbreviated definition to which the above construction is equivalent, the implicit definition says that formal sentences implicitly define the translations of the non-logical terms that yield a consistent interpretation of the overall set of sentences. It is Humean sense data reduction that is the less common of the legitimate forms of definition. Hume's restriction to factual premises reflects the substance-ontological commitment: substances motivate empiricist notions of perception and representation, and substances are themselves not normative.

I would simply note that a theory that gives appropriate energetic process characteristics to perception and representation does not need to have the possibility of normative emergence further demonstrated. The absence of a principle of antagonism in energy leads Bickhard to focus on the locus of his otherwise correct dynamic model of emergent normative function in far-from-equilibrium systems of the Prigogine type. Living systems are indeed far from some ultimate equilibrium, and the operation of their complex cybernetics, close to the dynamic equilibria I have defined, also requires energy such that entropy is maximized locally as well as globally, as suggested by the principle of Maximum Entropy Production (MEP; see Section 8.8), *via* functional input from and interaction with the environment.

My claim is only that the operation of MEP is necessary but not sufficient for emergence, and that as suggested on several occasions in this book, some principle of exclusion between like entities, of which the Pauli Exclusion Principle for electrons is the simplest expression, is also required.

8.3.3 Catastrophe Theory and Emergence

In Chapter 5 I discussed some aspects of the catastrophe theory of Thom and Petitot as a metaphysical theory of morphogenesis. I give credit to Thom and Petitot for giving new vitality to the problem of form in biology and elsewhere. But they went too far; my use of the word 'vitality' here could be considered sarcastic, under the circumstances, if it were not for the fact that Thom considered his method as one of 'geometric vitalism'. I can agree with Thom's criticism of reductionist biology as metaphysical in a negative sense, since it postulates "a reduction of vital phenomena to a pure physical chemistry that has never been experimentally established" (Petitot 1988), whereas vitalism "is based on an impressive ensemble of facts of control and finality that cover the quasi-totality of vital activities (Thom 1972)."

Petitot converted this vitalism of Thom, for which Thom had been (of course) criticized, to something which is far from the naïve idealist vitalism of the early 20th century. It is methodological and geometric, compatible with a local physico-chemical determinism of the substrates and strictly structural.[2]

Petitot thus claimed to have achieved, through catastrophe theory, a reconciliation of the principle of finality (teleology) inherent in vitalism (structuralism) with physical objectivity (mechanism, reductionism). I can claim not to have reconciled them, but suggest that one can show, through application of the PDO, where each fails both to describe its own elements correctly and to include the proper aspects of the other, and that a third possibility for explication exists. LIR eliminates the need for any form of vitalism, and suggests a functional relation between physics, chemistry and biological phenomena, based on the recurrence of energetic antagonism at different levels of organization and reality.

The pure geometrical-topological modeling of reality in catastrophe theory, as I have discussed, fails to capture the dialectical mechanism of process reality – emergence in other terms. I have thus been at pains to show that the categories of the logic of/in reality in my New Energy Ontology (NEO) instantiate a form of conditional dualism, comparable to the Axiom **LR2** of Conditional Contradiction whose principle is that the two elements of a duality are not totally separated and independent but linked by a relation of dynamic opposition.[3] I will now show in more detail how the principles and categories of LIR provide approaches to questions of emergence in phenomena at the biological level.

8.4 EXPLAINING EMERGENCE

To summarize, based on the principles of LIR, emergence as a process is not separable, or different from, its instantiations. It is no more correct to say that emergence 'is' something than that cause or consciousness 'is' something. The only criterion or locus for emergence is the real existence of all entities or processes, that is, all those which consist of energy-in-change. Where emergence does not take place is in or between non-spatio-temporal entities that can be described

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[2] Petitot was able to incorporate, in his synthesis, the concept of *entelechy* that Goethe developed as the *a priori* constitutive of the universe of forms, the basis of his speculative idealist vitalism.

[3] Processes that instantiate dynamic opposition can also be the source at the mental level of emergent phenomena as included middle T-states by Axiom **LIR3**.

as following binary logic. I have touched in Chapter 3 on the ontological status of such objects, our mental representations of them, the nature of 'non-existence' *vs.* existence and what it might mean for such objects to exist in 'other worlds'. On the other hand, the degree of emergence in our world at short time scales can be minimal: the billiard ball that is struck and modified in the process is, to all intents and purposes, not a 'new' billiard ball, but it can be so considered, both logically and physically (experimentally). Once this is accepted, emergence can be seen for what it is, a universal metaphysical principle.

I will therefore state, as a result of my analysis to date, the second thesis of the application of LIR to biological emergence:

Thesis 8.2: The logic of/in reality, LIR, and its associated new energy ontology, NEO, provides a doctrine of emergence that is *both* physicalist and dualist, but its dualism follows the category of dynamic opposition and the axiom of Conditional Contradiction, and confirms the physical and metaphysical reality of emergence.

Let us now compare this thesis with the three views mentioned in the first section and see how they can be interpreted using the principles of LIR. As will become clear, I support the second two, but not the first.

8.4.1 Emergence Is a Dogmatic Concept?

The position taken here, for example by Maurel (2005), is a consequence of frustration at the lack of proper explanations for the origin and functioning of living systems. It is expressed by a resistance to emergence, characterized as an 'artifice', in the same category as (standard) logic and reductionism. That life has 'emerged' from non-life is considered as a linguistic device that fails to describe in any way the chain of events necessary for the construction of biological molecules and macromolecules. Thus, emergence is not a valid concept because the underlying theory is not available.

The problem is of course real. There is as yet no agreed upon pathway leading from the simplest amino acid, the probable result of the combination of small molecules produced by electrical discharges in the primitive atmosphere, to simple peptides capable, perhaps with the aid of inorganic catalysts, to the emergence of polypeptides with a capacity for self-replication. There is no detailed way of understanding how "molecules acquire an order that puts them in the right place at the right time" in the organization of a pre-biological entity. For this author, the term of emergence corresponds to a kind of revealed dogma of life, a bit mysterious, not to say mystic, that refers to the sudden appearance of properties *whose foundations are unknown* (emphasis mine).

An additional, metaphysical problem, related to the formulation above by Kim, is the following: if emergent properties depend in fact on the methodology of scientific explanation, how can a scientific explanation not be reductionist and mechanist?

The above view demonstrates the point I wish to make: LIR cannot, in any specific case such as this one, describe how an event of chemical synthesis on a particular surface of slate or clay *x* billion years ago might have been *the* 'real beginning' of life, the obvious identity that is the only thing that will satisfy most people.[4] LIR in a sense seeks to change the climate in which such questions are posed, and to see what other questions might be posed and what the acceptable form of answers to them could be.

One can say, as a start, that the appearance of the small molecules of life, ammonia, formaldehyde and so on required the input of substantial amounts of energy, and potential catalysts such as silicate materials have high surface energies. Since these energies appear to have had real consequences, a reasonable assumption is that such developments in existence are not accidental but deterministic, inherent in the potentialities in nature. A better strategy, which, summarizing rapidly is that of this book, is to look closely at what this inherence involves without postulating new laws of physics, but seeing how existing ones might be interpreted, as in LIR, in a contradictorial manner.

If one accepts that the PDO explains *something*, that potentialities have *some* functional role, and that 'time' is a complex property of matter involving *both* synchronic and diachronic aspects,[5] one is perhaps in a better position to evaluate and support new theories that give substance to the concept of emergence. I will now to do this with reference to some work of the Danish school.

8.4.2 The Emmeche Synthesis

Emmeche (2000) has made a trenchant critique of what I have designated in various parts of this study as attempts to construct theories of life or existence using, implicitly or explicitly, the axioms and concepts of binary logic. In considering the epistemological problems in such general theories about living systems, he sees a number of 'hidden connections' between different areas of human experience, such as folk biology and scientific biology, as well as hidden connections between central concepts of theoretical biology such as function, semiosis, closure and life. These connections are, in my opinion, of the utmost relevance for fresh approaches to these areas.

In this view, there must be some form of a 'hidden prototype fallacy' in most discourses that results in the *reification of their own abstractions* and hides

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[4] Or cause them to reject scientific realism.

[5] Cf. Chapter 7.

the fuzzy, basic and problematic semantic references to the particulars of system types, in other words, the real world. The five examples given are

- The theory of autopoiesis, the ‘self-production’ of systems;
- Non-equilibrium thermodynamics, which takes its examples basically from the macroscopic physical world, or primitive biological entities like slime molds, which he compares, in concordance with my approach, to simple syllogisms;
- Dual mode theories of life, in which the hidden prototype is the genotype-phenotype duality of classical genetics
- Complexity studies, with their heavy computational bias and agenda, leading to
- Artificial life research.

Autopoiesis is the term Maturana and Varela gave to the continual production by a network of the very components that comprise and sustain the network and its processes of production. Despite the extraordinary insights of these thinkers and their followers, I believe their systems approach suffers from the retention of abstract and absolute terms, of which circular causation is an example. Maturana indeed talks about the inseparability of a living system and its niche, and structural coupling is the term used to denote their interdependence. Structural coupling is the conjoint result of thermodynamic or macrophysical openness, which allows (how?) the flow of matter and energy through the organism, and operational closure, which enables autopoësis and homeostasis. The resulting adaptation is an *invariant* relation because the operations of the living system “cohere with – they are not contradicted (sic) or thwarted by – the surrounding medium (Maturana 2003)”.

My critique of this approach is not so much that it fails to refer explicitly to some form of dynamic opposition at the level of organisms, although I believe such reference would be desirable. It is that without some such concept of opposition, and the concept of potentiality as well as actuality subsumed by it, the systems described cannot be physico-chemically related to any substrate levels.

In the Maturana system, the result of an interaction between an organism and a stimulus external to the organism is not determined in any way by that stimulus, but only by the aggregate state of the organism itself at a given moment. The effects of molecular interactions ramify and amplify into behavior at the macromolecular level, all the way up to the level of the organism, and the same is true in the other direction. In the LIR view, as I have indicated, it is in the potentialities of the molecules involved that the source of the upward (and downward) causation should be sought.

As alternatives to the above five points, Emmeche proposes the minimum complexity of the endosemiotic biological code as a requirement for maintenance of life. He speculates about the unknown laws of complexity that may be involved and the primitive kinds of metabolisms that cover the continuum no-life – primordial life – life. Obviously, LIR does not provide a description of these unknown laws as such, but as indicated above, its basic postulates can been seen as potential constituents of such unknown laws.

Emmeche's conclusion exemplifies the non-absolute aspects of a vision based on LIR. For a prototype organism, say, a single cell, biosemiosis implies functionality, and functionality is only possible under a closure of operations in the special sense of the category of closure that I will propose below:

> This closure is an emergent phenomenon of a semiotic character, and as a *closure*, it is only partial, imperfect, relatively open. Therefore we can conclude: (1) synthesis is needed; (2) further epistemological clarification of these concepts is needed also; and (3) a null hypothesis – that the four notions of life – biosemiosis, functionality, emergence and closure, express four independent characteristics of life – has been refuted.

In support of his view of emergence, Emmeche et al. (1997) calls for an ontological, materialist but non-reductionist theory of levels of reality that includes a concept of their origin. In this view, several additional relationships to the LIR theory 'emerge'.

Emmeche shows that the 'emergence' which is described by computational, mathematical and algorithmic (formal) notions fails to capture key aspects of real-world emergence. Citing Cariani, apparent emergent behavior in cellular automata is not intrinsic to the formal system, although it may be the source of ascriptions by the observer. As noted above, simple examples in physics and chemistry of thermodynamic emergence (self-organizing behavior) are not easily related to a theory of biological evolution. This picture is consistent with my view of a general division of the world into domains of applicability of binary and ternary logic. Binary logics are adequate for mathematical or computational cases of emergence, but ternary logic is required for an understanding of biological and psychological emergence. The fact that emergence is also observed in the former, binary domain should not be a source of amazement, given that it is a basic feature of our world, but it is the properties of the latter that explain the former. 'Thermodynamic' macrophysical emergence, without an appropriate source of heterogenization, results only in limited, 'static' entities or processes.

The remodeling of the relation between determinacy and prediction has the consequence that "it is no longer a problem to defend the statement that systems with emergent processes can be deterministic; the concept of emergence does not necessarily entail the presence of indeterminacy, nor of any kind of 'invention' of the process." Emmeche takes the side of Thom in his debate with Prigogine: the latter takes the unpredictable event as his deepest level of explanation. For Thom, science is the embedding of a realized process in the space of virtual (in my terms, potential) processes, supporting an ontological view of science by 'expelling' the various ideas of indeterminacy as being a relevant fact. The application of the PDO to determinacy, indeterminacy and a-determinacy clarifies this view, and supports the position, *contra* Prigogine, that potentiality in the sense of the possibilities existing for a given process is a fundamental necessity. "Emergence is not an omnipresent creative force, but simply the fact that some of these virtual (i.e. potential) processes possess new properties."

Emmeche defines primary ontological levels and proposes a difference between the "first time emergence of a primary level and later repetitions of the creations of entities". Constitution of levels is accomplished by the application of initiating and constraining conditions, whereby the constitution of the primary levels is the emergent process that selects the constraining conditions for subsequent levels. In LIR, as in Emmeche, *potentiality* describes an entity at a given level in relation to the levels above and below it.

The significant difference between the above primary levels and those of LIR is that the quantum level is subsumed under 'physical-chemical'. This occults the clear difference in applicable laws between microscopic and macroscopic physical entities and results in a category error. The thesis of this book provides two hypotheses that are ontologically applicable: (1) that the lowest relevant level is the microphysical one; and (2) that the notion of the alternating, antagonistic relation between actual and potential not only applies to it and all subsequent levels. Any 'next level' does not exist (is not actualized) *synchronically* with the initial level but exists as non-localized potential in it. I make a similar argument in Section 8.6 on downward causation.[6]

It is true that the appearance of biological systems in the whole phase space of the universe is determined by physics, and given some specific changes, the universe *might* have developed in a way leading to different species. The ones we know would have been unrealized and existed as potential only. The existence of parallel evolution, however, suggests a simpler, non-skeptical picture. The existence of some degree of organization at the lowest physico-chemical level implies that the evolutionary response to similar external conditions *may* be similar. This is an alternative argument that does not require the postulation of some prior physical contact between land masses to allow for animal migration. A similar argument can be made for the appearance of pyramids in Egypt and Central America, without the intervention of aliens from outer space. More frighteningly, it is a possible model for the development of terrorist cells in the absence of any 'mastermind'.

8.4.3 Biosemiotics

The further thesis of Emmeche that Peirce's semiotics (theory of signs) can be extended to comparable semiotic processes(Emmeche 2003) at physical and biological levels is a major advance toward a needed theory of emergence. If the current physical universe and its chemical elements is indeed a "particular way of 'coding' the energy of the universe", and biological phenomena are a particular way of 'coding' organic chemistry, and if, as discussed above, the energy is inherently antagonistic, instantiating dynamic opposition, then all these semiotic processes also encode this fundamental antagonism and its ontological

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[6] For an opposing view, see again the work of Salthe, Chapter 6.

predicates. In fact, all of the processes associated with living systems can be captured in an NSC sub-category of Emergent Processes in which the key axiomatic meta-physical concept is that of dynamic opposition.

In this theoretical biology, for example, analog and digital codes are shown to be equally necessary, interdependent forms of activity "arising like twins in the individuation of that logic which we call life (Hoffmeyer 2000)". In general, theoretical biology has always been forced to consider two dynamically related elements and an emergent third element, but the availability of a logical framework facilitates discussion of the processes involved. In fact, I will show that the logic and the ontology I propose provide a way of bridging the *epistemic cut*, the 'cut' between knower and known, and also between life and non-life, in a way congruent to my proposed bridging of the ontological-metaphysical 'cut'.

8.4.4 Quantum Morphogenesis

The concept of quantum morphogenesis, developed by Aerts et al. (2003) suggests a universal treatment of morphogenesis, understood as a temporarily stable change of form of both quantum and non-quantum systems, that does not depend on the details of the interactions that form a concrete ecosystem, organism or society. Systems are described by an abstract state-space, and the following aspects show the relation to LIR:

1. Sets of mutually inconsistent propositions are allowed, thus the law of non-contradiction does not hold absolutely. The situations involve non-Boolean logic and contexts, in which the logical value of the propositions depends on the history of the system.

LIR: The reciprocal relation between the degree of actuality and potentiality of a phenomenon and its contradiction in the principle of antagonism are such 'propositions'.
2. The systems are probabilistic. Morphogenesis is described in terms of probabilities or uncertainties associated with given sets of propositions. The contextual nature of the propositions requires non-classical probability distributions (non-Kolmogorovian).
LIR: LIR logical values are contextual, i.e., also depend on the history of the system (are systems of systems, etc.), and the shifts from actual to potential and inversely are probabilistic.
3. *Feedback* is a crucial element. Changes in the environment and system interact and influence one another.

LIR: All complex systems involve feedback, enabling a parallel with Aerts' construction.[7]

Aerts' key point is the following:

> "What makes our construction essentially different from the models one finds in the literature is the role of non-commutativity of the system of propositions. Non-commutative propositions are related by uncertainty principles and are typical of systems which cannot, without an essential destruction, be separated into independent parts."

I developed this concept in Chapter 1, and suggested the concept of actuality and potentiality as probability-like, as a basis for the more formal axiomatization of LIR. Aerts hoped that his "quantum mechanical model for the cognitive layer of reality could be an inspiration for the development of a *general interactive logic* that could take into account more subtle dynamical and contextual influences than just those of the cognitive person on the truth behavior of cognitive entities." This is what I propose LIR is in principle capable of doing.

8.4.5 Half of the Story

I return for a moment to Bickhard's refutation of Kim's argument against emergence. It states that it is not particles that are fundamental units of physics but quantized fields. These are processes, and processes are inherently organized, since a point process is an incoherent notion. "Processes are distributed in space and time, unlike dimensionless point particles." Fields are formulated in terms of differential equations, and such equations are not definable on discrete point sets.

While, as indicated, I agree with Bickhard's conclusions, his argument makes some classical assumptions, e.g., about the relation between particles and space-time that detract from its usefulness. Cao, whom Bickhard quotes, says that the theory of quantum electrodynamics (QED) within quantum field theory (QFT) has an ontology underlying the mechanism of interaction that is essentially the field rather than the particle. However, as locally quantized fields, they have to a great extent (not completely!) lost their continuity (Cao 1997). Therefore, in LIR terms, quantum fields instantiate both continuity and discontinuity. Further, as discussed in Chapter 4, emergent processes at quantum critical points, unlike simple macrophysical changes of state, have both particle and field aspects.

In either the particle or field descriptions, some principle of organization seems to be involved which grounds emergence at the quantum level, and I have

[7] The reason is, as discussed in detail in Appendix 2 on Systems Theory, that every feedback loop, natural or artificial, (cybernetics) can be viewed as a dialectics involving dynamic opposition, since every cybernetics involves an alteration, a perturbation by an antithetical contradictory aggression, followed by the return to the (state of) regulation that must prevail for the system to be temporarily stable.

suggested that dynamic opposition is just such a principle. If this is so, LIR and the categories of NEO support a theory of emergence, evolution and life that contains at least one new and generally applicable physical (scientific) principle (or law of nature, see Chapter 6). It could provide the metaphysical justification for an interpretation of the relations between the terms of the dualities that are observed throughout the physical, biological and cognitive worlds. There is no reason to assume, because the quantum processes underlying the universe are not (yet) completely known, in the absence of further experiment, that they are irrelevant to higher level emergent phenomena involving self-organization, and that such self-organization follows totally different rules.

My conclusion is that the PDO is an additional *necessary* condition for life and evolution, but it is not *sufficient*, or rather that we do not know if it is sufficient or not, and if not what categories any additional principle might involve. I claim that there is something 'true' and potentially open and fecund about this ignorance. This is similar, albeit formally so, to the anti-realist position that propositions about reality are either true or false but we cannot tell which.

Nevertheless, I *have* added one more explanatory step between us and the universe, consisting of a model of reality and a set of its categories that capture some essential aspects of living systems. I take seriously, in my development of this 'step down', the apparent confrontation or dynamic opposition between dark matter and negative energy (cf. Section 7.6.4 on the cyclic model of the universe). If one assumes that this opposition may have produced, as an emergent by-product, standard matter-energy, in which opposition is also inherent, it is not unreasonable to follow the PDO to higher levels of organization to see what insights it may provide.

Let us now see how the LIR picture might apply to the closely related concept of closure in biological systems.

8.5 CLOSURE IN LIVING SYSTEMS

8.5.1 Defining Closure

The term closure is usually defined as the establishment of a domain of discourse within a given discipline that is complete and self-sufficient. The concept developed from set theory: the closure of a set and its internal structure provide for adding additional elements. Closure in propositional logic means that the logic contains all the rules and elements necessary for the development of further theorems. The basic idea of closure in general is to separate objects into one class of interest that is included in the domain and the exclusion of other objects or classes. However, also as shown by Aerts, there is a tight formal connection between quantum mechanics and closure (Aerts et al. 2005), and hence a potentially significant relation to the quantum-like aspects of LIR. This section compares the roles of LIR and closure in explaining the emergence, development and evolution of structurally stable systems at chemical, biochemical, biological, psychological and cultural levels.

Closure is defined and used by its proponents in a large variety of ways (Chandler and van de Vijver). In the physical sciences, the concept of closure implies addressing the basic issues of the organization of matter in space and time, in which the assumptions of set theory are seldom applicable. A thermodynamics that is grounded on isolated systems at equilibrium begins as a well-defined closure, but many other scientific theories lack a persuasive logic of closure. In LIR, of course, the logical property of closure is *also* a dynamical property of closure – closure with respect to a dynamic system.

Thus it is the dynamic characteristics of energy in general that can provide the basis for an understanding of closure. For example, I would add to theoretical basis of closure the Pauli Exclusion Principle, giving it importance equal to that of thermodynamics, whether systems are at equilibrium or not. What this means is that no theory of emergence could be closed without reference to the Pauli principle. However, there is nothing in LIR that should be taken as stating or implying that the actual world is not closed under the laws of physics.

There are many issues in accounts of closure, implicit or explicit, which the logic of/in reality could clarify. For example, the idea that living organisms construct their own time from internal molecular-biological dynamics is difficult to reconcile with a standard relativistic but non-contradictorial account of space-time. How time is 'entwined' with space in temporal biological closure can be approached by looking at the dynamic opposition in the dependent relation between living organisms and their lower level dynamics.

8.5.2 The Category of Closure

In view of the above comments, I believe it is useful to consider closure, like emergence, as a formal sub-category of Process.

Thesis 8.3: Closure is a formal sub-category of Process describing a more or less complete set of functional relations between a system and its environment that embody the categorial features of antagonistic duality and fit the Axioms of LIR.

Closure thus is accompanied, as any real process, by its non-separable opposite of Non-Closure. Indeed, people talk freely of autonomous systems being based a *special form of closure* that involves active, functional relations with the environment, hence with what is *outside* the system, a closure that is unclosed. The LIR-NEO categorial view provides a formal way of discussing internal and external closure and their coupling, as Moreno (2000) puts it, "in such a way that they cannot exist without each other." This is simply a less specific statement of the PDO in other terms. (For those who might balk at the expression that closure is in this sense closed *and* not closed, or is 'leaky' as suggested by van de Vijver, I suggest the term *exclosure*, which captures the concept in French behind the cognate *éclosion* – opening or budding).

8.5.3 Opening Up Closure

Continuing the thought in the previous section, let us recall that in the LIR concept of levels of reality, differences in laws and fundamental concepts exist as one goes from contradictions between elements at one level of reality to another, according to the Axiom **LIR3** of the Included Middle. On the other hand, movement between hierarchical levels of organization *within* a level of reality also takes place, and there must be some energetic mechanism that drives this movement as well. In other words, the proper objective of an analysis, applied to studies of hierarchies in complex systems, would be to give meaning to the verbs in such phrases as "*going* up one level in scale" or "an open variation that *is reorganized* at some higher level".

Lemke (2000) offers an hypothesis about the relationship between semiotics and the dynamics of complex self-organizing[8] systems within the biological level of reality. The standard Peircean definition is used of semiosis as a process of meaning making, of construing a material entity or phenomenon as a *sign*, rather than simply interacting with it energetically: "semiotic interpretation differs from simple physical interaction." One could consider information and meaning as energy here, but the *distinguo* is not trivial; meaning is at a higher level of interpretation in the sense of Section 5.2 in its including of 'meaning for'. This is the essential distinction between information considered in the sense of Shannon as simple negentropy and what Logan (2007) has called instructional or biotic information. Standard logic is applicable to the first since it represents only the non-contradictory aspects of diversification. The second requires LIR since it involves emergence and meaning, described below as "topological semiosis".

From this one can derive what effectively is a Principle of Alternation and a Principle of Emergence: a new level in the scale hierarchy of dynamic organization emerges if and only if a new level in the hierarchy of semiotic interpretation emerges. The examples of typological alternation or typological semiosis seem essentially equivalent to what I have referred to as alternation between limiting

[8] See Section 6.2.8.2 on self-organization.

cases of opposing terms without internal dynamics. This term is defined as a generalization of digital signaling and as the principle for mathematical and scientific symbol systems, that is, ones that are dynamically inert. Topological semiosis, on the other hand, is a generalization of the notion of analog signaling.[9] In topological semiosis, all the interactions, responses, etc., of the organism involve dynamic opposition, and in any movement to any higher 'level', say, even of complexity, that opposition results in the emergence of a T-state, equivalent to a logical included middle. There is no reason why this T-state cannot be, at its level, a discrete type. Semiotically, each higher level is characterized by its own exhaustive paradigms of types, and *at* levels of organization where only typological difference matters, and *for* levels for which this is true, one speaks of semiotic closure *within* a level. However, if the Principle of Alternation is involved, then *across* semiotic triples of levels there is always somewhere a lack of *topological-semiotic* closure, and it is this source of *potentially* meaningful open variation that is reorganized at some higher level again into a new typological-semiotic closure. This is to me a most interesting example of the dynamic, functional role that can be played by an absence or lack.

8.6 DOWNWARD CAUSATION

8.6.1 The Category of Downward Causation

One way of defining downward causation (Heylighen 1995) is as the converse of the standard reductionist principle, namely, that the behavior of a whole or system is completely determined by the behavior of its parts, elements or sub-systems. In downward causation, "The whole is to some degree constrained by the parts (upward causation), but at the same time the parts are to some degree constrained by the whole." Thus, determinacy is not complete. It is necessary, however, to give an explanation of why parts and wholes have these abilities. According to the principles of LIR is because they share in part one another's properties: the LIR approach is an attempt to resolve the inevitable problems resulting from the classical concepts of space, time and causality as categories with *separable categorial features*, and these include final and effective cause.

I thus construct the material category of processes instantiating downward causation, also as a sub-category of Process – Downward Causation that fits the Axioms of Conditional Contradiction and so on.

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[9] Lemke gives a useful table, with the suggestive name of "Trans-organization across modes, of Level *N*-1 topology to level *N* typology, and of Level *N*-1 typology to level *N* topology".

Emmeche (2003) also states that downward causation, like emergence, should be considered as a category of the processes instantiating it. However, I do not agree that it is a formal category of cause that is independent of any time-sequential effective cause. I thus rephrase Emmeche's claim by saying that downward causation from the emergent level to the parts level *is* extended in sequential time *and* is a movement through phase space. This way the use of the word 'movement' does not beg the question (by implying a notion of time), and the picture is not simply a loose metaphorical analogy.

8.6.2 Synchronic Reflexive Downward Causation

Processes of downward causation in emergent biological phenomena are those by which, for example, an organism acts on its own constituents in a way that can be distinguished from the behavior of those constituents. Symons (2002) captures a metaphysical picture of downward causation in his paper on emergence and reflexive downward causation. In this view, emergence provides a necessary conceptual framework for understanding the related notions of causation, explanation and individuation that are required for an explanation of downward causation. He claims that (1) a probabilistic interpretation of causation gives a meaningful sense in which a whole can act on its parts, without becoming something other than itself in the process; and (2) the structural property of the whole, *qua* emergent property exerts a change on the causal power of the parts, but a "funny kind of change", namely, a change in their *potential* (emphasis mine) for behavior in the moment immediately following their entry into the whole.

In the LIR category of Process (change-as-process), the passage, spiral not circular, from actual to potential and back, is indeed to be sought in statistical and probabilistic factors, and the antagonistic picture of wholes and parts eliminate the 'philosophical risk' of things becoming other than themselves since they were not 'all themselves' to start with, but, as dynamic systems, shared properties of the other member of the pair, given the ontological predicates of NEO applied in this case to parts and wholes. The point (2) above, together with the thought experiment on which it is based, shows the power of the concept of potentiality as a cause or mechanism of downward causation.

Symons points to the problem of trying to resolve differences between constitution and identity, between what something is made of and what it is, using functionalist concepts of something 'half-way' between physicalism and classical dualism, equivalent to an instance of the concept of 'both-at-once' that I have criticized as non-explanatory.

As proposed throughout this book, LIR is an argument for the reality of entities and the relations between them. It both accommodates and supports a concept of emergence and supports the objective for it of "providing a way of recasting our basic metaphysical assumptions so as to account for the usefulness of higher-level phenomena." LIR, unlike standard non-reductive materialist views, provide a way of differentiating between the causal power of mental events *qua* mental events and the causal power of the microphysical phenomena that realize, but do not embody them *per se.* What is embodied in both is the PDO, and the function of the microphysical entities is to act as carriers of the conflict between the intensional and extensional properties of energy to the higher levels, where they combine in obviously more and more complex ways. I would again point to the significance of this concept for a potential new philosophy of mind.

The LIR approach can be used to undercut Kim's epistemological criticism of reflexive downward causation that suggests that higher-level phenomena are only artifacts of our representational systems. As noted, I have no difficulty in accepting the physicalists' metaphysical assumptions that non-basic properties supervene on their physical constituents or that the world is causally closed under the laws of physics. Supervenience in this sense requires only the generalized application of the category of Dynamic Opposition, plus the definition I have given of the relation between cause and effect. It seems to me that this goes a long way in the direction of providing emergentists the needed support for legitimizing emergent phenomena as real.

Using LIR, a number of illustrations of downward causation can be given, involving physical, biological or neuro-psychical systems. For example, in the internal dialectics of concepts (Lupasco 1979), the resultant systems (of systems, etc.) involve the interaction of all three of the corresponding contributing dialectics, that is, those of the 'higher level' T-state itself with the 'lower' ones from which it emerged. However, how can the existence of downward causation as an interaction be reconciled with a requirement of the discontinuity of levels of reality, involving a change in the laws applicable at each level?

I suggest that where the principles apply and a T-state emerges from the dynamic opposition of two terms, it can be at another level either of reality or of complexity. The latter can be a hierarchical level within the same level of reality (e.g., socio-political), provided the contradictory elements are in a dynamic relation, and not a classical logical relation, of conjunction or disjunction (Nicolescu 1999), and complex enough to instantiate some form of internal representation. LIR is also a logic of complexity that permits crossing between different domains of knowledge. In higher, ontological levels of reality, the dynamic 'complementarity' of Paul (2002, private communication) can be the organizing principle, rather than contradiction in the sense of counter-action as noted earlier. However, at all levels, those involving complex mental phenomena, in which macrophysical and biological components are (almost) absent, and those in which the latter are predominant, the category of T-states as included middles always enables, and is in fact equivalent to, a downward causal connection between adjacent levels. In this picture, as indicated in the discussion of levels, a change of one significant parameter is sufficient to characterize the difference between level and meta-level.

The major challenge to a theory of emergence, as formulated by Kim, is to resolve the apparent paradox involved in *synchronic* reflexive downward causation. Given the layered picture of the natural world as the most acceptable one, along the lines of my discussion of levels of reality in Chapter 1, within this world, properties can cause instantiations of other properties at the same level, at higher levels or at lower levels. Upward causation and same-level causation have been easy to imagine, even for reductionists, despite their lack of understanding of the contradictory processes that I consider are involved in both, but which yield different results. Upward and downward causation involve T-states; same-level does not, that is, only relations practically without internal dynamics or representation, *qua* the level, are involved, the conditions for applicability of standard logic.

Kim says in effect that higher-level properties can serve as causes in downward causal relations only if they are reducible to lower-level properties. If this is not the case, and downward causation is, also, transitive, it is circular, equivalent to self-causation. Introducing the concept of time, Kim attempts to show that synchronic reflexive downward causation is unacceptably paradoxical "by virtue of the assumption that for an entity to be responsible for an act, *it must have had the power to perform the act prior to performing it*". In a certain deep sense, this statement of Kim's is literally true, but one must not look for this 'power' in some impossibly actualized structure. It is there as *potential*, or perhaps better, in the interaction of the set of potentials of the parts, as implied by point (2) above.

Diachronic reflexive downward causation can be reduced to supervenience by removing the reflexive aspect, free of self-causation and self-reference, but this is an unacceptable weakening of functional emergence. A better approach is to suggest alternatives to the usual concepts of synchrony and diachrony, which amount to binary logic in temporal terms. Something more fundamental and 'exciting' than supervenience *is* involved in the apparently diachronic case, since I feel there are no merely additive consequences of interactions, as if we were dealing with purely standard categorial properties. The causes and effects occur in space-time that is both successive and simultaneous, one or the other aspect being predominantly actualized and the other potentialized, in turn. To restate the basic concepts of antagonism somewhat differently, it is the dynamic opposition between parts and wholes, carried by the structure of the whole, which is the basis for the effect of the structure on its constituents that is distinct from the powers of those same constituents. In the probabilistic, antagonistic system of cause (or cause/effect), one can propose an account of this effect 'taking place' that is both synchronic and diachronic. This is my proposed interpretation of Symons' phrase "the moment immediately following their (the parts') entry into the whole."

Given the principle of dynamic opposition inherent in the logic of energy and of levels of reality, and their consequences for the causal and temporal properties of phenomena, I have shown how emergence seems to follow naturally. We have seen in Chapter 7 how the LIR theory supports a non-reductionist, relational view of quantum mechanics. Downward causation can follow as a corollary to *any* ascriptions of causal relations above the (quantum) level of basic physics. I have tried to demonstrate, in effect, that the *essential contradictory aspect* of those relations is the same for quantum level and for higher level phenomena, and thus that it holds throughout nature. There is, accordingly, nothing objectionable to downward causation being of a reflexive form that is consistent with emergence.

8.7 EVOLUTION AND THE ORIGIN OF LIFE

The processes involved in contemporary living systems at the biological level are more or less completely accessible to direct investigation, and enormous progress has been made in determining critical aspects of structure and function at all levels from biological macromolecules such as proteins and polynucleotides to complete individuals and groups. The use of DNA analysis has made possible new, more accurate models for the migration of primitive man from an initial locus in Africa to the rest of the world.

Systems biology is the name of the new discipline that seeks to convert the masses of new data that have become available into an explanation of how whole organisms function. Relying heavily on mathematics and statistics, new data-intensive techniques and new algorithms, it is an attempt to build models and make predictions about how complete biological systems behave. In the view some of its practitioners (Pennisi 2003), the similarities between evolved circuits and engineering circuits raise the hope that there are deep laws of nature that unite living and designed systems. Others believe that the 'rules' of biology will remain elusive.

Despite these developments, many questions over larger scales of time and complexity cannot be directly studied, and remain without satisfactory answers. These are the problems of life in their most general form:

- Origin of Life – the emergence of animate from inanimate matter
- Evolution – the emergence of new species
- Growth – the emergence of new forms in the life of an individual
- Reproduction – the emergence of new individuals

Common to all of these problems is the issue of emergence, how more complex entities, or less complex but still new entities can emerge from lower level substrates. As we have seen, there is substantial debate over what emergence is, and even if it exists as a valid concept, as well as over the related issues of 'inverse' emergence – downward causation, and the meaning of closure for living systems.

Death and disappearance, the 'opposite' of these processes, are in a sense intuitively well-understood as the inability of a living system to 'resist' antagonistic, invading forces of various kinds, followed by, ultimately, the return to a lower, macrophysical level of matter-energy. Emergent life processes, on the other hand, have not yet been modeled in the laboratory, despite major research efforts in this direction. Little progress on the origin of life had been made since the simulation by Miller in 1953 of the production of organic molecules in the Earth's atmosphere. Attempts to create precursors to the macromolecules of life by polymerizing them on existing inorganic templates have been partly successful, but require highly artificial conditions (Rasmussen 2004). 'Simple' organisms such as bacteria and viruses can be seen to evolve on short time scales under pressure from anti-bacterial and anti-viral drugs, but there are few explanations as to how such processes, or even normal embyrogenesis, are related functionally to biologically active substances, from hormones to ones as simple as calcium ions.

In my position statements in Chapter 5, I stated that classical logic biases the debate in science in two ways, because (1) the internal structures of theories such as those of theoretical biology follow the rules of classical logic; and (2) the domain of description of these theories is a reality that is conceived of in classical logical terms, that is, it is misrepresented by classical ontologies.

My 'ideal state' would be, therefore, that in biology as in other science, (1) arguments would be presented that would see new concepts and patterns of inference emerging, more or less according to the LIR theory suggested, something like T-states from the 'clash' of opposing alternatives at the theoretical level; and (2) that the domain of description of biological theories should be understood as suggested by my New Energy Ontology (NEO), that is, involving the all its categories and sub-categories.

8.7.1 The Absence of Logic in Biological Science

It is perhaps an understatement to say that logic has not had a major role to play in current biological science. Given the limitations of logic to linguistic and mathematical domains this is not surprising, and I can understand the resistance of biologists to considering that any *logic* could have something explanatory to say about biology. As in the case of other disciplines, however, I claim that it is the underlying presuppositions of classical and neoclassical logics that vitally affect the kinds of interpretations of biological phenomena and theories that are made to explain them. I will show, in support of this claim, that recourse is often made to a dialectics, a duality, the function of whose elements cannot be understood when they are, as in the vast majority of cases, considered as independent of one another. Calling attention to the function of dynamic opposition, as defined in LIR, may not resolve the problem or the dichotomy completely, but the gain in explanatory power may provide guidance for further experiment.

The debate between mechanists and vitalists, presented earlier in this chapter, can be viewed as a logical one in the extended sense of the logic of/in reality. No one espouses vitalist positions today, but the debate reappears in other forms, in the transcendentalism of catastrophe theory and in attempts to explain emergence itself. Descriptions of biological processes in terms of dynamic feedback mechanisms or cybernetics[10] (cf. Section 8.8.2) are now common, but little reference is made to these processes as *logical* consequences of something more fundamental. In general, any logically binary position involves ideal, or idealized or abstract entities, as one prefers. Such positions, like those that base their arguments on some form of spontaneity, are not vitalist ones, but they share the abstract properties or categorial features of absolutism and exclusivity with vitalism.

My extension of logic to reality and its structuring as an ontology permits another way of approaching biology. This approach is in a sense quite novel, but I believe it may useful as a way of insuring that correct insights of conflicting views receive serious recognition. Let me therefore summarize some current views and the problems with them, and suggest initial LIR alternatives.

8.7.2 Natural Selection

Natural selection as the basis for evolution *looks* like a notion that embodies antagonism, but on closer inspection, there is nothing to distinguish it from a purely physico-chemical concept of life. It can be placed together with other reductionist notions of hierarchy, progress and Manichean conflict. Some sort of efficient cause seems to be the only basis proposed for natural selection to operate, whereas I propose a fundamental role for the antagonisms found at the physical and chemical levels of reality and consequently for the phenomena the origin of life and evolution at the biological level as well.

Both Lupasco and Emmeche have castigated the account of evolution in the neo-Darwinian paradigm of natural selection as brutal, cynical, algorithmic and mechanist, adequate at best as a theory for insentient zombies. However, the establishment of the categories of Emergence, Closure and Downward Causation is necessary but not sufficient as an approach to a theory of the origin of life and evolution. Emmeche considered biosemiotics, as noted above, as a promising perspective, but was concerned that its concept of code-duality also might imply a hidden prototype fallacy, the genotype-phenotype duality of classical genetics (Emmeche 2000). He later described biosemiotics as a "corrective theoretical enterprise" that enables investigations of questions to be made that have been dismissed due, in his view and mine, to the materialist and reductionist assumptions of much neo-Darwinism. As Emmeche remarked, "the real challenge is not just to consider life as semiotic processes rather than as organized molecular systems but

[10] In Appendix 2, I provide an overview of developments in cybernetics and systems science from the LIR viewpoint.

to investigate the relation between the molecular and semiotic aspects of life processes".

I consider that LIR and NEO provide another form of 'interactionist' explication in the evolution-developmental debate that does not suffer from the absence of physical grounding as in the research of Kauffman, Maturana and others. Above all, my task is simplified by the fact that naïve dualism should no longer be an issue. Contradictorial or conditional dualism and its related conception of contradictorial cause and effect offer a non-traditional, non-mechanistic metaphysical and methodological approach.

In this section, I will first point to the not-so-hidden prototype fallacies (cf. Section 8.4.2) in one approach to semantic closure and the epistemic cut. Since these considerations are fairly complete, they provide a good testing ground for the principles of the logic of/in reality. I will then indicate my preferred way of looking at the problems of life.

8.7.3 The Epistemic Cut

The concept of an epistemic cut was originally formulated by von Neumann in his demonstration that the function of measurement of some physical variable is irreducible to the dynamics of the measuring device (Pattee 2001). The logic here is related to the necessary separation of the symbolic memory and the dynamic laws required for the self-replication of a biological system. It has been considered as a special case of a general epistemic problem: how to bridge the separation between the observer and observed, the controller and the controlled, the subject and the object.

The first observation I make, from the point of view of LIR, is that such separation, that is, the existence of such a cut, is not an necessary property of all systems, but involves a category of processes in which Separability is instantiated, which is accompanied by another in which the cut is replaced by a relation of interaction that I have called Non-Separability.

An epistemic cut appears in a view of dynamical laws which requires that such laws and the initial conditions of a system are sharply separated, the initial conditions are capable of being measured, and measurement and laws have no reciprocal influence. This intellectual distinction between initial conditions and laws *allegedly* has its origin and embodiment in living organisms. In this concepttion, our perceptions as well as our natural languages support a deterministic, either-or logical syntax and causal semantics that conform to a classical dynamics. This happens to be true. I would say science is *burdened* with this concept of state-determined behavior as a modern form of Laplacean determinism, but it does not validate these considerations as the basis for a theory of biology in particular or reality in general. I have shown that such a view of syntax and dynamics is suspect, since it fails in many areas in addition to quantum mechanics. For example, natural language cannot be described even by categorial extensions of classical logic.

Non-integrable conditions, or constraints, can be proposed for bridging the epistemic cut. One constraint states that, in order to provide configurational space for hereditary processes, there most be more degrees of freedom available for the description of the total system than for following its actual motion. As stated by Pattee, since law-based dynamics are based on energy, in addition to non-integrable memory reading, memory storage requires alternative states of energy. Constraints are formally equivalent to laws, and the evolution of systems depends on both.

The complementarity of dynamic laws and the measurement function is irreducible, based on a demonstration by von Neumann that the contrary would lead to an infinite regress of measurement devices operating on systems of systems plus measuring devices and so on. However, Pattee makes the assumption that epistemic irreducibility does not imply any *ontological dualism* (emphasis mine) and that it arises whenever a distinction must be made between a subject and an object, or in semiotic terms, between a symbol and its referent. But an ontological (read metaphysical) dualism is exactly what results, and the consequences are subject to my version of the Leibnizian analysis (of similarity and difference, etc.). If the terms are different they cannot communicate or interact; if they are the same there is no cut. The only possibility of a bridge is that they are the same *and* different.

The classical view of logical disjunction is that something is totally different from something else. Is the epistemic cut, then, essentially equivalent to classical? I think it is. The terms are only epistemologically and not *functionally* connected. No one would think of 'separating' conjunction and disjunction. However, this does not confer any additional reality to the cut, but demonstrates its limitations.

Without any epistemic cut, it can be argued, any use of the concepts of measurement of initial conditions and symbolic control of structuring would be gratuitous. I disagree, and the category of Subjects and Objects and their included middle – Subject-Objects – offers an alternative approach to a description of the relation between the terms in this picture. To recall my definition, being a subject means primarily instantiating actualization (efficient cause) and being an object potentialization (final cause). One can easily associate potentialization with symbolic control and actualization with measurement, following the approach implied by the categorial features of Subject and Object.

The absence of a non-interactive relation between the two sides of the epistemic cut, as proposed, leads to a dead end. Pattee admits that the cut itself is an epistemic necessity, not an ontological condition. What is going on ontologically at the cut is not analyzed, but is it true that only the subject side of the cut can measure or control? For genes to control protein synthesis, they must rely on previously synthesized macromolecules such as enzymes and RNA. Semantic or semiotic closure is defined as such an additional self-referent condition for being the subject-part of the epistemic cut, a "molecular chicken-egg closure that makes the origin of life problem so difficult."

Pattee then says:

> "The concept of an epistemic cut must first arise at the genotype-phenotype control interface. Imagining such a subject-object distinction before life existed would be entirely gratuitous, and to limit control only to higher organisms would be arbitrary. The origin problem is still a mystery. What is the simplest epistemic event?"

I do not begin the story of life with enzymes. From my point of view, the 'simplest epistemic event' was the emergence of matter-energy, as we now know it, in the universe, or multiverse, etc. All the necessary distinctions were present as potentialities, sometimes referred to in theological contexts, independently of any LIR interpretation, as *haecceities*. Given the prior definition of subject and object by the standards of classical logic, von Neumann's argument that the distinction between them requires a description of the constraints that execute measurement and control processes and that such a description is not reducible to the dynamics being measured or controlled is correct, but it is not complete, in the sense that subject and object also instantiate partial categorial conjunction (cf. Section 4.6).

If we have come to think of symbol systems as being independent of physical laws, in my view this independence is *apparent*. The view that genetic symbol systems have evolved so far from the origin of life and that semiotics does not *appear* to have any necessary relation whatsoever to physical laws is also true, but it occults the fact that the processes involved instantiate the same categories of Dynamic Opposition and Non-Separability. I can thus agree with Pattee on the following points: (1) the illusion of isolation of symbols from matter can arise from the arbitrariness of the apparent epistemic cut; (2) the apparent isolation of symbolic expression from physics seems born of an epistemic necessity, but ontologically *it is still an illusion*; making a clear distinction is not the same as isolation from all relations; (3) one clearly separates the genotype from the phenotype, but one certainly does not think of them as isolated or independent of one another.

Further elaboration of the matter-symbol problem is possible using the two-level framework of Section 5.2. If the illusion of isolation is an epistemic illusion, whose reality is accepted, the paragraph above *must* mean that symbolic expression is *not metaphysically isolated from physics*. Consequently, their relation or interaction is real, and it can be considered to have an appropriate dynamics. The remaining question concerns the use of antagonism or constraints to characterize these dynamics. This can be resolved by a view of symbolic memory constraints as dynamic processes in themselves, co-evolving with the other components of the biological systems.

My purpose in reviewing these ideas was to provide background for my essential claims, namely, that there must be some form of dynamic interaction between the members of the various dualities involved in evolution, and it is the proposed cut itself that is the most serious 'illusion'. If something is not independent of something else, then the dependence relation must be specified, ontologically or otherwise, and my thesis is that LIR and NEO accomplish this.

8.7.4 Semantic Closure: The Matter-Symbol Problem

In the terminology of LIR, the macrophysical phenomena studied by physics display an essentially exclusive tendency toward homogeneity, following the 2nd Law of Thermodynamics. This is equivalent to a sharp categorial distinction between matter and symbol. As implied in Chapter 5, material systems, *in general*, do not contain intrinsic symbolic activities or functions. In extreme physicalist-reductionist positions, symbols are considered epiphenomenal and fated to become superfluous when adequate material descriptions of symbolic behavior are found. Like classical physicalism, functionalism and computationalism make the same distinction between matter and symbol, but they focus only on the symbolic category. Functionalists consider the specific material embodiment of symbolic activity as unimportant. Computationalists are functionalists who interpret all processes in terms of computation, and the matter-symbol relation is ignored. It is, however, possible to see these two sets of approaches as limiting cases, the first of identification and the second of diversification in the sense of an absence, or lack of grounding or meaning. Models of artificial life and artificial intelligence 'float' in an abstract domain, and their relation to an empirical reality seems to me forced.

Organisms, on the other hand, depend on internal symbolic controls, and the process of the origin of life requires, among other things, the existence of some form of symbolic genetic code as a crucial component. For a hereditary process to function, that is, have open-ended evolutionary potential, biological macro-molecules must have specific capacities for acting as templates for exact replication and mechanisms for handling mutations. A specific form of self-reference (Pattee 2000) applies to the relation between the material and symbolic aspects of, in particular, living organisms. Self-reference that has sufficient evolutionary potential is an autonomous closure between the dynamics (physical laws) of the material aspects and the constraints (syntactic rules) of the symbolic aspects of a physical organization. Pattee calls this self-referent relation semantic closure "because only by virtue of the freely selected symbolic aspects of matter do the law-determined physical aspects of matter become functional (i.e. have survival value, goals, significance, meaning, self-awareness, etc.) *Semantic closure* requires complementary models of the material and symbolic aspects of the organism."

The definition of a symbol now becomes crucial: a symbol can be described as a relatively simple material structure, material including the senses of energy and information, which while conforming to laws of physics, has significance or semantic function that is not describable by those laws. Physical laws are supposed to describe only those properties of matter that are independent of observers and individual measurements, in order to be sufficiently universal.

Symbols, however, are selected for their context-dependent contribution to the survival of individual unity or identity in a local environment. The universal aspects of matter that are described by laws have no significance for individuals; they are the material equivalent of logical constants. To insure that physical theory can treat symbols as something more than matter described by laws, a division of experience must be made into things that change and things that do not change. Only the independence of symbolic and material aspects allows the clear fundamental separation of laws and initial conditions. Symbols must be viewed as belonging to a general category of initial conditions, which also includes boundary conditions and constraints.

The difficulty with such a picture of symbolic function in developmental evolution is that it depends on either the assumption of an absolute duality – change and non-change – or a clear hedge: physical laws describe only those properties of matter that are independent of observers and individual measurements *as far as possible.* Laws and measurements are different categories, since individuals, not laws, make measurements, but the problem is not about laws, it is about the relation between the allegedly complementary material and symbolic aspects. From the perspective of the origin of life and evolution, the problem is how material structures following physical laws (or their equivalent) with no function or significance gradually developed into symbolic entities possessing such function and significance. It is also difficult to see, from the epistemic cut position, how life could have evolved. The suggestion of mechanism is made of "a sort of downward causation through the action of natural selection" does not answer the question of how physical constraints could become semiotic controls.

The absence of an answer to this question suggests that there is something wrong with or missing in the argument and LIR provides two possible corrections: (1) as discussed above, the concept of passive complementarity should be replaced by that of Conditional Contradiction and Functional Association. Matter and symbol are dynamically, contradictorially related; and (2) the assumed division of experience is not foundational. The minimum requirements of a theory of evolution and the origin of life are a chemistry that incorporates the PDO; an actual physics of living matter that includes the details of how subject and object interact; and the involvement of that chemistry and physics in the potentiality – memory controlled construction of biologically active macromolecules as suggested above.

8.7.5 Code Duality: Bridging the Epistemic Cut

It should be obvious that the simplistic continuity approach (the *no-*cut position) to evolution tends to exclude essential aspects of evolving living systems. A standard no-cut position is as follows:

> The increasing complexity of evolution is the function of operation of contextual constraints. Parts no longer independent of each other constitute the self-organization of a higher level; as such, contextual constraints are the agents of inter-level, bottom-up causality. Acting top-down they simultaneously create new roles for those parts as they create them.

Despite its apparent Peircean pan-semiotic flavor, there is no physical meaning in these contextual constraints. I suggest that higher level contextual constraints were provided by the basic dynamic antagonisms in energy and were operative at an early pre-biotic stage, and that most of the subsequent expansion of biological space took place guided by these constraints, at both the 'high' level of the universe and the 'low' one of the photon. Auto-catalytic cycles, tornadoes or other such entities are real, but that there is an important sense in which they are logically different from living entities, namely, they do not interpret their environments.

As I remarked, I believe any absolute distinction between a dynamic and linguistic mode is incorrect given the dynamic origins of language. The dynamic mode in living systems is always a semiotic mode both index-coded (digital) and analog-coded (symbolic), and distinguishes between digital and analog contextual constraints. Such a distinction, based on a fundamental duality of life, is needed to account for the evolutionary origin of any apparent epistemic cut.

Through the introduction of the concept of tacit cellular knowledge, Hoffmeyer (2000) provides the equivalent for an alternative antagonistic mechanism for the evolution and higher development of living systems that embodies some of the key concepts of LIR. The tacit knowledge aspect of cellular (or organismic) activity, the recognition capabilities of macromolecules, Hoffmeyer argues, is "the strangely overlooked key to biosemiosis." As I suggest below in the systems model of evolution, 'genocentrism' is only one aspect of a general cultural bias towards what can be called 'digitalism', the *preferential allocation of realness to digital aspects of the world, numbers and sequences.* Digital aspects refer to everything I mean by the paradigm of identity and its binary.

The idea that the developmental control value of "activator, repressor or hormonal" molecules is not an inherent chemical property, but only a complex *relation* established by a collective hierarchical organization requiring the whole organism is incomplete. It is *also* in part an inherent *potentiality*, a meaningful semiosis or sign. Pattee did not assign a semiotic nature to this hierarchical organization, which he saw as "safely belonging to the world of dynamics." The concept of code-duality as outlined here claims that the dynamic mode is basically a semiotic mode. What is essential is the "interdependence of the analog and the digital as two equally necessary forms of referential activity arising like twins in the individuation of that logic we call life." Digital codes provide stable access to the temporal world, and analog codes provide the basis for interaction with the world, other-reference and preference. "To claim that only the digital twin is semiotic, whereas the analog twin remains in the sphere of classical dynamics, is to block the only possibility for ever transcending the epistemic cut." It may be a source of sardonic amusement that classical dynamics comes to occupy here, in a classical, binary mode of reasoning, the 'despised' role of the source of diversity!

In the LIR view, it is the inherent potentialized chemical properties in molecules that correspond to 'tacit knowledge', as well as the relations. They are arbitrary, in a sense, but they are tied back to the antagonistic categorial processes that pervade existence. From this standpoint, *even* digital codes have some residual potential semiotic character, and one would be ill advised to make the separation too absolute. The 'interdependence' of analog and digital, is an example of contradictional dynamic opposition, one aspect being temporarily and alternatively actualized at the expense of the other, with the emergent organism playing the role of an included middle.

The pattern of processes out of which life arose may have reflected the same general logic. The first process is an 'interiorization', in which membranes build up an asymmetry between their excluded interiors and exteriors. Pre-biotic membranes 'chose to prefer' their insides from their outsides, or one might perhaps see this as a sort of colonization of the interior space.

Hoffmeyer coined the term *selfication* to describe a particularly human kind of natural individuation as "a necessary theoretical resource not reducible to thermodynamics nor to an emergent hierarchy of contextual constraints."

> … Thus, persistent architectures appeared as entities engaged in the trick of conjuring up a *virtual reality* at their insides for the purpose of coping effectively with their outsides. … The general principle described here might be called *semiotic closure*, a closure that locks analog (indexical) and digital (symbolic) codings into a shared selfication context.

I see the selfication context as a T-state emerging from the interaction of analog and digital processes. The potentialities postulated by LIR can be considered an alternative term for a physical virtual reality that is a necessary stage in the emergence of life.

8.7.6 A Systems Picture

The concepts of LIR and the categories of NEO explicate the systemic-historic perspective on developmental and evolutionary biology. Its chief tenet is that an epigenetic structural drift that is not solely genetically determined constitutes the ontogeny of an organism. Biological epigenesis implies that although the development of the phenotype is made possible by an initial structure including, but not limited to, the genome, it is not determined by it (Cecchi 2004).

The genotype-phenotype relation (phenotype as cell or complete organism) contributes to the expression of new structural features, but only by participating in a process that takes place in a structural context that is distinct and operationally complementary to the genotype. The LIR picture is very similar, but provides in addition a description of the lower level, contradictorial processes that combine or couple to result in this complementarity.

In the gene-centered view, genes establish and determine the direction that the structural change of the whole undergoes, independent of the prior dynamics of the whole. The systems-historical view stresses the reciprocal relationship between the whole and the parts and the organism/environment relationship for ontogenetic changes during development of the phenotype *as well as* changes in the genotype or in any other component in the evolving lineage. The phenotype is the result of development understood as the ontogenic history of the individual.

In other words, an organism is a unique organized whole of mutually correspondent parts that exist only in realizing a particular mode of relationship with their environment, neither as the consequence of design ('intelligent design'), acting an Aristotelian final cause, nor as the result of an internal component, the gene, as an efficient cause, acting as a plan or program of construction.

Cells as biomolecular systems must have the capacity for continuous structural change and be at the same time discrete, as noted above, with a self-generated boundary as a condition of existence. Biological macromolecules are ontologically related to cells in the same way that organs are related to organisms. They do not exist nor can they be formed in nature outside their structural context or a laboratory environment. In the latter case, it is the cellular structural context that it is proving even more difficult to duplicate. Both biomolecules and the cells that they compose are assumed to have arisen together in a historical process of origin and evolution of cells as multi-structural totalities.

The problem with this historical process view is that it is considered, by its proponents as a *spontaneous* one, and this is enough to render it suspect, at least to me, without further discussion. As I have suggested in other cases in which recourse to spontaneity is made at the lowest explanatory level, the only possibility available is to look at a lower level of physical and chemical entities as also instantiating, not the full set of actualized symbols that would lead, ulti-mately, to pan-psychism, but contradictorially adequate potentialities that insure the emergence of the next level of entities such as those in this picture.

Johnson (2000) supports my critique of this systems picture in his view of a functional role of the categorial feature of diversity, specifically, in self-organizing ecosystems and their natural selection. Although a concept of diversity has always been part of the lexicon of ecologists and social scientists, any formal or quantitative understanding of diversity, like that of complexity, has been limited. "The difficulty is that diversity is only meaningful in heterogeneous constituent systems and available analytical tools for evaluating diversity have been lacking." Although some detailed concepts of non-local diversity exist, there appears to be no satisfactory explanation for both local and global diversity in the simple application of natural selection. Johnson suggests a multi-level perspective that says that natural selection is responsible for improvement in the performance of the individual, but as an interdependent, multiple-level system develops, the need for selection is reduced, as non-competitive processes for global performance start to function.

My preferred answer to question of the *origin* of processes of global system functionality during evolution is that the global system itself contains the relevant structural aspects, and individual organisms form and exist within it, but that there are also mechanisms for the global co-evolution of the traits necessary to propagate the global system. Both the ecosystem and the individuals themselves contain, as potentialities, some of the relevant structures necessary for such co-evolution. This view is consistent with the idea that natural selection has a major function role in the potential production of new *combinations* of phenotypic character traits, but that the effects of mutations of the genome are constrained by the interactions with the environment of the organism's existing systems resulting from the non-mutated genes already present.

8.7.7 Evolution as Context-Driven Actualization of Potential

In this further example of the LIR approach to an explanation of the emergence of life from non-life and evolution, I will look at the implications of the LIR principle of the two opposing properties of matter, toward identity or homogeneity and toward diversity or heterogeneity, with both always actual and potential to differing extents in relation to a model of evolution proposed by Aerts.

As I mentioned in Chapter 1, Aerts has also applied his concepts, in particular that of context-driven actualization of potential (CAP) to a theory of evolution (Gabora and Aerts 2005). The basic idea is that all entities evolve through a reiterated process of interaction with a context. As before, the interaction between context and entity leads to indeterminism that defines a non-Kolmogorovian distribution of probabilities that is different in this case from the classical distribution of chance described by a Darwinian theory of evolution based on natural selection alone. The Darwinian view is seen as materialist, selection for "forms of concrete and actual matter" – materially actualized states.

In this more general theory of evolution, potentiality states, defined with respect to a given context (superposition states in standard quantum mechanics) co-exist with actuality as the basis for context-entity interaction, making possible in turn different pathways for evolution that do not exist in the classical sense. The general evolution process is broadly construed as the incremental change that results from recursive CAP. Aerts believes that this theory of evolution provides explanations for the non-code-dependent processes of real evolution, including other non-Darwinian, that is, non-selective processes such as autopoësis, emergence and symbiosis, noting that the concept of natural selection offers little in the way of explanation for why biological forms and phenotypes arise in the first place. A model of an evolutionary process may consist of both deterministic segments, where the entity changes state in a way that predictably follows given its previous states and/or the context to which it is exposed and/or non-deterministic segments where this is not the case.

The 'pure' randomness or indeterminacy that is a necessary condition for Darwinian natural selection is incorrect, but it is so not because it does not exist, but because it is not absolute. As we have seen, in LIR, potentiality and actuality do not just 'co-exist', they mutually determine one another, and potentiality is not a superposition of states, but a property of matter that, with actuality, can define another state as an included middle. Finally, potentializations, as energetic phenolmena, should not be considered as non-material, simply because non-actual.

Aerts is correct to call attention to CAP as describing evolution in other domains, for example creativity and culture, as requiring a non-classical formalism given the possibility for inheritance of acquired characteristics. I will not suggest specific criticisms or alternatives here. What I wish to point out is that CAP, like the theories of Pattee and other discussed above, also fails to explain "why biological forms and phenotypes arise in the first place", as well as at the other two critical junctures in the story of life.

1. Assuming that prior to self-replication, there was random formation of biopolymers on some template, possibly inorganic, and some of these catalyzed the formation of others in an auto-catalytically closed set, some residual potentialities must have been involved derived from lower levels to result in the high free-energy surface or structure that catalysis requires. If there is a further requirement that some polymers adhere to one another, to form a proto-cellular structure, it is again otiose to say that they must have done so spontaneously. Further dialectical interaction with the context, including some internalization of elements of the environment, also requires that relevant potentialities be available for that process.

2. The transition from uncoded, self-organized replication to replication *per* the instructions given by genetic code is indeed significant, especially in placing restrictions on passing on acquired characteristics to the next generation. But what on earth results in the "advent of explicit self-assembly instructions"? Certainly something more than random processes are involved, but attempts to make DNA only from small molecules in the laboratory under biological conditions have failed. The only thing I can suggest is that further transformation of high-energy bonds of precursors of DNA and RNA into the additional necessary complexity occurred because such complexity was present as potentialities. A better understanding of the interaction between the precursors and their proto-cell environment seems necessary to define what these were.

3. The same problem exists for the "advent of sexual reproduction", although here the terminology becomes almost familiar: a mate is needed (as context) to actualize an organism's *potential* for offspring. The question remains open as to what might have been at the basis of the transition to this form of living system.

8.7.7.1 Exclusion-Driven Potentialities

As I discussed above, the picture of the origin of life and evolution that emerges from the fundamental postulate is one of the creation of entities of increasing complexity under the influence of *two* causal energetic processes: one the familiar dynamism of homogenization described by the 2nd Law of Thermodynamics, and the other, much less familiar, of a 'drive' toward locally increased heterogeneity of the same matter-energy. This drive expresses the Pauli Exclusion Principle in more and more complicated ways, and I could use the term for this process "exclusion-driven", to emphasize its fundamental importance relative to context.

The predominant actualization of a trend toward entities with increasing levels of heterogeneity is made possible by an input of energy in various free or bound forms – heat, radiation, high-energy chemical bonds, unequal electric charge distribution, and so on to atoms, other chemical or electrostatic bonds, sterically hindered structures, secondary and tertiary biopolymer structures, cells and organs. Part of this energy will always be degraded to lower levels or less differentiated forms, but not all. Some of it will bring the potentialized aspect of the entity to a state of equal or greater energy to that which was opposing its actualization resulting in the possibility of emergence of a new form as a T-state. In this, homogeneous and heterogeneous structures, and homogenizing and heterogenizing functions are all present in new configurations, but ones in which the latter predominate.

LIR states that the potentialities that are necessary and sufficient, over time, to effect the transitions mentioned above and at the beginning of this chapter consist of the re-expressions of the fundamental heterogeneity of the existence of electrons in two spin states, a heterogeneity that includes the potential for further actualizations. At any level, an entity expresses homogeneity and heterogeneity, stability and functional potentiality for effecting change to the next level.

Some readers may conclude that a form of teleology has crept back into my argument: given the existence, say, of amino acids embodying asymmetry (optical isomers), proteins were inevitable and all the rest follows. I do not consider this a serious objection to the overall theory. There is no more teleology in the usual idealist sense in this view than in the statement that if two electrons of the same spin cannot be in the same sub-shell around a nucleus, a definite number of such levels are possible and, with an input of energy, an electron can be added or removed, or jump to a higher energy level, providing the basis for chemistry, biology and life. No further external *structuring* influence is required, as in other self-structuring or – organizing processes (see Section 4.8.1 and below). Life is the embodiment of the PDO in the category of Non-Separability of self and other. I will close this chapter with a few further final remarks on biological theory.

8.8 THE THERMODYNAMIC AND CYBERNETIC STANDPOINTS

The purpose of this final section is to use the LIR categorial antagonistic principles of actuality and potentiality, and identification (homogenization) and diversification (heterogenization) to refine the usual picture of the functioning and auto-regulation of living systems, that is, of goal-directed organisms whose first goal is survival, as a minimum requirement for reproduction.

In Appendix 2, I provide a discussion of an LIR theory of systems that is in fact another statement, in general terms, of the logical necessity of the PDO and its axiomatic consequences. I also show the relation of my theory to the General Systems Theory of von Bertalanffy and some recent developments of it.

Here, I will mention some examples in chemistry and biology that illustrate the operation of these principles and relate them to current views in biological theory.

- Reduction and Oxidation

Oxidation and reduction are clearly contradictorial in the LIR logical sense since one always implies the other. One in fact always speaks of reduction-oxidation (redox) systems. The quantity of energy-as-potential can even be readily measured *in vitro* in this case: it corresponds to the standard oxidation or reduction potential. Oxidation-reduction processes *in vivo* are characterized in addition by their tendencies to lead to homogeneity or heterogeneity. In any case, the key point is to not to look at single values and to represent phenomena, not in terms of substances or elements but as processes, events and energetic actions. Photosynthesis amounts to the reduction of carbon dioxide to carbohydrates, complex, biological polymers by solar photons. It is a biological process that illustrates a process inverse to the degradation of energy according to the 2nd Law of Thermodynamics, since in it photons are ‘up-graded’ to the electrons that effectuate the reduction.

- Enzyme-Substrate Reactions

Most processes catalyzed by enzymes involve two or more steps. Rather than a system acquiring energy from a high-energy bond *here* and using it *there* to produce the desired new structure, one can talk in terms of the actualization of the bond’s energy and the potentialization of the energy of heterogenization of the new biological systems, followed by a second step of its actualization by another enzyme. The enzyme inherits *its* catalytic properties from the gene coding for it due to the antagonistic physical and biological systems incorporated in the gene, homogenizing and heterogenizing, structuring and operational. Enzymes and other catalysts act at the critical point of stability and instability of molecular systems (threshold phenomena), such that only a weak, statistical "flick" is necessary to effectuate the reaction.

Additional antagonistic dualisms are the operation of activators and inhibitors of enzymes and of hormones operating antagonistically in pairs – androgens and estrogens for example.

- Nerve Cell Polarization, Depolarization and Re-polarization

Before excitation by internal or external stimuli, a nerve cell system is in a state of *potentiality*, maintained by the antagonistic actualization of the polarization or electrostatic equilibrium – equilibrating antagonism (Lupasco 1986). Excitation results in a new actualization, potentializing the ionic equilibrium, equivalent to a heterogeneity of sensations; the next step is an inhibition, a re-equilibration (re-polarization) of the excited nerve cells.

Obviously, for these processes to occur, input of energy is required, according to the principles of thermodynamics, but these are at the same time clear examples of cybernetic systems instantiating *feedback.* The principle of dynamic opposition applies to and explicates the operation of feedback, as I discuss in Section 8.8.2.

8.8.1 Thermodynamics and Complexity

I referred to the thermodynamic view of Salthe and others in connection with causality in Chapter 6. It is interesting that the situation has not evolved (sic), at least, to any new consensus, since Lupasco first stated in 1960 that relative to the macrophysical world, some biologists thought that life could be fully explained by the 2nd Law of Thermodynamics; living systems simply accelerated the entropic becoming of the universe (Salthe says that evolution of more and more complex living systems, which dissipate energy more rapidly than inorganic processes, "is the Universe's devious route to its own negation.").

The attraction of such theories is that they provide fairly complete descriptions of living systems in terms of the emergence of levels or hierarchies of complexity, a vast and complex field in itself that I have not made a major focus of this book. It is based on the fairly obvious notion that individual living systems function globally far from thermodynamic equilibrium, degrading large quantities of energy (generating entropy) from which, at different scales, enough is extracted to support the chemical and biological processes of life. More complex dissipative structures are said to evolve in order to accomplish this more and more efficiently. There is then no 'difference' between the way human beings and hurricanes, for example, exist, from a thermodynamic standpoint, and no additional *fundamental* principle is needed to account for the emergence and functioning of new forms of life, biological structure and mind. The applicable picture of causality is one of classical finality and efficient cause.

The thermodynamic view requires several supporting theories, including an irreversible Big Bang cosmology, with its inexplicable singularity, and exclusive application of the 2nd Law of Thermodynamics in the currently known universe of light energy and matter. The existence of immanent levels of reality or complexity in real entities is hinted at, but not ascribed foundational importance, which might imply interactive antagonism with other factors as causally significant. Further, it is known that in mental processes, large quantities of energy are degraded. Mental systems in the LIR view are highly contradictory, that is, not far from the point of a dynamic equilibrium between opposing elements that can be called variously drives, concepts, beliefs, and so on. LIR proposes: (1) the Pauli Exclusion Principle as an organizing principle, at the level of electrons; (2) an isomorphic principle of exclusion at the level of organisms, self and non-self; and, perhaps, and (3) an equivalent one at the mental level of human individuality. To ground the phenomena of emergence, evolution and cybernetic processes at the lowest level, many thermodynamic views have no recourse other than spontaneity. This is for me the ineluctable area of conflict between LIR and such theories, but perhaps from *this* conflict new insights may emerge.

8.8.2 Cybernetics and Information

The standard view of cybernetics is a science that studies the abstract principles of organization and functioning in and of complex systems. It focuses on how systems use information and control internal and external processes to steer towards and maintain their goals, while counteracting various disturbances or aggressions that are perturbing or could perturb them. Both so-called first-order and second-order cybernetics assume the influence of an observer, although the latter does so more explicitly (Heylighen 2001).

Cybernetics is composed of a certain number of laws and principles, of which the following are most relevant to this analysis:

- Variety, Constraint and Entropy

Variety refers to the number of states that a system can exhibit. If this number is smaller than that potentially available, the system is said to be constrained. A Constraint is the difference between these and as it reduces uncertainty about the system, it is a kind of information. Variety and constraint can also be expressed in terms of probabilities, where variety is equi-valent to entropy. Entropy is maximum when all states are equally probable, in which case entropy reduces to variety. As in LIR, the probabilities need not sum to zero or 1.

- Asymmetric Transition

Variety and hence the statistical entropy diminishes as the system goes toward what is for it a more stable or dynamic equilibrium as it is going from a larger number of states to a smaller one. Negentropy increases but energy is required to achieve this self-organization. In dissipative structures, the stability is dynamic, in the sense that what is maintained is not a static state but a process.

- The Law of Requisite Variety

During regulatory or control processes involving feedback, in the face of perturbations with a variety of possibilities for action, the regulative mechanisms must be able to produce at least as many types of counteractions as there are disturbances. The regulator should thus have a maximum *potential* of internal variety or diversity.

- Control Loops

There is a tendency in standard views of the perturbation relation between an entity and its environment to focus attention on the former as agent and the latter as patient. Cybernetics correctly views control loops as symmetric: the environment can be the system and the perturbation the goal. I look rather at the scheme as one of two interacting systems in the original sense of LIR, a process and its contradictorial conjugate. If the goals are incompatible, this is a model of conflict or competition, and there is the possibility of emergence of a new goal. If they are compatible, the interaction can result in simple compromise or cooperation.

In the LIR probabilistic view, which is largely consistent with the above, every cybernetics, natural or artificial, is a dialectics, since each one involves an alteration, a perturbation by an antithetical contradictory process, followed by the return to the (state of) regulation that must prevail for the system to be "stable". In other words, a cybernetics alternately actualizes certain phenomena and potentializes the antagonistic, contradictory phenomena in consequence. It is an "oriented dialectical systematization of energetic events, inherent in the nature of energy" (Lupasco 1987b).

I have used the term 'feedback' on previous occasions in this book as a natural property of the complex dynamic systems to which the logic of and in reality applies. Any cybernetic system (Lupasco 1979) has the capacity for *feedback*, for counter-action using the term mentioned in Chapter 2. Also, any normally functioning, unperturbed system has a potentiality for being perturbed, for malfunctioning. As "Murphy's Law" in Anglo-American popular culture states: "Anything that can go wrong, will." A perturbation is the information that potentializes the normal (probabilistic) functioning of the system and provokes the subsequent and consequent actualization of the control mechanism that re-equilibrates or regulates it.

The cybernetics of physical systems is characterized by a return to an identity, a constant value, invariance, or homogeneity; biological cybernetics results in a further variance, a heterogeneity. This tendency by negative feedback toward a homo- or heterogeneity is equivalent to a return to a progressive non-contradiction in the two cases. In the dialectics of quantum or psychic phenomena, there is a third dialectic cybernetics, in which feedback leads to the semi-actualization and semi-potentialization of the two terms in the T-state of the included middle.

Kauffman and his colleagues propose a new reading of information that unites matter, energy and information (Kauffman et al. 2006). They show that neither the Shannon definition of information as a scalar quantity of bits, devoid of meaning, nor Kolmogorovian information which refers to standard probability distributions of non-interactive systems is applicable in biology. Information should be designated as 'instructional' or 'biotic' in the sense that it carries meaning and consists of constraints or their physical equivalents – boundary conditions that also partially cause events, where the coming into existence of the constraint is itself part of the propagating organization of the entity. "Constraints are information and information is constraints." This recursive aspect is characteristic of Markov chains, the non-Kolmogorovian probability behavior of two mutually dependent entities to which LIR applies.

LIR brings the 'missing ingredient' of dynamic opposition or antagonism that reinforces this picture of information for the evolution of living systems. It provides a cybernetic explanation of how a constraint in its physical manifestation can be causally effective.

Any theory of biological development or becoming must capture the duality of biological systems, that is, the composition of living systems by non-living substrates. This can be presented as the existence, concomitantly and contradictorially, as the presence of a cybernetics of macroscopic matter and one of biological matter. In the absence of a logic that defined their existence, there has been little justification for such a distinction. One can then look at the unique relation between these two cybernetics and the quantity of information present, as follows: in physical systems, with the increase in positive entropy, that is, homogenization, the quantity of variety or information decreases in direct proportion. Biological phenomena, from this standpoint, are highly improbable, and their information content should also increase in direct proportion to the negentropy generated.

From the standpoint of the living system itself, in its dissymmetrical equilibrium with inorganic matter, the production of negentropy has a *higher* probability, and the amount of information should *decrease* in proportion. Improbable and hence information-rich 'homogenizing' perturbations provide the information that initiates the control loop, permitting the information-poor system to maintain its heterogeneity (repair itself, etc.).

Information can thus vary directly or inversely to the quantity of negative or positive entropy being produced, according to the relative probabilities of homogenization or heterogenization. At the microphysical and cognitive levels, entropy and negentropy result in increased quantities of information, since the probability of any dominant development of either homogenization or heterogenization decreases or is blocked (but their contradictorial coexistence has a high probability). This is another way of describing the decrease in indeterminacy with increased contradiction that is a corollary of the PDO.

It is at this point that the thermodynamic view and the LIR/Cybernetics view intersect. The evolution of cosmological and simple physical structures – far from equilibrium dissipative systems (FFEDS) – requires an extensive degradation of energy and 'production' of entropy. A principle has been defined for such systems (Lineweaver 2005), the Maximum Entropy Production principle (MEP) that states that structures that destroy energy gradients for their growth or maintenance will arrange matters such that a maximum amount of entropy is produced. However, the principle is limited to *reproducible* systems and Lineweaver questions whether MEP applies to biological systems, given their *non-reproducible aspects*. "Whether biogenesis is reproducible is unclear and without this MEP may not be applicable to biotic activity." That it may not would be consistent with the above analysis from the principles of LIR. This discussion also suggests that some principle, such as functional exclusion of the Pauli type, is needed in addition to the 2nd Law that grounds non-reproducible aspects of biological phenomena. My thesis is, again, that the two, together with the general principle of dynamic opposition, ground *both* the two characteristic life processes of monotonic proliferation and morphoneogenesis, some of which will occur *near* equilibrium.

8.8.3 Teleonomy

As noted above, a form of non-theological teleology has reappeared in the thermodynamic view of biology that assigns some thermodynamic purpose to the operation of the 2nd Law as a means of explaining life and evolution. Monod (1970) introduced *teleonomy* as one of the three fundamental properties of biological objects, together with autonomic morphogenesis and reproductive invariance. Teleonomy was defined as the *apparent* purpose or possession of a project in the organization of a living system. However, Monod fell back on pure chance as the basis for change and a spontaneous process of "matching" for the functioning of DNA (see Section 5.5.1.2 on Spontaneity). Subsequently, despite these and other weaknesses of explanation, teleonomy became quite popular as a theoretical basis for discussions of mental and other phenomena by Edelman and others.

LIR offers the possibility of retaining some of the descriptive elements of teleonomy by proposing a foundation for the reality of which teleonomy is the appearance. I recall that reality and appearance are both real, as are the dynamics of their alternating actualization and potentialization. An alternative picture of chance and necessity, determinism and indeterminism was suggested in Chapter 6. As indicated previously in this chapter, the origin of life and evolution are only possible because of the inherent, residual potentialities in the molecules built up in turn from lower physical levels, which coexist with the actualities.[11]

A proponent of teleonomy may object at this point that I have made the inherent potentialities and antagonisms of whatever might have been the first quantum entity or process in the universe responsible for all subsequent development, and such an entity is no more probable than some fully organized one. The only possible response at this time is that if the entire universe instantiates a contradictorial dynamics, as suggested by the cyclic model of Steinhardt (Chapter 7), and that dynamics is available for any subsequent organization of normal matter-energy. (I have admitted that the question of a first cycle or first entity is unanswered, but it may be badly posed). The creationist argument[12] for the appearance of life and its complexity, as well as the teleonomic one, accordingly, fails. The existence of the universe, that there is something rather than nothing, was discussed from a logical-metaphysical perspective in Chapter 3, and the subsequent analysis has been an attempt to restate its most fundamental characteristics. The question of *why* the universe exists, and the meaning of this question, if any, is beyond the scope of this book.

In the last pages of this book that constitute its conclusion, I will point to some additional areas to which the principles of LIR may apply.

References

Aerts, Diederik et al. 2003. Quantum Morphogenesis: A Variation on Thom's Catastrophe Theory. *Physical Review E67*, 051926. archref and link: quant-ph/0211105.

Aerts, Diederik, Jan Broekaert and Liane Gabora. 2005. A Case for Applying an Abstracted Quantum Formalism to Cognition. In *Mind in Interaction*, ed. R. Campbell. Amsterdam: John Benjamins.

Batterman, Robert W. 2002. *The Devil in the Details. Asymptotic Reasoning in Explanation, Reduction and Emergence.* Oxford: Oxford University Press.

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[11] Monod did see the origin of processes of morphogenesis at the microscopic level of the chemical structure of DNA, not preformed as such, but offered no explanation of a) why this should be and b) what might be the role of the atoms constituting the molecule.

[12] Creationism alleges that the rationally unexplainable emergence of a viable cell, cellular structure or individual, necessitates a deity.

Bickhard, Mark H. 2003. Process and Emergence: Normative Function and Representation. In *Process Theories: Crossdisciplinary studies in dynamic categories*, ed. J. Seibt. The Netherlands: Kluwer.

Boogerd, F. C. et al. 2005. Emergence and its Place in Nature: A Case Study of Biochemical Networks. *SYNTHESE* 145: 131–164.

Cao, Tian Yu. 1997. *Conceptual Developments of 20th Century Field Theories.* Cambridge: Cambridge University Press.

Cecchi, Claudia et al. 2004. Answering Cuvier: Notes on the Systemic/Historic Nature of Living Beings. *Cybernetics and Human Knowing* 11: 11–19.

Chandler, Jerry L. R. and Gertrudis van de Vijver. 2000. In *Closure; Emergent Organizations and Their Dynamics.* New York: Annals of the New York Academy of Sciences 901.

Emmeche, Claus. 2000. Closure, Function, Emergence, Semiosis and Life: The Same Idea? *Closure; Emergent Organizations and Their Dynamics.* New York: Annals of the New York Academy of Sciences 901.

Emmeche, Claus. 2003. Causal Processes, Semiosis, and Consciousness. In *Process Theories; Cross-disciplinary studies in dynamic categories*, ed. J. Seibt, The Netherlands: Kluwer.

Emmeche, Claus, Simo Köppe and Frederik Stjernfelt. 1997. Explaining Emergence. *Journal for General Philosophy of Science* 28: 83–119.

Gabora, Liane and Diederik Aerts. 2005. Evolution as Context-Driven Actualization of Potential. *Interdisciplinary Science Reviews* 30(1): 69–88.

Gillett, Carl. 2006. Samuel Alexander's Emergentism: Or, Higher Causation for Physicalists. *SYNTHESE* 153: 261–296.

Heylighen, Francis. 1995. Downward Causation. *Principia Cybernetica Web.* pespmc1.vub.ac.be//DOWNCAUS.html/

Heylighen, Francis. 2001. Cybernetics and Second-Order Cybernetics. In *Encyclopedia of Physical Science & Technology*, ed. R. A. Meyers. New York: Academic.

Hoffmeyer, Jesper. 2000. Code-Duality and the Epistemic Cut. Tacit Knowledge. In *Closure; Emergent Organizations and Their Dynamics.* New York: Annals of the New York Academy of Sciences 901.

Johnson, Norman L. 2000. The Importance of Diversity. In *Closure; Emergent Organizations and Their Dynamics.* New York: Annals of the New York Academy of Sciences 901.

Kauffman, Louis T. 1997. Virtual Logic – Fixed Points and Paradoxes. *Cybernetics and Human Knowing* 4: 65.

Kauffman, Louis T. 2002. Time, Imaginary Value, Paradox, Sign and Space. In *Computing Anticipatory Systems*, ed. D. Dubois. *AIP Conference Proceedings* 627. Liege, Belgium: CASYS-Fifth International Conference.

Kauffman, Stuart et al. 2006. "Propagating Organization: An Enquiry", preprint for publication, May 2006 (by permission).

Kim, Jaegwon. 1999. Making Sense of Emergence. *Philosophical Studies* 95: 3–36.

Lemke, Jay L. 2000. Opening Up Closure. In *Closure; Emergent Organizations and Their Dynamics.* New York: Annals of the New York Academy of Sciences 901.

Lineweaver, Charles H. 2005. Cosmological and Biological Reproducibility: Limits on the Maximum Entropy Production Principle. In *Non-Equilibrium Thermodynamics and the Production of Entropy: Life, Earth and Beyond*, eds. A. Kleidon and R. Lorenz. Dordrecht, The Netherlands: Springer.

Logan, Robert K. 2007. The Relativity of Information and Its Relationship to Meaning", preprint for publication, July.

Lupasco, Stéphane. 1973b. *Du devenir logique et de l'affectivité; Vol. 2: Essai d'une nouvelle théorie de la connaissance.* Paris: J. Vrin. (Originally published in Paris: J. Vrin, 1935).

Lupasco, Stéphane. 1979. *L'univers psychique.* Paris: Editions Denoël/Gonthier.

Lupasco, Stéphane. 1986. *L'énergie et la matière vivante.* Monaco: Éditions du Rocher. (Originally published in Paris: Julliard, 1962).

Lupasco, Stéphane. 1987b. *L'énergie et la matière psychique.* Monaco: Éditions du Rocher. (Originally published in Paris: Julliard, 1974).

Maturana, H. R. 2003. Autopoësis, Structural Coupling and Cognition. *Cybernetics and Human Knowing* 9: 5–34.

Maurel, Marie-Christine. 2005. L'apparition de la vie. In *Sciences et Avenir, Juillet/Août*: 60–64.

McCrone, John.2007. Dichotomistic Logic. http://www.dichotomistic.com

Merricks, Trenton. 2001. *Objects and Persons.* Oxford: Oxford University Press.

Monod, Jacques. 1970. *Le hasard et la nécessité.* Paris: Point Seuil.

Moreno, Alvaro. 2000. Emergence of Formal Causation. In *Closure; Emergent Organizations and Their Dynamics.* New York: Annals of the New York Academy of Sciences 901.

Nicolescu, Basarab. 1999. *Le tiers inclus. De la physique quantique à l'ontologie.* In *Stéphane Lupasco; L'homme et l'œuvre*, eds. H. Badescu and B. Nicolescu. Monaco: Éditions du Rocher.

Quine, William van Orman. 1969. *Ontological Relativity and Other Essays.* New York: Columbia University Press.

O'Connor, Timothy and Hong Yu Wong. 2002. Emergent Properties. *The Stanford Encyclopedia of Philosophy (Winter 2002 Edition)*, ed. Edward N. Zalta. http://plato.stanford.edu/archives/win2002/entries/properties-emergent/

Pattee, Howard H. 2000. Causation, Control and the Evolution of Complexity. *Downward Causation*, eds. P. B. Anderson et al. Aarhus: Aarhus University Press.

Pattee, Howard H. 2001. The Physics of Symbols: Bridging the Epistemic Cut. *BioSystems* 60: 5–12.

Pennisi, Elizabeth. 2003. Tracing Life's Circuitry. *Science* 302: 1646–1649.

Petitot, Jean. 1988. *Structuralisme et phénoménologie: la théorie des catastrophes et la part maudite de la raison*, in *Logos et Théorie des Catastrophes.* Geneva, Switzerland: Editions Patiño.

Queiroz, João, Claus Emmeche and Charbel Niño El-Hani. 2005. Information and Semiosis in Living Systems: A Semiotic Approach. *SEED Journal* 5–1: 60–90.

Rasmussen, Steen et al. 2004. Transitions from Nonliving to Living Matter. *Science* 303: 963–965.

Symons, John. 2002. Emergence and Reflexive Downward Causation. *Principia* 6: 14–39.

Thom, René. 1972. *Stabilité structurelle et morphogénèse*. Reading, MA: W. A. Benjamin.

Wilson, E.O. 2000. *Consilience*. New York: Knopf.

CONCLUSION: NEW DIRECTIONS AND A NEW SKEPTICISM

Contradiction is the safeguard of eternity.
Stéphane Lupasco

In this book, two terms relevant to philosophy and science, logic and reality, have been juxtaposed and brought into a new kind of correspondence. Foundational questions of logic and philosophy are still the subject of debate, and the logic of/in reality proposes a rigorous alternative way of looking at them (Corsi et al. 1989). Quine (1986) asked "Is logic a compendium of the broadest traits of reality, or is it just an effect of linguistic convention?" I have argued that it can be the first of these, and that there is a principled way of describing the link between science and logic, with empirical evidence able to support a unified scientific system.

Logic has been given an extended interpretation, such that it refers to and describes, as far as possible, real processes considered as the instantiations of energy in various forms that constitute reality. The idea that everything that exists is energy and behaves in a regular manner due to the antagonistic properties inherent in energy is a fundamental metaphysical concept, implying a logic and a method. I have reviewed some of the areas of knowledge to which this idea may have the greatest relevance, following in particular two lines of inquiry:

- The metaphysical, to a potential *rapprochement* between physics, logic and categorial ontology
- The logical, to a proposed ternary, transconsistent logic, applicable to the domains of both complex phenomena in and of reality and existence, and their corresponding philosophical and scientific theories

I have developed the logic of/in reality as a formal logic, based on a set of informal and formal axioms that imply metaphysical and physical relations between the elements of the logic, seeking to construct a model that is the closest possible to reality. The logics most similar to my logic are inductive probabilistic logic and quantum logic, including in part the contextual reading of it given by Aerts. The values of the elements described are shown to be similar to those of a non-standard, quantum-like system of probability, that I have called the reality values of the degree of actualization, potentialization or included middle T-state of a dynamic system, process or event. In the metaphysics of LIR, context and contextuality are ontological, involving the interactions of dynamic systems and not only epistemic.

LIR provides a new 'twist' on the concepts of actuality and potentiality that have existed since Aristotle: its axiom of Conditional Contradiction sees their alternating, reciprocal instantiation in phenomena as the basis for all change and the eventual emergence of new entities as included middle T-states. I have suggested that LIR attempts to capture the 'feel' of real processes in the course of change and provides a basis for logical inferences about them. The formal categorization of the aspects of change, and their grounding in the physics of energy and its antagonistic properties at the heart of all phenomena has enabled the development of a New Energy Ontology (NEO). NEO permits a systematic organization of reality into categories of entities that can and cannot be separated from their associated opposites or contradictions. The former corresponds to the domain studied with classical logic and ontology, with its requirement of exhaustivity and exclusivity and the entities of binary, formal, deductive logic as well as those that, at the level of reality in focus exhibit, to all intents and purposes, no mutual interaction. The latter domain is that of real processes and events, especially those at the microphysical, biological and mental levels. I have attempted to show the value of my theory in this domain in resolving metaphysical and scientific issues whose origin has been, in part, the very ignoring of the proposed structural distinction in reality. I have proposed that the logic of/in reality is a valid extension of logic that provides, among other things, a theory of reality in terms of the fundamental duality of energy and gravity. I suggest that the duality of dynamic opposition at macroscopic levels reflects and is the expression of the self-duality of the quantum and gravitational fields at the most basic level of existence.

Other examples I have given of areas where LIR could assist in resolving dichotomies are the analytic/synthetic distinction; the debates over the relation between scientific and structural realism; and the fundamental structure of time and space. The metaphysical principles of LIR make possible a new reading of the relation between causes and effects, establishing them as essential properties of processes, in fact equivalent to the processes themselves as they undergo (experience) change.

LIR adds to classical and neo-classical logics the notion of inference and implication as *real processes*, applicable to real phenomena. Classical logic is in a sense opposite or 'orthogonal' to reality, going in the direction of abstractions from it. These abstractions certainly have a form of existence or being, but standard logic does not add to our knowledge of reality. It often biases research in the various disciplines towards solutions, for example, in defining emergence, which fit its principles. The domain of logic in reality should not be criticized as being too broad, but the classical definition of the domain of logic as too narrow. We have seen that the complexity of the binary domains of mathematics and of language, and the opportunities for new discoveries in them, described by the principles of the adequate classical logics, are inexhaustible. LIR puts these in the proper perspective, avoiding the tendency for their application outside the domain, for example in the borderline areas of temporal and deontic logics, influenced by the classical concepts of time.

Readers may well ask, however, given that science and ontology are disciplines available for describing reality, what is the role of LIR? The answer is that LIR is a conceptual framework that establishes the logical and metalogical characteristics of that reality, making explicit and systematizing its underlying principle of dynamic opposition. LIR as a 'physics' and metaphysics is also a theory about what there is in the world. Its logical principles are not only in line with current developments in General Relativity, but support aspects of that physics that avoid any absolute commitment to either geometry or matter/energy as being fundamental in the universe to the exclusion of the other. The New Energy Ontology (NEO) of LIR, including the critical sub-category of Non-Separability, serves as a control or 'reality check' of the validity of the LIR approach. LIR thus shares some of the features of science and ontology, but provides the additional dimension of logic to a picture of the world.

1. NEW DIRECTIONS

It is difficult to see at this juncture the directions future research on and with Logic in Reality may take. Some increased formalization or mathematicization is desirable to establish LIR in the Western tradition of this form of authentification. On the other hand, the most obvious applications may be in the areas of cognitive science and the further naturalization of phenomenology. The questions of the existence and nature of free will may be amenable to new readings, providing the support for a more realistic basis for this intuition. In the philosophy of knowledge and belief the disappearance of the barriers of standard bivalent logic may also offer advantages. I have given a few examples in this book of advances in theoretical and experimental science that also imply the operation of the PDO, and one can expect that further ones will be made. It is the *absence* of antagonistic interaction between man and machine, seen as elements in the category of *Separability*, which in my view confirms the uniqueness of the human, living condition.

Two examples of the ways in which the LIR approach can make a contribution to debate are the following, which indicate possible new directions for philosophical and metaphysical research:

- LIR avoids the dichotomy of chance and necessity as the driving principles of change.
- LIR is grounded in both physics and experience and provides a principled separation of phenomena into pre-semiotic, without internal representation, and semiotic, involving emergent qualitative

complexity, in which the equivalents of both efficient and final causes are functional.

LIR as logic in this interpretation is able in principle to naturalize the operations that are involved in internal mental phenomena and their expression in behavior and action. LIR can thus be considered as a framework theory of mental phenomena, including intuition, considered as an essential dynamic property in the world, a part that is not separated from the rest of it. It could support an emergent, interactive model of normative function and representation that might resolve, in a novel way, the opposition between the so-called factual, non-normative world and the mental, normative world.

The ideas in this book may thus offer a new approach to, for example, the problems of the explanatory gap in consciousness studies as it does of the epistemic cut in theories of evolution. LIR provides potential support for a version of an identity theory of mind in which experiences of both internal and external reality are processes in the brain that retain first-person character as an emergent phenomenon. These are other areas in which a strict separation of two phenomena or terms seem to be required by current theory may be amenable to bridging by application of the contradictory links between them. The language of quantum physics and cosmology may provide new ways of formalizing this approach that will make its discussion both simpler and more rigorous, but there may be parts of it that will resist formalization as too restrictive.

That my approach goes contrary to received wisdom in many areas is true, but it is also true that many logical and philosophical aspects of current science can be seen as either limiting cases of the proposed dynamics or as details of the processes for which these dynamics provide the framework. LIR does not devalue the massive amount of knowledge garnered on the basis of non-contradiction, but places it in a new perspective. In the future, it should not be considered unscientific to take into consideration the contradictorial as well as the non-contradictorial aspects of existence and science, and develop theories based on them.

Priest, da Costa, Béziau and others have shown once and for all that classical logic is not the standard by which other logics can be judged. Classical logic is a sub-logic of their paraconsistent logics, applicable in the limited domains I have defined. The logic of dynamic contradiction, of and in reality, reduces to classical logic for phenomena that have approached, asymptotically, the limits of non-contradiction.

Volken (1997) echoes this view of contradiction:

> It is time to give a new logical status to contradiction. … It will be the different paraconsistent logics that will enable this new status to be attributed to it. And if these logics disturb our habits, they can generate theories that go beyond the existent theories of which they will be the generalizations. And, in addition to their intrinsic interest, they will open new horizons for us, epistemological as well as mathematical.

As far as the social level of reality is concerned, it is not possible to evaluate here the various approaches being made from scientific, sociological or political perspectives to effect minimal improvements in the human condition. Commenting on the original work of Lupasco, Ioan (1999) believes it provided "a vision of the real based on systemic and morphogenetic parameters which can lead to the reconciliation of man and nature and that of the exact sciences with social sciences (*sciences humaines*)". Applications in the related disciplines of ethics, politics and social science may thus also constitute a fruitful new direction for LIR.

2. A NEW SKEPTICISM

If there is one message that this book could convey, it might be something in the direction of a new skepticism. The standard epistemological definition of skepticism states that there may be inevitable errors in the knowledge of our own experiences that make it impossible to have adequate knowledge of the world. By pointing to the interactive relations between phenomena at different levels, the logic of/in reality reformulates this skepticism. We can know adequately, but we cannot know completely or absolutely, as is being recognized by the increasing acceptance of the implications of Gödel's work. In and of itself, this is not a novel position. What is novel in LIR is the proposal that one should recognize not only the contradictions in science and knowledge, especially as regards time, space and change, but also another kind of more or less unconscious contradictory bias in the assumptions one makes and in the methodology one uses.

As discussed in Chapter 5, terms should not be used in a dogmatic manner. Any explanation, for example, always implies its potentialized contrary explanation. The theoretical conclusions of LIR itself should always be understood conditionally: counterexamples and borderline cases can always be found. The core thesis of LIR is that such cases do not invalidate the theory. They are not pathological in the negative sense, any more than certain mathematical curves that display fractal properties are 'pathological'. *They are a logical aspect of the universe in which we find ourselves.*

Such skepticism, applied to new developments in science and technology could result in recognition of their reductionist aspects that exemplify primarily identity or homogeneity on the one hand, or excessive diversity on the other. Digital recording of sound, especially music, involves a reduction in the complexity of waveforms, and the difference can be perceived by sensitive hearers. Artificial intelligence work sees a possible elimination of any fundamental difference between living and non-living supports. Navigation in virtual reality, on the Internet and elsewhere, offers unusual possibilities of new forms of perception and human association, but it entails risks to fragile individuals. The point here is not to detract from the value of highly creative discoveries and inventions in these fields. It is to counter the ideological, absolutist components that may contaminate them by rehabilitating, 'within reason', by giving a logical status to, the related non-computable, imprecise and intuitive aspects of our 'classical' biological existence.

The application of this principle of skepticism applies also to theories and fields of thought. For example, the last words of the conclusion of Petitot's *Physique du sens* (Petitot-Cocorda 1992) are that the humanities *are* natural sciences ("*die Geisteswissenschaften sind Naturwissenschaften*"). This is a desirable, even a necessary conclusion, but it is not complete and even partly misleading. The approach in this book has enabled us to give meaning to the phrase, the title of an important book by Hoffmann (1995) that two disciplines both *are* and *are not* the same, by seeing the different ways in which the same underlying logical principles apply to and characterize the disciplines and those who practice them.

The question of the existence of competition or parallelism in theories, in particular theories of logic, is not trivial. I conclude with a view of this matter by the paraconsistent logician da Costa, whom I have cited earlier and whose fundamentally neo-classical position on logic is rather different from that of this book. In a major article (Da Costa et al. 1999), da Costa talks to the question of the "philosophical problematic of knowing if a paraconsistent logic is rival or complementary to classical logic". He refers to claims by Priest that paraconsistent logic is *rival* because of the existence of some 'true contradictions' (the quotation marks are da Costa's). The choice should depend on the problematics of rivality *versus* complementarity and the belief in the existence or non-existence of contradictions. As da Costa continues, "The big question is to know whether our world is in fact contradictory or not, and such a question has not yet been definitively answered." A pertinent example of this debate is an attempt (McGinnis 2006) to reconcile classicality and paraconsistency in a modal logic, namely, deontic logic. The proposed logic depends on the assumption that the actual world (home world) is complete and consistent, without true contradictions (dialetheias). However, there are possible, non-actual worlds in which normative conflicts (some things are both obligatory and forbidden) exist, which follow paraconsistent logic.

LIR, of course, claims that not only the above possible but abstract worlds can be inconsistent and incomplete but that the actual world is also. Lupasco said that his contradictorial logic of the included middle was the correct one "if, of course, the world is logical." From the competition of views, from such opposition, new, more useful theories may emerge, along the lines suggested by Cao for the ontology of the development of science. It is hoped that this book will stimulate questioning of the current reliance on binary logic and contribute to a countervailing consideration of a logic of energy as the ternary logic of and in reality.

The concept of reality itself – being as well as becoming – receives further illumination through the LIR approach, placing aspects of quantum field and general relativity theory in a context of dynamic opposition that extends to other levels of reality. I will close, therefore, with the insight of Penrose of what may be at the heart of physical reality, cited first in Chapter 4, supported by the recent work of Lusanna and Pauri. In his discussion of the vacuum (Penrose 1991), Penrose says:

> We cannot at all draw a clear dividing line between what we call 'matter' or 'substance' and what we call 'empty space' – supposedly, the voids entirely free of matter of any kind. Matter and space are not totally separate types of entity. Actual substance need not

be clearly localized in space. *These are hints that our treasured intuitive views as to the nature of physical reality are less close to the truth than one would have thought* (emphasis mine).

Perhaps this book will help to move us closer, in some small way, not to *the* truth about the nature of reality, but to new useful and open ways of studying it. One of these ways may be to look at reality as instantiating principles of dynamic opposition and contradiction, and to take these aspects to their logical conclusion.

References

Corsi, Giovanna, Maria Luisa Dalla Chiara and Gian Carlo Ghirardi, eds. 1992. *Bridging the Gap: Philosophy, Mathematics and Physics*. Dordrecht, The Netherlands: Kluwer.

Da Costa, Newton et al. 1999. Aspects of Paraconsistent Logic. *Bulletin of the IGPL* 3: 597–614.

Hoffmann, Roald. 1995. *The Same and Not the Same*. New York: Columbia University Press.

Ioan, Petru. 1999. Stéphane Lupasco et la propension vers le contradictoire dans la logique roumaine. In *Stéphane Lupasco; L'homme et l'œuvre*, eds. H. Badescu and B. Nicolescu. Monaco: Éditions du Rocher.

McGinnis, Casey. 2006. Semi-Paraconsistent Deontic Logic. In *Paraconsistency with No Frontiers*, eds. J.-Y. Béziau and W. A. Carnielli. Amsterdam: North-Holland.

Penrose, Roger. 1991. The Mass of the Classical Vacuum. In *The Philosophy of Vacuum*, S. Saunders and H. R. Brown. Oxford: Clarendon.

Petitot-Cocorda. 1992. *Physique du Sens*. Paris: CNRS ÉDITIONS.

Quine, W. V. 1986. *Philosophy of Logic, 2nd Edition.* Cambridge, Mass.: Harvard University Press.

Volken, Henri. 1997. Le statut logique de la contradiction: l'approche paraconsistente. In *Introduction aux Logiques Non Classiques*, Vol. 11, ed. D. Miéville. Neuchâtel: University of Neuchâtel, Centre de Recherches Sémiologiques, pp. 257–271.

APPENDIX 1 CLASSES AND SETS: THE AXIOM OF CHOICE[1]

1. THE LOGIC OF FROZEN DIALECTICS

The aspects of the LIR theory that I will discuss in this appendix derive from the concept of the operation of implication as a dynamic process, cf. Chapter 2, whose elements follow the axioms **LIR 2**, **3** and **5** of Conditional Contradiction, Included Middle and Functional Association. Returning to the two-element notation **e** and **u** used in the Classification Table for Connectives (Section 2.4.1), I will now show that these elements are themselves implications.

Where **e** actually implies **u**, this implies that non-implication is potentialized. Thus two elements are always linked either by positive implication (standard) or by negative implication, **e** is not the antecedent of **u**. Since neither of these situations, by axiom **LIR6** of Asymptoticity is ever complete, this means that, essentially, for any two elements or events that appear to coexist without a relation between them, some link can be found. This is a formal way of saying that everything in the world depends in some way on everything else. What constitutes the relations are positive and negative implications, one more or less actual and the other more or less potential, and *vice versa*.

The critical next step in this approach is to see that the co-instantiation of an actual positive implication or a potential negative implication, its inverse, or the contradictorial T-state, implication positive and negative equally actual and potential, constitutes a conjunction, an event or element in reality.

$$\copyright\!\!\ll [(\supset_{A}) \supset (\bar{\supset}_{P})] \vee [(\bar{\supset}_{A}) \supset (\supset_{P})] \vee [(\supset_{T}) \supset (\bar{\supset}_{T})] \;\; \overline{\circledR} \supset (e,u)$$

(App. 1.1)

The existence of these elements is a consequence of the axioms of LIR and can be seen as temporary arrest or interruptions in the dynamics due to the discontinuity of the change from actual to potential, waiting, so to speak, for the right statistical conditions (‘frozen dialectic’). The subsequent change can be seen

[1] See Lupasco 1987.

as a dialectical *disjunction*, and thus the element or event is both the point of arrival and of departure of an actual positive implication and a potential negative implication or *vice versa*.

Thus, in contrast to classical logic, with separate and strictly actualized elements, the elements in LIR are sets of implications. If **e** and **u** represent two such sets, frozen dialectically, the first positive implication $\supset_A$ in the formula $(e \supset_A u)$ in turn plays the role of a new element, **m**, that encompasses the elements **e** and **u**. As a certain relative positive implication, with a compound actual identity, it appears as a *synthesis* of **e** and **u**, as a class that contains the classes these elements represent.

$$\text{©}\ [(e \supset_A u) \supset_A (e \overline{\supset}_P)u] \supset_A [(e \supset_A u) \overline{\supset}_P (e \overline{\supset}_P u)] \quad \overline{\circledR} \supset_A \text{©}\ [(\text{etc.}\ldots$$

(App. 1.2)

The next positive implication produces new elements, **n**, that are syntheses of syntheses and so on. In these syntheses are always present, in a more or less potential states, negative implications represented by the formula $(e \overline{\supset}_A u)$. These will also present themselves as elements but unusual ones from the point of view of classical logic. These elements are links but negative ones, an actualization of diversity, a ‘backward’ or negative synthesis. In reality, they multiply diversities, and can be denoted by $\overline{m}_P$ and $\overline{n}_P$, negative elements and negative classes. Applying the same reasoning to the T-states yields elements $\mathbf{m}_T$ that are equivalent, contradictorial syntheses or classes thereof.

The contrast with the Hegelian system referred to in Section 6.8 can now be seen more formally: to the dialectic ortho-deduction of positive syntheses of positive syntheses, the ‘branch’ of the tree that Hegel saw, is opposed, also dialectically, the ortho-deduction of negative syntheses of negative syntheses, that is, the concatenation of negative implications of negative implications, where each negative implication, when ‘frozen’ as above, characterizes a negative notion or concept.

$$\text{©}\ [(e \overline{\supset}_A u) \overline{\supset}_A (e \supset_P)u] \overline{\supset}_A [(e \overline{\supset}_A u) \supset_P (e \supset_P u)] \quad \overline{\circledR} \overline{\supset}_A \text{©}\ [(\text{etc.}\ldots$$

(App. 1.3)

Combining these concepts and symbolizing the inclusion that is carried out by implication of implication by **(** I write:

$$
\begin{aligned}
&e_A \bullet \bar{e}_P (m_A \bullet \bar{m}_P (n_A \bullet \bar{n}_P \ldots\ldots \\
&\bar{e}_A \bullet e_P (\bar{m}_A \bullet m_P (\bar{n}_A \bullet n_P \ldots\ldots \\
&e_T \bullet \bar{e}_T (m_T \bullet \bar{m}_T (n_T \bullet \bar{n}_T \ldots\ldots
\end{aligned}
\qquad \text{(App. 1.4)}
$$

In this conception, all these implications of implications constitute, form and operate on sets of sets (*ensembles d'ensembles*). But these sets of sets of ortho-deductions also have the aspects of classes. In classical logic, the distinction is made as follows: a class is a union of elements that are substantially identical and everything that might distinguish the elements from one another is set aside. A set is a union that can contain all kinds of elements, although they have to be 'things' in order to constitute a set. There is only a difference of degree in the principle of inclusion between a set and a class. Using Lupasco's tables of deductions, a functional difference appears: classes are sets generated by implications of implications of ortho-deductions. Positive ortho-deduction enhances, in the element-sets formed by dialectical freezing or 'arrest', identity actualized by its positive implications and potentializes the differentiation of the same elements that they possess due to negative implications. In LIR, both a class and its elements are dualistic; a class is always the contradictional conjunction of a positive and negative class.

The classical logic of classes takes into account only the identity of its elements. First, from the subject, and then from the class, is taken away everything making it less extensive, until one arrives, from species to genera, following an Aristotelian hierarchy, to a final kind where there is nothing but a pure identity – a void in LIR. The critical concept, here as elsewhere, is that there is a progressive identification, but at the same time the potentialization of a growing differentiation. The negative class accompanies, transfinitely, the positive class.

Negative ortho-deduction forms an inverse series of classes of classes, with the same dynamics. In classical logic, the negative class was subsumed under appellations like logic of intension or inherence, or qualitative logic. The thought process involved consisted of ascribing quality or diversity to the subject, as a passive recipient. But in the absence of a proper concept of subject and object, the former would be defined as an identity, and the rest, the elements of diversity, as modes of being or accidents of substance. An advantage of LIR is that it gives the proper metaphysical foundation to the flow of diversities, as a negative class, but one that is neither totally separated nor separable from the positive class.

The third contradictorial series of classes of classes, in which the values of the antagonistic classes are T-states, are classes of classes that are contradictions of contradictions, contradictory complexes of contradictory complexes. But these are in fact the states of affairs prevailing at the quantum level and in psychological and esthetic experience. I then write, even more generally than before, using the symbol < for inclusion of one class in another:

$$
\begin{array}{l}
(A_m \,\overline{(}P_{\bar{m}} < (A_n \,\overline{(}P_{\bar{n}} \ldots\ldots \\
\overline{(}A_{\bar{m}} (P_m < \overline{(}A_{\bar{n}} (P_n \ldots\ldots \\
(T_m \,\overline{(}T_{\bar{m}} < (T_n \,\overline{(}T_{\bar{n}} \ldots\ldots
\end{array}
\qquad \text{(App. 1.5)}
$$

This notation specifies that elements are, also, classes, since they are operations, as classes, that generate the operation that is implication. As Lupasco put it:

> In our experience is there any element that can be conceived of or lived other than as a class? When I speak of a table, of tables, I distinguish this object as such, only as a member of a class of such objects: the class of tables. When I speak of this particular table (which in all its detail) appears to me as a veritable element, I appeal to what we have precisely named the negative class of tables, that in which the identity of the class of tables is more or less potentialized by the actualization of the differentiation, of the diversification of the class of tables, that form a set of diversities and constitute thereby the negative class of tables.

One never leaves the domain of logical functions imposed and explicated by the logic of contradiction, of the contradictory.

> What is called the particular, the individual, by opposition to the universal and general, is never grasped, as such, as an element, rigorously actualized and accordingly independent and absolute. It is only, in its turn, a class, the negative class that is contradictory and antagonistic to the positive class; but our understanding, formed by classical logic, looks only toward the positive class, in which identity is confounded with the class.

For classical thought, everything outside of relations of identity is outside the notion of class, of logic, and even of science. In this conception, the relations of identity and diversity in some form accompany every object, process, relation or operation and confer on them their dynamic existentiality.

2. THE AXIOM OF CHOICE

The Axiom of Choice refers to a function *f* for any set A that includes in its domain every non-empty subset of A and selects (chooses) exactly one element from each subset. This axiom was first introduced by Zermelo to prove that sets can be well-ordered, and it has subsequently been used, not without controversy, to solve problems in set and number theory (Suppes 1972). The relation to current logic and philosophy is a consequence of the implications of the axiom for completeness, continuity and demonstrability of mathematics in view of Gödel's incompleteness theorems (Longo 1999).

Priest (2001) showed that his Logic of Paradox (LP) can be used, among other things, to produce a paraconsistent set theory that provides a picture of the "set-theoretic universe". The universe contains all sets, consistent ones and inconsistent ones, i.e., those giving rise to set-theoretic paradoxes. Nothing here establishes, however, that such paradoxes could or could not be resolved at some higher level; in this interpretation, in my view, one simply oscillates from one term to the other. Priest shows that proofs in the metatheory of relevant paraconsistent logics, even if they use essentially classical reasoning, can be interpreted as establishing their results in a way that is acceptable in these logics. In particular the orthodox set theory of Zermelo-Frankel can be subsumed by paraconsistent set theory.

In 1951, Lupasco mentioned a project (Lupasco 1987), unfortunately never realized, for a contradictorial set theory, based on the PDO and the logic of the included middle. He did show, however, that the Axiom of Choice, which he considered a difficult problem for classical logic, was a natural illustration of such a set theory. As noted above, the key insight, which at the same time illustrates the fundamental difference between LIR and all other classical or non-classical logics, is that each element of a set is a contradictory duality, composed of an element and its anti-element, such that the former expresses primarily an actualized identity and potentialized diversity (or non-identity) and the second the contradictory picture of diversity and identity. Since sets, as well as elements, must be accompanied by their contradictories, the LIR system described above results in the existence of three related sets. One of these sets is the set M of Zermelo, in which the identity of the elements is actualized and the diversity of the elements is potentialized; one, of maximum contradiction (T-state) which forms sub-sets whose elements are characterized by both identity and diversity – the set P of Zermelo; and the third which is *exactly the set N* – that of choice, in which diversity is actualized and identity potentialized. This is why it can, and must, contain one element and one element only of each of the sets in P (otherwise, if more than one, it would be equivalent to a partial actualization of identity). It is the principle of non-identity, absent in classical logic, but here given its correct place in the scheme of things, which makes possible this result. Lupasco also noted the analogy with the Pauli Exclusion Principle (which partly inspired this approach), which standard logic seems to pay little attention to. The objection that the Axiom of Choice deals with infinite sets and the physical Pauli Principle with, necessarily, finite ones is not valid since the principal quantum number of a particle can be a whole number with values from one to infinity, and that it is the contradictory logical structure of the Axiom of Choice and the Pauli Principle that is the same. This view of the Axiom of Choice should indicate that the LIR could be applied to other mathematical as well as non-mathematical problems.

References

Longo, Giuseppe. 1999. The Mathematical Continuum. In *Naturalizing Phenomenology. Issues in Contemporary Phenomenology and Cognitive Science*, eds. J. Petitot et al. Stanford: Stanford University Press.
Lupasco, Stéphane. 1987. *Le principe d'antagonisme et la logique de l'énergie.* Paris: Editions du Rocher (originally published in Paris: Éditions Hermann, 1951).
Priest, Graham. 2001. Paraconsistent Belief Revision. *Theoria* 01: 214.
Suppes, Patrick. 1972. *Axiomatic Set Theory*. New York: Dover.

APPENDIX 2 THE SYSTEMS VIEWPOINT

1. THE ONTOLOGICAL BASIS OF SYSTEMS IN REALITY

To further illustrate the thesis of this book, another ontological approach to reality can be described that starts from its simplest aspects, the existence of more than one thing, of many things and of their collection in more or less stable groups or systems. I will define systems as elements linked by either some internal property, or by the forces or operations that they express of which they are or could be the agents. From the dynamic view of reality discussed here, the appearance of a principle of contradiction (or its equivalent) in this line of argument, that is similar to the one derived from considerations of the dualistic aspects of energy as such, supports the idea that there is something of fundamental theoretical importance about contradiction or antagonism, physical dynamic opposition, throughout nature.

1.1 The Relation of Antagonism

The first axiomatic statement to be made, that determines the possibility of all systems, is the following: systems are not possible if there is no force of repulsion or exclusion between elements which prevents their "agglomeration" into an undifferentiated mass, and not possible if nothing attracts or associates two or more elements; they all fly apart, so to speak. (I consider here that repulsion; exclusion and dissociation are equivalent terms.) Accordingly, for a system to form and exist, its constituents, by their nature expressed in the laws that govern them, must be able, at the same time, to both attract and repel one another, associate and dissociate, to integrate and disintegrate. Every system is therefore a function of two antagonistic forces, linked to one another, constituting a relation of antagonism (Lupasco 1986). In Lupasco's notation, a system s is a function of the relation of antagonism $\overleftrightarrow{R}$ that is a function of two antagonistic dynamisms, d, that can in principle be measured and quantified, given an adequate algorithm, in a quantity of antagonism, Q, as follows:

$$s = f\left(\overleftrightarrow{R}\right) = f(d\ \overline{d}) \qquad \text{(App. 2.1)}$$

$$\overleftrightarrow{Q} = d\ \overline{d} \tag{App. 2.2}$$

This quantity is a maximum when d and $\overline{d}$ are equal. One can also say that this quantity measures the dynamics of the system. Every system, be it nuclear, atomic, molecular or at the level of the macroscopic objects of our senses is always, in this view, a function of, in its constitution, this relation of antagonistic or opposing forces. Systems which tend towards an equality of tension, such as the nucleus of an atom, will be more stable and resistant to disintegration than those in which one of the dynamisms is heavily favored over the other.

1.2 The Relation of Contradiction

The second axiomatic determination has a form of argument similar to the first: a system would not be possible if all its constituents or elements were strictly identical, strictly also meaning with relation to their location and configuration in space-time. They would be "confounded" in the same continuity or homogeneity. No system would be possible, either, if all elements were totally heterogeneous, without some degree of homogeneity that would prevent this diversity not only from not being a system, but even a class or set.

Every system thus implies at the same time homogeneity and heterogeneity. One can therefore write equation (App. 2.3), where i stands for identity, homogeneity or the capacity for positive entropy and $\overline{i}$ for heterogeneity, diversity or the capacity for negentropy or negative entropy, in which these two coefficients are mutually defined by a *relation of contradiction*, C, due to the existence in the same element of logical identity and non-identity:

$$s = f\left[(d\overline{d})(i\overline{i})\right] = f(\overleftrightarrow{Q}.C\overline{C}) \tag{App. 2.3}$$

The relation of contradiction is maximal as identity and diversity approach equality. The relation of non-contradiction thus depends on the levels of both antagonism and identity. As antagonism decreases, non-contradiction increases and contradiction decreases. But for the point of maximum contradiction, we have equation (App. 2.4):

$$\overleftrightarrow{Q}_{\max} = s = f\left[(d = \overline{d}).(i = \overline{i})\right] = f(C_{\max}.\overline{C} = 0) \qquad \text{(App. 2.4)}$$

The inverse relation, where $C = 0$, is impossible in this theory.

1.3 The Principle of Antagonism Applied to Energy

The third axiomatic determination, which places some previous notions in the systems context, is based on the concept that every system *requires* the energy involved in its dynamic relations in order to exist. All its constituents and elements, according to the equivalence of mass, energy and information, must consist of energy,[1] as I have already suggested. Lupasco developed his "logical algebra of energy" as a chain of implications expressing the above, with the addition of another key concept. Every energy (or phenomenon) passing from a potential state to an actual state finds itself necessarily, at a certain moment in an intermediate state T, called the T-state, where it conflicts with the antagonistic energy passing from a state of actualization A to one of potentialization P, which can be summarized as follows (cf. also Chapter 2):

$$e_A \supset \overline{e}_P, e_T \supset \overline{e}_T, \overline{e}_A \supset e_P \qquad \text{(App. 2.5)}$$

Each of these three elements is an antagonistic energetic duality or alternatively an antagonistic conjunction. Each is a system, and all more complex systems are generated by such antagonistic dynamisms. One can therefore replace, in the systems formulas above, the *d* values by the values of the element *e*, adding, to the coefficients of homogeniety and heterogeneity, those of the states of A, P and T. Simple substitution shows that two of these three types of system imply a progressive actualization of non-contradiction, and the third an actualization of contradiction and potentialization of non-contradiction.

These logical systems of energy apply to all phenomena or aspects of experience, from microscopic to macroscopic, if it is agreed that antagonism and contradictory values are irreducibly constitutive of all real events. Their validity is experimental, and their logic is a logic of antagonism. These logical systems are the basis for the generation of systems of systems, formally, by the extension of the concept of actualization, potentialization and T-state to the operation of implication itself as used above. The corresponding three systems *S* of implication are the following:

[1] The exceptions are the elements of classical mathematics and all other abstract elements, including semantic elements, such as paradoxical sentences, in which the quantity of energetic interaction is nil.

$$
\begin{aligned}
&s(\supset_A \;\supset\; \bar{\supset}_P),\\
&s(\supset_T \;\supset\; \bar{\supset}_T),\\
&s(\bar{\supset}_A \;\supset\; \supset_P)
\end{aligned}
\qquad \text{(App. 2.6)}
$$

The first of these corresponds to progressive homogenization, i.e., the 2nd Law of Thermodynamics, the second to the progressive actualization of heterogeneity, a "systemogenesis" of living matter or life, and the third to the situation of maximum contradiction applying to both the quantum and mental levels of reality. Finally, all these chains of systems and systems of systems can be considered as constituting dialectics and dialectics of dialectics, generated by the contradictory nature of energy and its principles as outlined above.

2. CYBERNETICS AND SYSTEMS THEORY

2.1 Feedback

As noted in Section 8.8.2, any cybernetic system (Lupasco 1979) has the capacity for *feedback* (in English in Lupasco's text), for "counter-action". Examples of biological cybernetic systems are consciousness and immunological recognition. The appearance or actualization of the perturbation or disturbance is preceded by the potentiality of the perturbation trying to become actual. The potentiality is the information that potentializes the normal (probabilistic) functioning of the system and provokes the subsequent and consequent actualization of the re-equilibration or regulation of it.[2]

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[2] Lupasco's description of the key aspects of feedback went as follows:

1. To enable a system to be constituted, it is indispensable that energy can turn against itself, that it implies the possibility of feedback to equilibrate certain forces by others that oppose them, which must be structurally and functionally capable of that opposition.
2. Especially in biological systems, all equilibria involve retroaction by antagonism, cybernetics or feedback.

It is the quantity of energy as information available, acting as a signal, triggering the feedback, which corrects imbalances in the system (cf. Aerts' "switching regime" for sudden transitions).

This information can be identified with the cybernetic operation (in its well-known original sense of governing or steering) of a need (lack) or surfeit, a potentiality that the system senses. "The content of every potentiality is an energetic state which contains what is going to be actualized." In this sense, every cybernetics, natural or artificial, is a dialectics, since every cybernetics involves an alteration, a perturbation by an antithetical contradictory aggression, followed by the return to the (state of) regulation that must prevail for the system to be "stable". (In Chapter 8, I examined the relationship to this process of the dynamic structuralism or catastrophe theory of Thom and Petitot.)[3] In other words, a cybernetics alternately actualizes certain phenomena and potentializes the antagonistic, contradictory phenomena in consequence.

Following the methodology of LIR, one should differentiate between a cybernetics of physical systems, characterized by a return to a relative identity, a constant value, an invariance, a homogeneity and a biological cybernetics which operates or results predominantly in a variance, a heterogeneity. This return by feedback to a homo- or heterogeneity is equivalent to a return to a progressive relative, partial non-contradiction in the two cases. In the dialectics of quantum or psychic phenomena, we have a third dialectic cybernetics, in which feedback leads to the semi-actualization and semi-potentialization of the two terms in the T-state of the included middle.

Pattee discusses feedback in the category of causal loops that include material systems such as autocatalytic cycles, and oscillators and cognitive processes such as introspection (Pattee 2000). In my view, all of these could be subsumed under the concept of cybernetic systems as defined. Pattee's specific form of self-reference applies to a *closure* relation between both the material and symbolic aspects of, in particular, living organisms, as discussed in Chapter 8.

2.2 General Systems Theory

Von Bertalanffy deserves the credit for taking various global theories, involving physical, biological and social sciences and proposing something that was intended to go radically beyond them. In his General Systems approach (General Systems Theory, GST), based on his fundamental research in biology and embryology, he proposed that the only meaningful way to study organization was to study it as a system. Like the logic of/in reality discussed here, the necessity and

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3 Lupasco's ideas about control and cybernetics were formulated in the period 1950 to 1970, and obviously can be related to those of Weiner, Shannon, von Bertalanffy and other early systems theorists. Nicolescu has called for a transdisciplinary "systemic methodology" to help bridge the differences in the different scientific foundations and systemic approaches of these and other workers.

potential feasibility of the systems approach was recognized only after the developments in theoretical physics and mathematics of the mid-20th century, despite the fact that they cannot be fully formulated mathematically.

Above all, von Bertalanffy saw both the physical and biological world as a play of energies and a flow of processes. There are clearly models, principles and laws that apply to generalized systems and sub-systems, irrespective of their particular kind, the nature of their component elements or the relations or forces between them (von Bertalanffy 1969). GST was to be a new discipline whose subject matter was the formulation and derivation of such principles that were valid for systems in general. He defined systems simply as "complexes of elements standing in interaction." GST was supposed to be capable of giving exact definitions of and even quantifying complex concepts. It gives a good basis for distinguishing between logical homology[4] as explanation, based on isomorphism in science, as opposed to analogy or metaphor. Von Bertalanffy provides a justification for an empirical intuitive approach to systems studies in contrast to the "top-down" mechanistic model of Ashby, which starts from an abstract concept of all conceivable systems, much as the Jacquette model starts from the combination of all (classically) logically possible consistent states-of-affairs.

Von Bertalanffy also made a Critique of Kantian absolutist conceptions in his statement that the categories of perception as determined by the biophysiological organization of the species cannot be completely fortuitous and arbitrary. "Rather they must, in a certain way and to a certain extent, correspond to "reality" – whatever this means in a metaphysical sense." Later, he suggests that "in a certain way" means that a certain degree of isomorphism exists between the experienced world (and its categories) and the "real" world. He did see the basis of the whole in a competition or struggle between its parts. This is an expression of the *coincidentia oppositorum* that reality presents, but no explanation is proposed for it. Without an appropriate concept of a dynamic relation between whole and part, von Bertalanffy is led to statements such as "Progress is only possible by passing from a state of undifferentiated wholeness to differentiation of parts." He imagines that systems can be split up into "independent causal chains", with the result that regulability disappears and partial processes go on irrespective of each other. This concept is in direct contradiction to my view that it is the fundamental dualism of any system that guarantees its (relative) stability. Von Bertalanffy was correct in saying that GST raised new problems in science in non-physical fields, although I disagree with his formulation of these problems as metaphysical *or* vitalist.

The problems with GST, however, emerged very early in von Bertalannfy's treatment: he stated that his "science of wholeness" should be a formal logico-mathematical discipline based essentially on the equations of differential calculus. But what logic does he have in mind? Where is the system of logico-

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[4] Homologies are defined as situations in which the efficient factors are different, but the relevant laws are formally 'identical'.

mathematical laws he would like to apply, and what is his guarantee that differential calculus can apply to real phenomena? True, he did say that the 'all-or-none' concepts of traditional logic fall short of continuity concepts basic for mathematical analysis, but he saw their origin in the structure of our central nervous system as a digital computer. This is the origin of our bivalent yes-or-no logic, thinking in terms of opposites and why "our mental representation of the universe always mirrors only certain aspects or perspectives of reality." He saw that this way of thinking, of occidental physics, could not handle problems of wholeness or form and thus, especially in biology, was a "tremendous embarrassment" to physics.

Nevertheless, confirming my view of the isomorphism between microphysical and mental levels of reality, von Bertalannfy suggested that: "The contrast between structure and process breaks down in the atom as well as in the living organism whose structure is at the same time the expression and the bearer of a continuous flow of matter and energy. Perhaps the age-old problem of body and mind is of a similar nature, these being different aspects, wrongly hypostatized, of one and the same reality."

2.3 The Neuchâtel Model

Schwarz (1997) has presented a succinct summary of the development of systems theories, starting with GST. Schwarz suggests that if cybernetics is based on a category of Relation, GST introduced a System (or Whole) as another basic category. However, although GST was able to show that vitalist transcendent ingredients were not necessary to understand the appearance and evolution of life, it did not propose mechanisms for the 'spontaneous' emergence of order in nature. Concomitant work by Prigogine and his school is well known (Prigogine and Stengers 1984). As I have noted and Schwarz also points out, Prigogine contributed to the understanding of living and other complex systems as emergent *dissipative structures*, far from equilibrium, to which classical determinism did not apply. However, the availability of energy cannot by itself provide an explication of morphogenesis. The next series of developments in the theory of self-organizing systems, dynamical systems theory, non-linear dynamics or chaos theory will not be discussed here. In my terminology, these approaches can be seen as attempting to break the bonds of a classical logic of identity by giving adequate foundational philosophic value to the diversity inherent in living systems. Unfortunately, due to the absence of an appropriate development, in these authors, of the dynamic relationship in the *feedback loop*, neither GST nor the concepts of Prigogine seemed to have fulfilled their early promise. Although von Bertalanffy's rejected all forms of absolutism in philosophy and science, he lacked a vision of logic that was broad enough to support this. His concept of a system saw antagonistic relations among the parts themselves, but not between the parts and the whole.

The further evolution of cybernetics, due to the generalizations by von Foerster toward second-order cybernetics, the cybernetics of observing systems and the elaboration of the notion of *autopoësis* (self-production) by Maturana and Varela have all led to substantial new insights into the "structure" of existence. Again, though, von Foerster, at the end of his life (Van de Vijver 1997), talked only of "circular causality" as a source of dynamic development and self-organization and did not, as pointed out by Schwarz (see below) propose mechanisms about the way spontaneous (sic) order can emerge in nature. The "Neuchâtel Model", proposed by Schwarz, places all these concepts, plus those of autogenesis (the self-production of rules of its production by an entity), in terms of planes (or levels) of structures, information and totality. Schwarz' model is useful in that objects and laws are not separated and do not appear to operate within the constraints of a static, binary Aristotelian logic, but form complex wholes which are existing (non-physical) entities. His ontology generates three basic epistemological categories for the study of natural objects: objects, relations and wholes. "Priority is not to conserved things (matter-energy) as in physics, nor to timeless non-contradictory statements as in binary logic, but to the permanent and ever-changing self-referential whole which is that which emerges from the ontological dialogue between objects and relations."

Schwarz considers his models as the "idealized patterns of a meta-language" which does not apply directly to concrete real-world systems, but rather represents the "production processes by which the systems of the world are made." LIR, in particular in its oppositional-energetic aspects, is intended to apply to the real world *directly*. Through the alternation of actualization and potentialization of a phenomenon and its opposite, one can give a reasonable basis for the dynamics of the whole, self-referential or not, to which Schwarz refers. Presuppositions of Aristotelian logic are still present in the static terms used in the following view of nature:

> In holistic approaches, …, where the world is not reduced to a problem of reality or non-reality, but where existence has two aspects, reality of things and validity of relations, the question of the mind-body connection is not a problem but the normal state of affairs. Mind and brain are the two aspects of a human being, like (sic) the laws of nature (the field of possibles) and the physical cosmos (the explicit actual) are the two aspects of the universe.

LIR provides an alternate view of the dichotomies that have been introduced into an otherwise holistic picture: there is a dynamic relation between the key pairs of opposites – things and relations and possible and actual. Mind and brain are, indeed, parts or aspects of an individual human being, and LIR gives a potential basis for understanding the way in which the three are related. In fact, relations are not relegated to a domain of non-reality (as if one was talking of abstract propositional logic, in which validity is the criterion of truth preservation). In LIR, the relations or interactions between terms are as important as the terms themselves.

2.4 Systems Science and Complex Systems

Systems science developed after GST from the interaction of information theory and cybernetics. One definition of systems science is the following[5]: "A new discipline that combines theoretical, practical and methodological approaches relative to research topics that are recognized as being too complex to be accessed in a reductionist fashion, and that pose problems of (1) boundaries, internal and external relations, structure and laws or emergent properties characterizing the system as such; and (2) modes of observation, representation and model building or simulation of a complex totality." The reader will recognize in this definition issues that have been addressed, in this book, in a logical fashion that hopefully is non-reductionist.

Systems science overlaps with complexity science, in that the latter is based on a definition of the complex systems that are the objects of systems science study, albeit from a less computational standpoint. A complex system is loosely defined as constructed by a large number of simple, mutually interacting parts, capable of exchanging stimuli with its environment and of adapting its internal structure as a consequence of such interaction. The non-linear interactions involved can give rise to coherent, emergent complex behavior with a rich structure. Key concepts in complexity science are, for example, the coexistence of diversity and stability, for which LIR provides an interpretation. Complexity science also looks at the dynamics of systems in transition regions of self-organized criticality. Schematic systems are used to investigate self-organization, but without the grounding in dynamic opposition and potentiality that I have proposed as necessary to explain the functioning of such organization, as well as the ambiguity in the particle 'self-'.

As stated at a Congress in 2005,[6] the major objective of systems science today is to provide a consensual, transdisciplinary approach to the increasingly complex problems faced by workers in all areas of society, with the laudable intention of 'placing man at the center of its preoccupations'. Models and strategies are designed to develop effective operational tools as well as conceptual and philosophical ones.

Systems science includes aspects of such a diversity of sciences and disciplines that makes it difficult to capture in a few words. One example is the science of ago-antagonist systems (SAAS), developed by Bernard-Weil, which bears as superficial resemblance to LIR. SAAS purports to identify and take into account, in concrete systems, pairs of elements that are both conflicting and cooperative, either at the same time or alternatively. As I have shown, it is necessary to specify more completely what is meant by 'at the same time' or 'alternatively' and

[5] French Association of the Science of Cybernetic, Cognitive and Technical Systems (*AFSCET*), 1994.

[6] 6th European Systems Science Congress, Paris, September 19–22, 2005.

to look for the origins of both conflict and cooperation in the potentialities of the systems' elements.

This theory, like many others in systems science, has practical applications as a step in understanding the role of pairs of antagonists in living cells, the human body, business enterprises, etc. Looking at the two areas of systems science and complexity science together, I conclude that there could be many applications to them of the more formal and physical approach to systems suggested in this book.

References

Lupasco, Stéphane. 1979. *L'univers psychique*. Paris: Denoël/Gonthier.

Lupasco, Stéphane. 1986. *L'énergie et la matière vivante.* Monaco: Éditions du Rocher (originally published in Paris: Julliard, 1962).

Pattee, Howard H. 2000. Causation, Control and the Evolution of Complexity. In *Downward Causation*, eds. P. B. Anderson et al. Aarhus, Denmark: Aarhus University Press.

Prigogine, Ilya and Isabel Stengers. 1984. *Order out of Chaos.* New York: Bantam Books.

Schwarz, Eric. 1997. Toward a Holistic Cybernetics; From Science Through Epistemology to Being. *Cybernetics and Human Knowing* 4: 17–50.

Van de Vijver, Gertrudis. 1997. Conversation with Heinz von Foerster 02/06/1995. *Cybernetics and Human Knowing* 4: 3–16.

Von Bertalanffy, Ludwig. 1969. *General System Theory*. New York: George Braziller.

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