A Cure For Metaphysical Illusions

Kant, Quantum Mechanics, and the Madhyamaka

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1-Introduction

My purpose in this paper is to show that the transcendental approach, first formulated by Kant, and then elaborated by generations of neo-Kantian thinkers and phenomenologists, provides Buddhism in its highest intellectual achievement with a natural *philosophy of science*. I take this highest achievement to be the Madhyamaka dialectic and soteriology[1], which was developed in India from the second century C.E. to the seventh century C.E. by masters such as Nagarjuna, Aryadeva, and Candrakirti.

Yet, I am aware that we are likely to meet obstacles in the course of this attempt at establishing a threefold relation between science (especially modern physics), transcendental philosophy, and Madhyamaka Buddhism. Every possible mutual relation between these three terms has been studied in the recent past, and each one of them has raised serious doubts. My preliminary task, in sections 2, 3, 4, is therefore to locate the obstacles. Then, in section 5, I suggest a promising way to overcome these obstacles. In sections 6, 7, 8, I use the ideas developed in section 5 to give three examples of a possible synergy between a neo-Kantian philosophy of science and the Madhyamaka. One example concerns reifications in particle physics, another one develops the dialectic of determinism and indeterminism in various readings of the quantum theory, and the last one deals explicitly with the concept of *relation* in quantum mechanics.

2-Kant, Modern Physics and the Madhyamaka: Three Difficulties for a Comparison

To begin with, what are the obstacles?

Firstly, the relevance of Kant's philosophy for modern physics has repeatedly been challenged during the first half of the twentieth century, by the very creators of the new theories. According to Kant, space, time, causality etc. are "forms" imposed in advance by our sensibility and understanding onto the "matter" of sensations. These forms are supposed to hold true "for all times and for all rational beings"[2]. But modern physics has undermined this invariability clause. According to Einstein, General Relativity has jeopardized an important aspect of Kant's *a priori* forms of sensibility (space and time), and according to Heisenberg, quantum mechanics has shown the lack of universality of Kant's *a priori* forms of thought (the categories of substance

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[1] A soteriology is a doctrine of salvation ("soteria" means salvation in ancient Greek).
I take the opportunity of this explanatory footnote to thank Rachel Zahn for her careful reading of this paper, and for helping me to adapt it to a broader audience.

[2] S. Körner, Introduction to E. Cassirer, *Kant's life and thought,* Yale University Press, 1981, p. XI

and causality). A large majority of philosophers of science currently accept these claims. Following the pioneering work of M. Schlick, E. Meyerson, and H. Reichenbach in the 1920s, they thus agree that most features of Kant's original *a priori* forms are outmoded, or at least that their validity is restricted to the cognitive ordering of the local mesoscopic[3] environment of humanity. Moreover, these philosphers implicitly consider that this failure of Kant's original philosophy of physics condemns any renewed transcendental approach of modern physics.

Secondly, a huge amount of work has been done in order to draw parallels between the most striking features of modern physics and several trends of Eastern thought, including the Madhyamaka. But a high proportion of this work (i.e. F. Capra's, M. Talbot's, or even D. Bohm's) was disparaged by the academic world at the very time it was arousing a large popular interest. Undoubtedly, part of this academic discredit was due to an overestimation of science as the only acceptable source of truth. Another part of it expressed a misapprehension of the high rational standards of many schools of Eastern philosophy (especially the Madhyamaka), which triggered a spurious fear of "obscurantism." But there were also good reasons to distrust the most popular parallels between science and Eastern philosophies. One of these reasons was the poor *methodological background* of the attempted comparisons. No systematic assessment of the difference of status between the two terms to be compared was made, no discrimination of the points on which the confrontation between physics and Eastern spiritualities do or do not make sense was undertaken, and no clear idea of what can or cannot be expected from the comparison emerged. With a few recent and remarkable exceptions[4], this type of reflexion thus resulted in little more than mere analogy at an ill-defined level of the two discourses, with obvious apologetic purposes.

Thirdly, T.R.V. Murti[5] already proposed, years ago, a Kantian reading of Madhyamaka thought. But this reading raised a series of sound objections which were remarkably expressed by J. May[6], and by other authors[7]. I will elaborate on this problem in the two following sections, for it has been less documented than the former ones. But readers who are more interested by solutions than by problems can perfectly well skip sections 3 and 4. After all, the aim of this paper is to undo some conceptual knots of our current belief system; it is not to indulge in philosophical technicalities.

3-Kant and the Madhyamaka: some similarities

The manifest resemblance between Kant's critical philosophy and the Madhyamaka system bear on at least four points:

(1) The Madhyamaka is intended, even etymologically, as a *middle way* between absolutism and nihilism, that is, between the view of an absolute self-subsisting reality and the view of no

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[3] The mesoscopic scale is intermediate between the true (cosmological) macroscopic scale and the (atomic and subatomic) microscopic scale.

[4] B.A. Wallace, *Choosing reality: A Buddhist View of Physics and the Mind*. Snow Lion, 1996.

[5] T.R.V. Murti, *The Central Philosophy of Buddhism,* Allen & Unwin, 1955; also M. Sprung, "The Madhyamaka Doctrine of Two Realities as a Metaphysic", in: M. Sprung (ed.), *The Problem of Two Truths in Buddhism and Vedanta,* D. Reidel, 1973. An early parallel between Kant and Dharmakirti's logic (with some references to the Madhyamaka) can also be found in T. Stcherbatsky, *Buddhist Logic,* Reprint: Motilal Banarsidass, 1994

[6] J. May, "Kant et le Madhyamaka, A propos d'un livre récent", *Indo-Iranian Journal,* III, 102-111, 1959

[7] e.g. J. Garfield, *The fundamental wisdom of the middle way,* Oxford University Press, 1995, p. 305-306 (footnote 119).

reality. Due to its insistance on holding no view about reality[8], it was wrongly accused of holding a no-reality view.

Similarly, Kant's transcendental philosophy was construed from the outset as a middle way between dogmatic rationalism (which tends to identify the ideas of reason with absolute realities), and sceptical empiricism (which radically challenges the claim of reason in regard to the possibility of gaining anything like objective knowledge). Due to his strong criticism of dogmatic transcendent realism, Kant was wrongly accused of defending a form of subjective idealism.

(2) The Madhyamaka and the philosophy of Kant both involve an analysis of the dialectic of reason. On the one side, Nagarjuna undertakes a systematic rejection of all opposing metaphysical views either by a form of logical *reductio ad absurdum* or by pointing out an absence of empirical proof[9]. On the other side, Kant develops an analysis of the internal conflicts of pure reason, which culminate in the so-called "antinomies."

At a more detailed level, one may notice a striking equivalence between (i) Kant's first cosmological antinomy, and (ii) Nagarjuna's symmetric rejection of the view that the world is limited, and of the view that the world is unlimited[10]. Even the ways in which Kant and Nagarjuna explain the antinomic character of any assertion about the world taken as a whole, are surprisingly close to one another. Kant insists that since cosmological questions bear on an ideal absolute totality, namely on a closed and static entity called "the universe," they transgress the bounds of human experience. Indeed, for human beings, significant questions can concern only the open series of phenomena and the unended progress of knowledge tending towards a synthesis[11]. As for Nagarjuna, he similarly suggests that the reason why neither the finitude nor the infinitude of the world as a whole make sense is that the world should not be construed as a single absolute entity of which something can be significantly predicated. If anything, the world should rather be construed as an indefinite "series of flickering events"[12] compared to the flame of a butterlamp.

(3) Kant restricts the validity of the concepts of our pure understanding, such as the category of substance or causality, to the formal ordering of the empirical contents; he also restricts the validity of the ideas of our reason to a "regulative" use, namely to providing us with an unaccessible goal (a *focus imaginarius)* which motivates the unended process of ordering of the phenomena. If we do not recognize these restrictions, we can easily mistake the form given by our intellectual faculties to the phenomena for the form of the things in themselves. We take the risk of projecting the *a priori* structure of the knowing subject onto the world, thus mistaking it for a pre-given worldly structure. This confusion defines what Kant calls the "transcendental illusion" which, unlike the ordinary empirical illusions, is all-pervasive and extremely difficult to recognize and to compensate for.

On the other hand, unlike subjective idealists, Kant accepts that our senses are affected by an "external" thing in itself taken as an absolute reality. He often explains that the *ground* of phenomena has to be found beyond the immanence of the phenomena in a "transcendental

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[8] See K. Bhattacharya, *The dialectical method of Nagarjuna (translation and comment of Nagarjuna's Vigrahavyavartani),* Motilal Banarsidass, 1998

[9] See G. Bugault, "Logique et dialectique chez Aristote et chez Nagarjuna", in: G. Bugault, *L'Inde pense-t-elle?,* Presses Universitaires de France, 1994, p. 260

[10] Nagarjuna, Mulamadhyamakakarika, XXVII, 21, in: J. Garfield, *The fundamental wisdom of the middle way,* op. cit. p. 350; or in: D. J. Kalupahana, *Mulamadhyamakakarika of Nagarjuna,* Motilal Banarsidass, 1986, p. 387

[11] I. Kant, *Critique of Pure Reason,* A479-B507

[12] J. Garfield, *The fundamental wisdom of the middle way,* op. cit. p. 350-351; comments on Nagarjuna, Mulamadhyamakakarika, XXVII, 22.

object"[13]. But this affecting *thing in itself,* this ground of phenomena, is, by definition, beyond any possibility of knowledge; it can but be for us a *noumenon,* a purely intelligible reality whose epistemological function is to be formally opposed to phenomena.

T.R.V. Murti then displays some analog features of the Madhyamaka system. He insists that, in the Madhyamaka as in Kant's philosophy, "causality is of empirical validity only"[14]; that causality is not (and cannot be) a process of substantial production giving rise to an intrinsinc being out of another intrinsic being. Moreover, whereas the Madhyamaka invites us to accept bodily forms as part of an empirical reality, it rejects them at the same time as not ultimate, not absolute[15].

The basic illusion, in the Madhyamaka as in Kant's philosophy, thus amounts to taking the empirical reality as it is moulded by our perceptive automatisms, basic presuppositions, concepts, and conventions, for some intrinsic reality. Disclosing this illusion, Murti says, would mean "(...) disabusing the mind of its presuppositions", and, to begin with, recognising these presuppositions *as such*. Yet, criticizing the absolutization of the elements of the empirical world does not mean denying the existence of any absolute reality. In fact, according to Murti, the Madhyamaka system *is* a variety of absolutism[16]. But the absolute it sketches is "utter indeterminateness and non-accessibility to reason. (...) Even existence, unity, selfhood and goodness cannot be affirmed of it"[17]. Murti concludes by equating boldly Nagarjuna's distinction of two truths, namely Samvrti (usually translated as conventional[18]) and Paramartha (translated as ultimate or absolute), with Kant's distinction between Phenomenon and Noumenon[19].

(4) Denunciation of false absolutes is associated, in both Kant's philosophy and the Madhyamaka system, with a strong emphasis on relations, constitutive relativities, or relative existence.

Kant describes two classes of relations, that one may call "transversal" and "lateral." Firstly, there is a "transversal" relation between the thing in itself and a knowing subject[20]. Secondly, there are direct "lateral" relations between consecutive perceptions, even though these perceptions admittedly arise from a human subject's being "transversally" affected by the thing in itself.

According to Kant, in the empirical world, we only know *relations between phenomena*[21]. Matter itself is construed by him as a bundle of relations, since the only characteristics by which it manifests itself are the (attractive or repulsive) *forces*. Developing systematically this conception in the *Transcendental Analytic* of his *Critique of Pure Reason,* Kant replaces any statement of inherence (say about substance or productive causality) by a corresponding *a priori* law of succession of phenomena. These laws, imposed onto the phenomena by our understanding, are constitutive of *objectivity*. Indeed, objectivity is understood by Kant as

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[13] I. Kant, *Critique of Pure Reason,* A379-380, A539-B567

[14] T.R.V. Murti, *The Central Philosophy of Buddhism,* op. cit. p. 167

[15] ibid. p. 251

[16] T.R.V. Murti, "Samvrti and Paramartha in Madhyamaka and Advaita Vedanta", in: M. Sprung (ed.), *The Problem of Two Truths in Buddhism and Vedanta,* op. cit.

[17] T.R.V. Murti, *The Central Philosophy of Buddhism,* op. cit. p. 229

[18] Literally, samvrti means "covering", or "conceiling". Samvrti-satya is, so to speak, the surface truth.

[19] ibid. p. 294

[20] Referring to this type of relation, Kant writes that "The absolute must be thought of as external to the empirical world, and the latter only consists of the relation with our senses". I. Kant, Reflections 5968, *Kants Nachlass,* AK XVIII

[21] I. Kant, *Critique of Pure Reason,* B321, B341

universal validity, for any subject, of a certain mode of *relational organization* of phenomena, rather than as intrinsic existence.

Not surprisingly, the most important categories among those that impose laws onto the phenomena, are the categories falling under the title "relation." They are derived from the class of judgments which state relations either between a predicate and its subject, or between a premise and its consequence, or between the terms of a disjunction. In the empirical network of interrelations, the only elements that can be taken as absolute are the very *principles* which govern the relations between the phenomena, since they are the conditions of possibility of there being an experience of phenomena at all. To summarize, one could say that, according to Kant, we have access only to phenomenal relations which are themselves in turn constituted by a basic epistemological relation.

Now, we find a fairly similar pattern in the Madhyamaka thought. Despite some obvious differences with Kant, to be discussed in the next section, the idea of a constitutive epistemological relation can for example be recognized in Nagarjuna's following remark: "Someone is disclosed by something. Something is disclosed by someone. Without something how can someone exist? Without someone how can something exist?"[22]. This sentence, and other ones in the same chapter or in other texts[23], can easily be understood as a way of emphasizing "(...) the corelativity and interdependence of subject and object"[24]. More generally, as it is well known, Nagarjuna considers that emptiness, understood as universal reciprocal relativity (or "dependent coarising"), is the very *condition of existence* of empirical (or "conventional") reality. Disclosing the true nature of this reality here means only *perceiving* it *as* empty, or *as* constituted by reciprocal relations of dependent coarising. Both the absolutists who think that existence can only be intrinsic, and the nihilists who think accordingly that their denial of intrinsic existence amounts to a denial of existence *tout court,* are thereby rebutted. Their construal of causality as a process of metaphysical production having been extensively criticized, it is replaced, in the Madhyamaka system as in early Buddhism, by law-like co-dependence of consecutive forms[25].

4-Kant and the Madhyamaka: the differences

J. May and other authors have given some reasons to regard virtually every point of the former parallel between Kant's philosophy and the Madhyamaka as approximative. They have thus reached the conclusion that there could be only superficial analogies between these two systems of thought whose status and aims are utterly different.

There are, to begin with, many noticeable differences between Nagarjuna's and Kant's dialectic.

To be sure, Nagarjuna's dialectic is much more radical than Kant's. Whereas Kant carefully analyzes the antinomies, and considers them as unavoidable (but unwelcome) consequences of an otherwise valuable functioning of reason, Nagarjuna treats them, according to J. Garfield, as nothing other than pairs of "nonsensical verbal formulations"[26].

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[22] Nagarjuna, Mulamadhyamakakarika, IX, 5, in: J. Garfield, *The fundamental wisdom of the middle way,* op. cit. p. 184-185

[23] Nagarjuna, *Lokatitastava* 6, 7, 10 *(Hymn to the Buddha transcending the world),* in: C. Lindtner, *Nagarjuniana,* Motilal Banarsidass, 1987, p. 131, 133. "(An object of knowledge is) no object of knowledge unless it is being known (...). Therefore you have said that knowledge and the object of knowledge do not exist by own-being".

[24] J. Garfield, *The fundamental wisdom of the middle way,* op. cit. p. 185

[25] G. Bugault, *L'Inde pense-t-elle?,* op. cit. p. 186, 292

[26] J. Garfield, *The fundamental wisdom of the middle way,* op. cit. p. 198

Even the structure of the dialectic is much stronger in the Madhyamaka system than in Kant's philosophy.

In his studies of the (cosmological) antinomies, Kant shows that we are able to derive *two* mutually contradictory conclusions from principles that are selected according to conflicting interests of reason. He then divides such couples of contradictory conclusions into two classes. In the first class, the two conclusions (i.e., that the world is limited, and that the world is unlimited) are both necessarily *false,* because they both apply to an ideal totality whose concept goes beyond any possible experience[27]. In the second class, the two contradictory conclusions (i.e., that there is free will, and that everything is ruled by the law of nature) are both *true* because each one of them expresses a partial but significant aspect of the situation. To summarize, Kant displays *either* negative *or* positive *dilemma.*

By contrast, Nagarjuna most often uses a *negative tetralemma*. In a tetralemma, he denies (by challenging their logical coherence [na yujyate, nopapadyate] or their factual relevance [na vidyate]) the four following forms of a thesis[28]: P, ¬P, P& ¬P, ¬P& ¬ ¬P. Moreover, unlike Kant in his second type of antinomy, Nagarjuna is careful not to endorse any one of the available theses. Indeed, even if a thesis were to express a significant aspect of a situation, this would mean that its truth is relative to a certain point of view and that it is thus, once again, merely "conventional".

Another difference concerns the situation of dialectic in the respective systems. In Nagarjuna's *Mulamadhyamakakarika,* dialectic is all-pervasive; it is already there in the first verses of the first chapter, which state a basic tetralemma about causality. But in Kant's *Critique of Pure Reason,* the *Transcendental Dialectic* comes quite late, after the *Aesthetic* and the *Analytic*. Even if one agrees with Murti that the dialectic *could have been* Kant's starting point[29], this factual difference of order and emphasis cannot be ignored. It manifests very clearly that Kant's priorities are diametrically opposed to Nagarjuna's. When Kant marks the bounds of reason, his purpose is to secure the mathematics and the (Newtonian) science of nature within these bounds. It is to drive back the illusion outside the bounds of a proper application of reason, in order to provide science with a new illusion-free foundation. Here again, a typical Madhyamika thinker such as Nagarjuna is much more radical. For him, illusions arise not only from an extension of concepts beyond their empirical domain, but also from their application to this domain. Indeed, the very fact that these concepts are successfully used within their range favors forgetfulness of their having a merely pragmatic-conventional value. As J. May points out, the Madhyamaka does not try to document the empirical validity of concepts, but rather to convey their *non*-validity at the ultimate level.

To recapitulate, Kant's dominant intention was to provide objective scientific knowledge with firm (though not ontological) ground. But Nagarjuna's exclusive mission was to free everyone from the spell of a reified conventional truth, *including science* understood as an exceptionally efficient (but thereby also exceptionally liable to reification) part of pragmatic-conventional truth.

Last but not least, the divergences about *the ultimate* and its status should not be minimized. In Kant's *Transcendental Aesthetic,* there appears to be a relation of transcendence between the affecting thing in itself (the ultimate or the absolute) and the affected human subject. This dual

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[27] I. Kant, *Prolegomena to any future metaphysics that will be able to present itself as science,* Manchester university press, 1971, §52c

[28] T.J.F. Tillemans, "La logique bouddhique est-elle une logique non-classique ou déviante? Remarques sur le tetralemme", *Les cahiers de philosophie (Lille),* n°14, 183-198, 1992

[29] T.R.V. Murti, *The Central Philosophy of Buddhism,* op. cit. p. 295

relation is underpinned by a presupposed duality of (sensory) matter and (intellectual) form of knowledge. Indeed, in the wake of Kant's "Copernican revolution", the form of the experienced world is specifically ascribed to the subject in general, not to the object(s), whereas the so-called matter of knowledge is considered as the byproduct of a subject's senses being affected by the thing in itself. A strongly dualist structure thus persists in the *Critique of Pure Reason,* despite many opposite tendencies, such as the criticism of the idea of a substantial self (the soul) in the paralogisms of pure reason. In that respect, Kant's philosophy is predominantly an epistemology. Ontology creeps in only when ethics is at stake. In the latter context, Kant ascribes free will to the subject *as a thing in itself,* and determination by the law of nature to the subject *as a phenomenon*[30].

By contrast, says J. May, the Madhyamaka can by no means be construed as an epistemology. It is, so to speak, ontological from the outset, despite the fact (i) that its exposition of ontology is apophatic[31] rather than dogmatic, and (ii) that this exposition has the status of a factor of transformation *in* being, not of a discourse *on* being. In the Madhyamaka, a modification in attitude and in knowledge is also an internal mutation of being (or rather, if one wishes to impute some slightly less inappropriate words on it, a change in the direction of becoming). Thus, one cannot say, as Murti does in order to strengthen the parallel with Kant, that the function of prajña is to induce "an epistemic (subjective), not an ontological (objective)"[32] change. Even less that prajña prompts a transformation of our attitude, not of the real. In the Madhyamaka, the duality of subject and object is empty; it is part and parcel of the "conventional" truth (it is even one of its most crucial departure points). It is not asymmetric and hierarchical, as Kant's dualities of form and matter or of subject and thing in itself; it is rather symmetric and reciprocally co-constitutive. One central function of prajña is appeasement of the latter duality in the immanent flux of becoming of which we are participants; it is therefore flatly mistaken to see it as operating at a purely subjective level.

This being granted, it is clear that there can be no relation of transcendence in the Madhyamaka system, as some expressions of Kant suggest there is between phenomenon and noumenon. Not even between samvrti and paramartha, or between samsara and nirvana. In no way can one say, for instance, that the ultimate truth points towards an underlying *ground* of the conventional truth, by analogy with Kant's referring to the thing in itself as the *ground* of empirical reality. The lack of any such relation of transcendence in the Madhyamaka thought is made as clear as possible by Nagarjuna, in the following celebrated sentence: "There is not the slightest difference between samsara and nirvana"[33]. Everything, including nirvana, is embedded in the same immanent plane, in the same network of relative co-arising. To be in nirvana, according to J. Garfield, means seeing the very same things that appear to the deluded consciousness of samsara, but seeing them "as they are - as merely empty, dependent, impermanent, and nonsubstantial." It does not mean "to be somewhere else, seeing something else"[34]. An even less inappropriate expression could be found by avoiding the expression "seeing

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[30] One can also distinguish these two cases by saying that free will holds from the standpoint of the actor, whereas universal application of the laws of nature holds from the standpoint of the spectator. L. W. Beck, *A commentary on Kant's critique of practical reason,* The University of Chicago Press, 1963

[31] "Apophatic" derives from the Greek "apophasis" that means "denial". Here, the features are denied rather than asserted of Being.

[32] T.R.V. Murti, *The Central Philosophy of Buddhism,* op. cit. p. 273-274

[33] Nagarjuna, Mulamadhyamakakarika, XXV, 19, in: J. Garfield, *The fundamental wisdom of the middle way,* op. cit. p. 331

[34] ibid. p. 332

as," which still conveys an epistemological connotation, and replacing it by "living as" or "being as." This would help to dissolve any residual picture of a transcendence.

5-Function rather than analogy: a methodological turn

At this point, one can see that part of the difficulties which hinder these comparisons arises from a static and reified conception of discourses and doctrines. No serious use of the evolution of the doctrines can be made if they are considered from the outset as immutable claims of truth. Furthermore, analogies between two closed systems of thought fail to be convincing if one does not display extensive elements of isomorphism bearing on their contents, presuppositions, and scope. No other relation than similarity and dissimilarity is conceivable between them.

Another part of the difficulties comes from a dominant representational conception of knowledge. It was implicitly accepted in some of the previous analogies that comparing two theories means showing that they provide the same picture of the world. It therefore proved easy to criticize these analogies by showing that the pictures (i.e., that of modern physics and that of the Madhyamaka) are only superficially similar, and that they are based on very different bodies of evidence.

But giving up the static and representational outlook is likely to allow a thorough renewal of our conception of the threefold relation between modern physics, transcendental philosophy, and the Madhyamaka. Let us then consider a scientific theory or a system of thought as an *operator* within an open network of practices, rather than as a closed set of truths, or as a (more or less) faithful representation of a pre-given reality. Let us construe scientific theories as operators of structuring of our actions within the world, and of anticipation of their outcomes. Let us construe philosophical doctrines as operators of mutual adjustment between our possibilities of action (stated by scientific theories), and the set of values, scopes, and representations which define our culture. And let us construe the Madhyamaka dialectic: (i) as a patient reminder of the all-pervasive impermanence and emptiness of appearances and, accordingly, (ii) as a universal operator of self-transformation.

In this case, establishing a relation between modern physics, Kant's philosophy, and the Madhyamaka does not amount to displaying their strict isomorphism; it means showing that, as operators, they fit well enough to be *articulated* into a higher-order, broad-range operator. Here, the analogies have no value by themselves; they are only signs indicating the most appropriate locus of articulation between the operators. Moreover, in so far as they are nothing but tools (operators), the three terms to be related must be taken as plastic and evolutive; each term has to be seen in the context of its history, of its potential developments, and of the dynamics of its possible co-adaptation to the other terms, rather than treated as a closed doctrinal system.

True, the widespread trend towards strict separation of domains between science, philosophy, and religion, which culminated at the end of the nineteenth century, may make this idea of a higher-order integrated operator look quite odd. But, actually, partial integrations work daily in the making of science, philosophy, and broader outlooks (or "forms") of life. Science is driven by extrinsic values, aims, motivations, epistemological conceptions, or metaphysical pictures, and it modifies them retroactively[35]. So much so that saying that scientific theories are *nothing but* guiding operators of action usually seems too narrow a characterization. On the other hand, philosophy is constrained (though underdetermined) by scientific advances, at the same time as it

[35] L. Laudan, *Science and values,* University of California Press, 1984; G. Boniolo, *Metodo e rappresentazioni del mondo,* Bruno Mondadori, 1999

provides scientists with general directions of research. As for the religious dogmas and forms of life, they have either been shaken by changes of values, behavior, and representations related to science, or forced to protect themselves by community closure and explicit denial of some scientific theories.

Furthermore, it is nowadays widely accepted that, from the end of the middle ages to the first half of the eighteenth century, Western science was given its impetus by Christian theologies and, more indirectly, by simplified versions of Jewish and Moslem metaphysical speculations[36]. Disclosing the fabric of God was no small motivation for the dawn of science. Concepts such as the laws of nature or absolute space were directly derived from belief in an omnipotent and omnipresent God. And the dominant realist-representationalist philosophy of science was clearly favored by creationism associated with theological foundationalism. Such a genealogical link between representationalism and theological foundationalism holds true notwithstanding the fact that the first reaction of the Catholic Church at the time of Galileo was to confiscate the benefit of realism for its own dogma and to impose a purely instrumentalist status on science.

This historical many-level organization having been recognized, the call for separation which has prevailed since the second half of the nineteenth century can be read retrospectively as an expression of felt failure. It reveals the breakdown of the original compromise between science, a predominantly representationalist philosophy of science, and Christian theology. True, the separation, and the correlative feeling of failure, had some positive consequences: an increased concentration on specialized tasks, and a better definition of the respective domains. But it also had very negative consequences: (i) a schizophrenic appraisal of indissociable aspects of human life, and (ii) a variety of *nihilism* as F. Varela[37] defines it, namely a state of mind where we are perfectly aware that our system of values and beliefs is incoherent, but where we cannot do without it.

The components of this contemporary nihilism are well documented: scientists who look toward religion for an ethical guarantee, even though they are deeply sceptical; philosophers of science who try to save realism at any cost in spite of the acknowledged resistance of modern physics, or who adopt empiricism with the bitter feeling of having renounced the very meaning of the scientific endeavor; and priests or monks who know deep down inside themselves that the dogmatic and mythological component of their religion has become untenable (or merely allegorical), but who see no other solution than maintaining it because they believe this is the pre-requisite of a truly religious stance (including morals, a contemplative life, and striving towards self-transformation).

Overcoming the failure and moving beyond nihilism is possible only if we identify a new higher-order operator articulating modern science, an alternative philosophy of science, and a non-dogmatic soteriology, thus fitting globally with the essential aspects of contemporary human life. The multiple analogies which have been discussed previously can be seen as a few partial steps towards such a higher-order operator. But, as I have already pointed out, most of them are definitely clumsy because they rely on the very (static and representationalist) assumptions about doctrines and knowledge that they purport to challenge. So, our task now is to show in some detail how the many-leveled articulation can be secured: (i) by relying on the dynamic potentialities of doctrines and theories rather than on their canonical text; (ii) by fully recognizing their functional-operational status; and (iii) by disentangling, in the available unselfconscious

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[36] A. Funkenstein, *Theology and the scientific imagination,* Princeton University Press, 1986
[37] F. Varela, E. Thomson, & E. Rosch, *The embodied mind,* MIT Press, 1991, chapter 6

presentations of scientific theories and philosophical doctrines, components coming from various layers of a half-forgotten but still efficient past higher-order operator.

The difficulties which hindered the attempts at establishing relations between modern physics, Kant's philosophy, and the Madhyamaka, can be thus overcome. Let us take them in the same order as in section 2.

Firstly, the obvious discrepancy between Kant's original *a priori* forms and some prominent aspects of modern physics does not mean that the very idea of a transcendental reading of science has failed. To see this, one has only to come down to the central idea of the transcendental philosophy (below the particular shape which was given to it by Kant), and to take into account its aptitudes to *development* as they have been displayed by the neo-Kantian philosophers of the nineteenth and twentieth century.

What is then the central idea of the transcendental philosophy? It is to construe each object of science as the focus of a synthesis of phenomena rather than as a thing-in-itself. And it is to accept accordingly that the very possibility of such objects depends on the connecting structures provided in advance by the procedures used in our research activities. Then, something is objective if it results from a *universal and necessary* mode of connection of phenomena. In other terms, something is objective if it holds true for any (human) active subject, not if it concerns intrinsic properties of autonomous entities.

Here, science is not supposed to reveal anything of a pre-existent underlying absolute reality; nor is it a more or less random aggregate of efficient recipes. Science is rather the stabilized byproduct of a dynamic reciprocal relation between reality as a whole, and a special fraction of it[38]. Defining this special fraction of reality *qua* subject is the reverse side of its actively extracting object-like invariant clusters of phenomena.

Somebody who shares this philosophical attitude is metaphysically as agnostic as empiricists, but as convinced as realists that the structure of scientific theories is highly significant. For, from a transcendental standpoint, the structure of a scientific theory is nothing less than the frame of procedural rationalities which underpin a certain research practice (and which, conversely, were constrained by the resistances that arose from the enaction of this practice).

A conception of science based of this central idea is perfectly able to develop nowadays, provided it drops the residual static and foundationalist aspects of Kant's system. Instead of accepting Kant's *uniqueness* and *invariability* claim about his forms of intuition and thought, one should acknowledge, as H. Cohen[39] and E. Cassirer[40] did, the possibility of *change* of the so-called *a priori* forms and their *plurality* as well. Recent flexible and pluralist conception of transcendental philosophy include Putnam's and Hintikka's transcendental pragmatism. According to H. Putnam, for instance, each *a priori* form has to be considered as purely *functional* (he also calls it a *quasi-a priori).* Each *quasi-a priori* is relative to a certain mode of activity, it consists of the basic *presuppositions* of this mode of activity, and it has therefore to be changed as soon as the activity is abandoned or redefined[41]. As for J. Hintikka, he characterizes the transcendental philosophy, in a neo-pragmatist style, as a process of redirecting attention from

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[38] This sounds very similar to F. Varela's theory of cognition. Actually, his autopoietic theory of cognition can easily be interpreted as a naturalized version of the neo-Kantian theory of knowledge. See: M. Bitbol, "Physique quantique et cognition", *Revue Internationale de Philosophie,* 2000 (to be published).

[39] Hermann Cohen (1842-1918) is the founder of the Marburg school of neo-Kantian philosophy (see footnote below about the Marburg school).

[40] Ernst Cassirer (1874-1945) is the most prominent philosopher of the Marburg school. His publications include *Substance and Function* (1910), and the three volumes of the *Philosophy of symbolic forms* (in the 1920's)

[41] H. Putnam, *Pragmatism,* Blackwell, 1995

the objects to our game of seeking and finding[42]. We shall see in section 8 that a neo-transcendental philosophy of science developed along these lines is able to account for quantum mechanics to a much larger extent than either scientific realism or empiricism.

Secondly, the gap which separates science and the Madhyamaka, due to obvious differences of methods and scope, could be filled in only by a third intermediate term. This is the bridging function I ascribe to a neo-transcendental philosophy of science (see *"thirdly"* below).

But, even before any precise assessment of this threefold articulation is attempted, one should identify the level at which an articulation, be it indirect, between a scientific theory and a dialectical-soteriological system is acceptable at all. To begin with, one must avoid the temptation of drawing from modern science a sort of monolithic official mythology, in order to display its superficial analogies with a popular Eastern mythology. Instead, one should insist on the manifest *underdetermination* of scientific theories and models by experiment, and on the fact that, in the history of science, this underdetermination was *de facto* removed by additional, extra-empirical, constraints. These additional constraints were provided by a demand of coherence between new theories and an older philosophical background[43] whose roots are profoundly embedded in the (partly religious) Western forms of life.

The problem is that these traditional (philosophical) constraints, which have been so easy to cope with in classical physics, have begun to introduce tensions, difficulties, and paradoxes in modern (relativistic and quantum) physics. The traditional conception of a world made of separate material bodies bearing intrinsic properties has not been completely relinquished; but in order to survive, it has assumed several hardly recognizable forms. The non-local hidden variable theories, whose archetype is Bohm's 1952 theory, is the most explicit one. But even the physicists who are most committed to the so-called Copenhagen interpetation still use remnants of the old mechanistic outlook together with fragments of a new non-mechanistic outlook. They use a versatile and flexible language which enable them to speak sometimes as if the particles were *individual entities* and sometimes as if they were *non-individual quanta* of field excitation; sometimes as if objects had monadic *properties* and sometimes as if one had to think that they are only relational *observables;* sometimes as if it were possible to ascribe a state to a "physical system" made of a set of particles, and sometimes as if the particles themselves reduced to states of the vacuum, and so on (see section 6 for more details).

The quicker solution to eliminate these difficulties and lack of conceptual unity (without resorting to a non-empirical world of hidden processes) would be to jettison both the mechanistic conception of the world and the dualistic epistemology. Unfortunately, there are deep-lying resistances to this seemingly extreme solution. Even our cultural familiarity with the most recent and radical varieties of transcendental philosophy of science (which, as we have seen, are pragmatic, dynamical, relationist, and non-dualist) is not strong enough to make us take this step collectively.

But aren't these resistances related to our elementary creeds and forms of life? Aren't they due to our distress about losing ground, if we are left without a belief in a pre-given and pre-structured reality? Would we not be deprived of our strongest motivation for making science if we did not have the regulative aim of disclosing a pre-existent reality lying, so to speak, in front of us? At this point, the Madhyamaka comes in. The Madhyamaka construed not as the purveyor of one more mythology, one more representation of the world, or one more philosophical doctrine but (i) as a patient dialectical deconstruction of the class of substantialist views and

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[42] J. Hintikka & I. Kulas, *The game of language,* Reidel, 1983, p. 33
[43] G. Boniolo, *Metodo e rappresentazioni del mondo,* op. cit. p. 123

dualist epistemologies which we find so difficult to abandon, and (ii) as a soteriology, namely as an introduction to a form of life in which losing ground is not a tragedy (it can even promote enlightenment...), and in which an alternative (say pragmatic, integrative, and altruist) strong motivation can be given to science.

To summarize, the meeting point of science and the Madhyamaka is not a common view of the world. It is rather a tension between the traditional views of the world and the recent advances of science, which can be formally avoided by transcendental philosophy, and relaxed at the deepest level by the Madhyamaka dialectic and soteriology.

Thirdly, some of the discrepancies which were pointed out between Kant's philosophy and the Madhyamaka are not as insurmountable as they appear to be. In order to overcome them, one has only to be sensitive to the evolution of Kantian and neo-Kantian thought.

Let us consider for instance the difference between Kant and the Madhyamaka on the status of the *ultimate*. As we know, Kant's position on this point apparently involves a remnant of substantial dualism (between the thing in itself and the affected subject). As a consequence, a kind of transcendence seems to be ascribed to the thing in itself. By contrast, Nagarjuna does not consider any other form of epistemological duality than a purely functional-relational one. The duality of subject and object, of perceiving and perception, is not denied; but it is shown to be empty, namely to arise from a symmetric relation of mutual dependence. Nagarjuna's critical analysis is thus maintained on a strict level of immanence throughout.

However, Kant's position on this point is much less elementary than what can be inferred from a selective reading of certain texts (such as the *Transcendental Aesthetic* of the *Critique of pure reason).* At the end of the *Transcendental Analytic,* one finds that the concept of noumenon is only a *limitative* concept; that it only points obliquely towards the *finitude* of our sensibility; and that its use is therefore only *negative*[44]. Some commentators then explain that Kant's thing in itself is nothing beyond the representation, that it is nothing else than the brute fact of this representation (of its givenness, of its not being arbitrarily produced by a deliberate act of our will)[45]. And thus the last shadow of dualism disappears.

Later on, the Marburg school[46] of neo-Kantian philosophy developed an even more explicitly immanentist position. Against substantial dualism, E. Cassirer recommended that one not construe subject and object as a pair of ontologically closed entities. He rather insisted on a purely methodological distinction between a *function* of subjectivation and a *function* of objectivation in the process of cognition[47]. He then stated, after H. Cohen, the idea of a *"reciprocal co-belonging" of the concepts of subject and object.* Against transcendence, P. Natorp also argued that there is *no external standpoint* from which a relation of causality can be established between a thing in itself and our senses. We can thus see how, in the course of its development, transcendental philosophy has come closer and closer to a crucial feature of the Madhyamaka.

Of course, there remains a momentous difference of scope between them. As we know, neo-Kantian philosophies aim at securing the validity of objective scientific knowledge in its specific domain. But the Madhyamaka has another priority. This priority is to denounce science as an

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[44] I. Kant, *Critique of Pure Reason,* A255/B311

[45] see e.g. L. Ferry, in the preface of: I. Kant, *Critique de la raison pure,* Garnier-Flammarion, 1987, p. XIX

[46] Marburg is a little town of the west of Germany (Land of Hesse). An important protestant university was created there in the 16th century. H. Cohen taught in this university until 1912, and he had remarkable students including E. Cassirer and P. Natorp. The most renowned school of neo-Kantian philosophy in Germany, made of followers of H. Cohen, was thus named "the Marburg school".

[47] E. Cassirer, H. Cohen, & P. Natorp, *L'école de Marbourg,* Editions du Cerf, 1998, p. 247

integral part of conventional truth, and to free us from the temptation of taking *any* part of conventional truth for an absolute truth. Such a difference clearly invalidates simple analogies, or straightforward identifications. But it cannot prevent us from establishing both a relation of complementarity and an operational articulation between the two systems.

(1) Complementarity.

Saying, as the Madhyamaka does, that scientific knowledge has only a conventional[48] validity is not tantamount to denying it any validity whatsoever. Exploring the extent and limits of this (admittedly conventional) validity, as transcendental philosophy purports to do, is thus worthy of the effort in a Madhyamaka context. Has not Nagarjuna pointed out that "Without a foundation in the conventional truth, the significance of the ultimate cannot be taught"[49]? In that respect, the Madhyamaka system and transcendental philosophy are complementary.

(2) Operational articulation.

Transcendental philosophy shows in exquisite detail that the credibility of scientific knowledge is in no way based on its correspondence with some immutable absolute reality, but on the consistent mutual relation between the processes of defining invariants (objectivation) and setting apart the non-invariant residue (subjectivation). This may well contribute to the effort made by the Madhyamika masters to dispel reifying illusions; for, in our culture, science is the most powerful source of these illusions. Challenging reification in the domain of science is likely to lower the triggering threshold of the sought after disabusing chain reaction.

Conversely, in the frame of life and thought which is likely to emerge from a self-transformation performed in the direction indicated by the Madhyamaka, an anti-foundationalist, immanentist, relationist philosophy of science, such as the neo-Kantian, would be immediately acceptable. The very existential roots of the widespread resistance of those scientists who are afraid to lose their landmarks and their motivation by adopting it would indeed be cut.

In this respect, the Madhyamaka system and transcendental philosophy are potentially synergetic, and they are therefore predisposed to operational articulation.

6-Ontological illusions in modern physics

To sum up, whereas neo-Kantian philosophy is concerned with revealing the detailed mechanism of reifying illusions in science, the project of the Madhyamaka Buddhist community is to dispel them from the outset. As we shall see in this section, the purely intellectual stance of neo-Kantianism may have been superficially sufficient in the context of classical physics; but, in the context of quantum physics, the need of a synergetic association with the existential stance of the Madhyamaka becomes manifest.

Let us return to the essential mechanism of the reifying illusions. It consists in projecting upon nature the commitment of human beings to the practices that enable them to relate to their environment and to live in it. The man-in-the-street is committed to the objects of his action and

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[48] Undoubtedly, this word "conventional", commonly used to translate "samvrti", has spurious connotations. A convention is an overt agreement between persons. But the samvrti-satya does not arise from an explicit discussion between the members of human societies. Every (human) being is so to speak bound to it by the very fact he/she partakes of a *form of life* which involves efficient practices including the use of language. I thank Christiane Schmitz for having raised this question, and for so many other valuable remarks.

[49] Nagarjuna, Mulamadhyamakakarika, XXIV, 10, in: J. Garfield, *The fundamental wisdom of the middle way,* op. cit. p. 298. Candrakirti comments that one must accept (and presumably analyze) the surface truth at first, for it is an instrument to reach Nirvana. Candrakirti, *Prasannapada Madhyamakavrtti,* translated into French by J. May, Adrien Maisonneuve, 1959.

discourse, and this commitment gives rise to what A. Fine[50] called the *Natural Ontological Attitude* (NOA). As for the scientist, she is committed to the postulated objects of her experimental practice, as well as to the heuristic guides of this practice. The latter commitment is not independent of the former one, for it often extrapolates its basic features. It gives rise to a scientific version of the NOA which is so deeply entrenched that it tends to resist at any cost. The scientific version of the NOA especially resists the rising tide of tensions and paradoxes which is induced by its being stubbornly imposed onto modern physics.

Can we do something to overcome this sort of illusion? Kant and his followers did not think so. They believed that nothing can be done beyond mere intellectual recognition of the transcendental illusion. According to them, we can *know* intellectually that certain subjective rules are mistaken for objective determinations of the things in themselves, but we cannot help *seeing* the world as if it inherently possessed these determinations[51]; exactly in the same way as an astronomer cannot help *seeing* the moon bigger when it is close to the horizon than when it is at its zenith, although she *knows* intellectually the optical mechanism of this illusion.

This rather pessimistic view is clearly expressed in the last part of the *Critique of pure reason*. But it is already latent in the first chapters of the *Critique,* where the "constitution" of valid objective knowledge by means of the forms of our sensibility and understanding is at stake. One can see this in the way Kant minimizes the implications of his philosophy for men-in-the-street and scientists. On the one hand, in the *Transcendental aesthetic,* Kant states that space is not a concept abstracted from our outer experiences, but rather the *a priori* form of all intuitions of the bodily objects which we take as external to us. It is only if this subjective status of space is accepted, he writes, that one can understand how it is possible to get a knowledge of the necessary propositions of geometry. For an *a priori* knowledge of necessary truths can only be about something we ourselves produce. But on the other hand, Kant also explains that, with respect to any possible human experience, everything remains exactly *as if* ("als ob") space were an intrinsic feature of the world[52]. The critical attitude thus stems from the meta-standpoint of the philosopher, and it proves mostly irrelevant from the ordinary standpoint of the man-in-the-street or of the scientist. The philosopher is aware of the *as if* clause, whereas the man-in-the-street and the scientist just make use of it unselfconsciously.

This dual, not to say schizophrenic, analysis may have been acceptable as long as the *as if* procedures worked without too many discrepancies (i.e., in classical physics). Indeed, the internal coherence of the ontological-like discourse of the classical physicists made it quite easy for them to forget the "as if" clause. But in quantum physics, discrepancies become so glaring that in order to save something of the Natural Ontological Attitude, especially something of the favorite ontology of material bodies, one needs tortuous (and thus too visible) strategies.

As I have suggested in section 5, these strategies include: (i) flexible use of the substantives and predicates in particle physics, (ii) implementation of new logic or new (quasi-) set theories, (iii) call for future theories endowed in advance with the aptitude of solving the paradoxes of quantum mechanics, or (iv) hidden variables theories which carry on some basic features of the classical mechanics of material points.

Let us explore briefly two of these available strategies. One concerns predication, and the other reference. The first one is quantum logic, and the other one is the particle label approach.

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[50] A. Fine, *The Shaky Game,* The University of Chicago Press, 1986

[51] I. Kant, *Critique of pure reason,* op. cit. A298-B354

[52] I. Kant, *Prolegomena to any future metaphysics,* op. cit., §13

Both of them reveal a strong philosophical and cultural bias in a situation where underdetermination of theories by experiments prevails.

Predication was already perceived as a problem during the period of emergence of quantum mechanics. At first, the formulation of this problem was quite clumsy. In 1927, Heisenberg and Bohr insisted on the fact that, due to the indivisibility of the quantum of action, no phenomenon may be observed without disturbing it appreciably[53]. Therefore, saying that a phenomenon merely reflects a predicate possessed by the (micro-)object is quite dubious. But a few years later (especially from 1935 on, after the celebrated Einstein Podolsky Rosen controversy), Bohr became increasingly suspicious about the concept of disturbance. As he noticed in 1954, "(...) one sometimes speaks of 'disturbance of phenomena by observation', or 'creation of physical attributes to atomic objects by measurement.' Such phrases, however, are apt to cause confusion (...)."[54]

Bohr was especially aware of the lack of coherence of the most widespread way of using this concept of "disturbance." Indeed, speaking of a disturbance presupposes that something like a property of the micro-object exists in nature, ready to be "disturbed" by the observing agent; it is thus difficult to invoke disturbances in order to prohibit (as some members of the Copenhagen group did) any reference to intrinsic properties of objects. Even worse, supposing that properties preexist but that they cannot be known due to disturbances is tantamount to accepting that our knowledge of the hypothetical properties is *incomplete,* and to encourage some physicists in their search for hidden variables. Bohr therefore insisted less and less on the crypto-dualist picture of disturbed (or created) properties, and more and more on a holistic definition of the phenomenon in which the hypothetical contribution of the object cannot be dissociated from the contribution of the structure and irreversible functioning of the measuring apparatus[55].

From the very beginning, quantum logic was aimed at restoring realism in quantum physics against Bohr's views. Rather than sticking to "phenomena" or "observation" as Bohr did, quantum logic enabled one to recover the possibility of speaking of "physical qualities"[56] or of properties of systems, at the cost of changing the algebra (namely the combination by conjunction and disjunction) of these properties. Instead of a Boolean algebra[57], one merely had to accept a non-Boolean "orthocomplemented non-distributive lattice."[58] So much so that the whole historical perspective was reversed by later quantum logicians. While history indicates that non-boolean logic is the realist reply to Bohr's criticism of the ideal of a complete separation between an object and an observing agent, some quantum logicians asserted that: "The rejection of the 'ideal of the detached observer' is the Copenhagen response to non-Booleanity."[59] Thus, according to these authors, the world is *inherently* non-Boolean, and Bohr's holism is a spurious epistemological interpretation of this ontological feature.

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[53] See e.g. N. Bohr, *Atomic Theory and the Description of Nature,* in: *The philosophical writings of Niels Bohr I,* Ox Bow Press, 1987, p. 53

[54] N. Bohr, *Essays 1933-1957 on Atomic Physics and Human Knowledge,* in: *The philosophical writings of Niels Bohr II,* Ox Bow Press, 1987, p. 73

[55] This being accepted, *complementarity* does not appear any longer as a trick to accomodate contradictory properties. It only expresses: (i) the indissociability of object and experimental device in a phenomenon, and (ii) the mutual incompatibility of the devices in the context of which certain classes of phenomena occur.

[56] G. Birkhoff & J. Von Neumann, "The logic of quantum mechanics", *Ann. Math.*, 37, 823-843, 1936

[57] This algebra, invented by G. Boole (1815-1864), underpins classical logic. It involves the following rules of combination of propositions (or properties) by conjunction and disjunction: commutativity, associativity, distributivity, and complementation.

[58] RIG. Hughes, *The structure and interpretation of quantum mechanics,* Harvard University Press, 1989, p. 188

[59] J. Bub, *Interpreting the quantum world,* Cambridge University Press, 1997, p. 12

Unfortunately for them, however, there is much to be said in favor of Bohr's original standpoint. I personnally tend to promote the following argument of simplicity. From the elementary supposition that phenomena are relative to their (sometimes incompatible) experimental contexts of appearance, it is easy to derive: (i) the full non-boolean structure of quantum logic[60], (ii) the quantization itself (through the commutation relations between conjugate variables), (iii) the wave-like aspect of certain distributions of discrete phenomena[61], and (iv) features which concern the hypothetical bearers of properties, beyond the properties themselves[62]. This derivation does not require any well-defined assumption about the structure of the world (with the exception of the non-zero value of the Planck constant).

By contrast, starting from a detailed non-Boolean structure of the algebra of properties of the systems which constitute the world introduces a high amount of *arbitrariness* in the premises. The derivation of consequences from this kind of premise thus have little explanatory power[63].

To recapitulate, even though the two starting points, namely holism-relationism and inherent non-Booleanity, cannot be settled by experiments, there are many good reasons (especially economy, unity and explanatory power) to choose the first one. The only reason which may make the second one more attractive is that a realist interpretation of physical theories seems to be so unquestionably desirable in the framework of our Western view of the world that the best ampliative[64] arguments in favor of another interpretation lose weight. Everything, in the philosophical debate about modern physics, goes as if the following maxim were enforced: 'whenever a realist interpretation of a physical theory is available, you must adopt it, come what may'[65].

Another important case of underdetermination with philosophical bias concerns two views on the traditional bearers of predicates, namely the particles. According to the first view, the world is made of labeled quasi-individual particles whose momentum exchange mimicks the empirical effects of fields; whereas according to the second view the world is made of fields whose non-individual quanta of excitation mimick the empirical effects of particles. The two views can be made empirically equivalent in virtually every respect[66], but, here again, they cannot fulfill to the

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[60] P. Heelan, "Complementarity, context-dependance, and quantum logic", *Found. Phys.* 1, 95-110, 1970; P. Heelan, "Quantum and classical logic: their classical role", Synthese, 21, 2-33, 1970; also: S. Watanabe, "The algebra of observation", Suppl. Prog. Theor. Phys., 37 and 38, 350-367, 1966.

[61] J.L. Destouches, *Corpuscules et systèmes de corpuscules,* Gauthier-Villars, 1941; P. Destouches-Février, *La structure des théories physiques,* P.U.F., 1951; P. Destouches, *L'interprétation physique de la mécanique ondulatoire et des théories quantiques,* Gauthier-Villars, 1956. See section 8 of this paper, and, for more details, M. Bitbol, "Some steps towards a transcendental deduction of quantum mechanics", *Philosophia Naturalis,* 35, 253-280, 1998; M. Bitbol, *Mécanique quantique, une introduction philosophique,* Flammarion, 1996, chapter 2.

[62] See the end of this section.

[63] A satisfactory explanation is usually a derivation of a great number of complex and apparently arbitrary observed consequences from a little number of simple and less arbitrary assumptions.

[64] According to L. Laudan's definition, ampliative arguments are rational but extra-empirical motives for adopting a scientific theory. They consist in an *amplification* of the purely empirical arguments.

[65] It is only if (as it was the case in the period 1927-1952) any such realist interpretation seems out of reach that most scientists accept to consider an alternative. But they then revert to a purely instrumentalist attitude which they feel as a renunciation, and they are thus usually delighted when realist interpretations become acceptable again, even if these interpretations sound extremely artificial. See B.A. Wallace, *Choosing reality,* op. cit. for a critique of the couple realism-instrumentalism.

[66] W. De Muynck, "Distinguishable and indistinguishable-particle descriptions of systems of identical particles", *Int. J. Theor. Phys.,* 14, 327-346, 1975. Doubts concerning this empirical equivalence are expressed in: J. Butterfield, "Interpretation and identity in quantum theory", *Studies in the History and Philosophy of Science,* 24, 443-476, 1993.

same extent the standards of economy, unity, and explanatory power. Let me state some important differences of this kind between them.

(1) In order to account for the quantum (Bose-Einstein and Fermi-Dirac) statistics, the quasi-individual particle view imposes a set of state-accessibility conditions: the restriction of states to their labeled symmetric and anti-symmetric forms. But the quantum field view needs neither labels nor imposed restriction of the set of accessible states (only a generalized version of the algebra of commutators which underpins quantum theories). As P. Teller points out, the quasi-individual particle view has the defect of carrying a "surplus formal structure" (the labels) and of accepting a certain arbitrariness (in the choice of the accessible states)[67]. Economy thus favors the quantum field view.

(2) What the particle view calls "creation" or "annihilation," thus evoking ontological quantum jumps, is construed by the quantum field view as a continuous change of state which reveals itself discontinuously only in experiments[68]. The quantum field conception is thus clearly more in the line of the general rules of quantum theoretical treatment than the particle conception. Conceptual and formal homogeneity thus favors the quantum field view.

(3) Both views must accomodate an indetermination in the number of micro-objects. However, they are not explanatorily equivalent. In the particle view, this indetermination is imposed; but in the field view it arises quite naturally from the principle of superposition which holds for any quantum state. Furthermore, in the particle view one must cope with the baroque picture of individual objects whose number (and therefore whose *being)* is not definite; but the quantum field superposition of states may easily be understood as describing a propensity for the *manifestation* of various numbers of discrete relational events in a given experimental context[69]. Coherence of representations and, here again, economy of thought, thus favor the quantum field view.

(4) The explanatory gap between the particle view and the quantum field view becomes even more striking when the problem of the so-called "Rindler particles (or quanta)" is at stake. The Rindler particles (or quanta) are observed by means of an accelerated detector, in situations (called the "vacuum state") wherein no particle at all is observed with non-accelerated detectors. It is quite difficult to understand this phenomenon in the frame of the absolutist particle view, for a particle is supposed to exist (or to be devoid of existence) irrespective of the state of motion of the detector. But the Rindler phenomenon raises no problem in the frame of quantum field theory as read by P. Teller[70], because each event of detection is here assumed to express a dynamic *relation* between the environment and the (accelerated or inertial) detector. The quantum field view is thus able to make us dispense with ontological questions which become almost intractable in certain situations.

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[67] P. Teller, *An interpretive introduction to quantum field theory,* Princeton University Press, 1995, p. 25

[68] ibid. p. 138

[69] ibid. p. 105. The superstring theories bring little change in that respect. But in order to understand this, one has to revert to the Feynman path-integral formalism. In standard quantum field theory, the propensity structure is described by an integral over (an infinity of) linear paths. Now, the cross-section of one path is a point. Hence the usual talk of point-particles. The problem is that taking seriously this mode of expression is unwarranted since one cannot reduce "what there is" to *one* cross-section of *one* of the multiple paths whose *complete* sum is required to calculate the probability of a final experimental event. In superstring theories, the cross-section of each *one* of the tubes which have to be added to give a probability is a string. But here again, and for the same reason as in standard quantum field theory, taking seriously (i.e. ontologically) the usual talk of string-particles is unwarranted.

[70] ibid. p. 110

Why then should one keep on with the contrived particle view, instead of adopting the much more natural relational-propensionist[71] reading of quantum field theory proposed by P. Teller?

Most arguments in favor of the particle view rely on a demand of historical continuity of representations and concepts: historical continuity with classical physics, but also with the Natural Ontological Attitude of everyday life. M. Born already insisted, in his discussions with E. Schrödinger, on the importance of historical continuity between the concept of particle and the concept of material body[72]. As for D. Bohm's original hidden variable theory of 1952, which develops and transforms the mechanistic picture of a world made of a plurality of material points, it was explicitly motivated by an ideal of historical continuity, not only methodological but also conceptual, between the new theory and classical physics[73].

True, the majority of realist philosophers of science currently accept that there cannot be an exact ontological similitude between two stages of the development of science. However, they still make a tacit use of what R. Harré[74] calls an *ontological type-hierarchy*. It is usually this choice of developing a single ontological type hierarchy over history which removes the empirical underdetermination of representations and replaces it by an effective determination. Let me give an example. Elementary particles are not mistaken for material bodies in microphysics; but the historical constitution of their concept, and the standard grammar of the expressions used about them by physicists, show that they belong to a well-characterized type-hierarchy whose archetype is the material body of everyday life. The residual affinity of the concept of particle with the material body manifests itself most clearly in popular science, where precautions are dropped and familiar representations dominate again.

The difference between classical physics and quantum physics becomes easily perceptible at this point. In classical physics, the type-hierarchical continuity between systems of interacting material points and the "things" of everyday life did not raise any difficulty. As we have seen earlier, awareness of Kant's *as if* clause was therefore confined to a little circle of philosophers and philosophically-minded physicists. The ordinary physicist and the (Western) layman could stick quietly to their reifying and materialist picture of the world. But in quantum physics, the distortions imposed by upholding the type-hierarchy of material bodies are manifest; the conventional, or normative, aspect of this preservation can hardly be ignored by anyone; and the *as if* status of the substantive (particle) / predicate (state) mode of expression in the micro-world then becomes all the more plausible. Moreover, adopting a radically different conception of physical theories, such as the relational-propensionist reading of quantum field theory, is an increasingly attractive option.

This being granted, the usual attitude which consists in asserting that the world is made of inherently existent particles yet recognizing that this is not a satisfactory picture and adding lots of qualifications, clearly appears as "nihilistic" in Varela's sense. A way out of this sort of nihilism is sorely needed. Now, in view of the previous analysis, the condition for taking

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[71] Propensions, according to K. Popper, are tendencies to realize a certain state of affairs. A relational-propensionist view refers to tendencies of a given relation (say between an apparatus and the rest of the world) to produce certain phenomena.

[72] M. Born, "Physical reality", *Philosophical Quarterly,* 3, 139-149, 1953; M. Born, "The interpretation of quantum mechanics", *British Journal for the Philosophy of Science,* 4, 95-106, 1953. Both articles are reprinted in: M. Born, *Physics in my generation,* Pergamon Press, 1956. See: M. Bitbol, *Schrödinger's philosophy of quantum mechanics,* Kluwer, 1996

[73] D. Bohm & B. Hiley, *The undivided universe,* Routlege & Kegan Paul, 1993, p. 4, 160.

[74] R. Harré, *Varieties of realism,* Basil Blackwell, 1986; A.A. Derksen, *The scientific realism of Rom Harré,* Tilburg University Press, 1994, p. 7-8

(individually and collectively) the way out is nothing less than: cutting the favorite ontological type-hierarchy at its archetypal root, namely the material body; recognizing (in the full existential strength of this verb) that the priviledged status enjoyed by material bodies in our lives is due only to pragmatical-conventional reasons; *seeing* or *living* the all-pervasiveness of the *as if* clause in our material environment. This condition is difficult to fulfill in a Western context (except, perhaps, for a few phenomenologists able to practice the Husserlian "bracketing" of the Natural Attitude), but it becomes almost trivial in a Mahayana Buddhist context. Hasn't the Buddha himself "(...) rejected the belief in matter"[75]?

7-A dialectic of determinism and indeterminism

From the standpoint of Western culture, both Kant's dialectical critique of metaphysics, and Nagarjuna's symmetric rejection of "views" (drsti), sound negative. They are felt as a renunciation of the grand project of *Episteme* inherited from the ancient Greeks. In this section, I will try to show, on the contrary, that a dialectical reasoning may convey an important positive teaching, and that it may lead one onto the edge of a renewed conception of knowledge.

My example of dialectical reasoning bears on determinism.

It is commonly accepted that the birth of quantum mechanics marks the triumph of indeterminism. But this word, "indeterminism", is so ambiguous that it has generated many misunderstandings about the status of quantum-mechanical laws. It is true that, in quantum mechanics, there is in general no strict predictability of phenomena; that predictions are usually only probabilistic. It is also true that the quantum rules of combination of probabilities[76] are not compatible with the idea that each phenomenon is strictly determined by other phenomena that we just happen to *ignore*. In other terms, the "ignorance interpretation" of quantum probabilities is precluded as long as one holds on to the plane of phenomena. However, this says nothing about the hypothetical "ultimate laws of nature" below the level of phenomena; this says nothing about whether quantum indeterminism is only epistemological, or ontological as well. As D. Bohm pointed out, "(...) the mere uncontrollability and unpredictability of quantum phenomena does not necessarily imply that there can be no quantum world, which would in itself be determinate."[77] Indeed, we now know that there exists a class of processes undergoing chaotic motions, which is both ruled by deterministic laws *and* remains unpredictable. Microphysics thus does not point towards strict, intrinsic, indeterminism; it rather illustrates the *undecidability* of ontological propositions by science, be they about the determinist or indeterminist status of the "ultimate laws of nature." As indicated by J. Harthong, this type of undecidability can easily be expressed in a form that mimicks Kant's dialectic of pure reason. The antinomy of probabilistic predictions develops thus:

Thesis: "The ultimate law of the world is chance, and any partial determinism which could be found in it results from the law of large numbers."

Antithesis: "The ultimate law of the world is entirely deterministic, and any random phenomenon which could be observed results from deterministic chaos."[78]

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[75] Nagarjuna, *Lokatitastava,* in: C. Lindtner, *Nagarjuniana,* op. cit. p. 131

[76] These rules essentially consist in adding the complex *amplitudes* and then squaring the sum.

[77] D. Bohm & B. Hiley, *The undivided universe,* op. cit. p. 25. These ideas about determinism are developed in chapter 8 of: M. Bitbol, *L'aveuglante proximité du réel,* Flammarion, 1998.

[78] J. Harthong, quoted in: A. Dahan-Dalmedico, J-L. Chabert, & K. Chemla, *Chaos et indéterminisme,* Editions du Seuil, 1992; Also: J. Harthong, *Probabilités et statistiques,* Editions Diderot, 1996

This being granted, the strongest argument which can be given in favor of indeterminism in microphysics is that any search for deterministic laws would be *sterile;* that applying the leibnizian principle of sufficient reason at any cost would be fruitless; that no experimentally testable consequence would arise from this research[79]. But, as we have seen, this argument is not compelling. Moreover, it does not prevent one from inquiring philosophically into the possible reasons for unpredictability at the level of microphysical phenomena.

What is fascinating at this point is that many results in the literature on the interpretation of quantum mechanics tend to converge towards one explanation of such an indetermination.

K. Popper[80], to begin with, noticed that, even in a world ruled by underlying deterministic laws, an observer could not predict a phenomenon if she were herself entangled with the process of its production. Unpredictability here results from a logical limitation in *self-prediction*. In short, as soon as the observer has predicted what she will do, the very content of the prediction can influence her future behaviour. This spurious effect of predicting on the predicted behavior may make the prediction wrong. Then, due to the entanglement of the predictor and the phenomena that have to be predicted, the logical limitation of self-prediction results in a limitation of prediction of phenomena.

Much earlier, G. Hermann[81], a young philosopher of science who worked with Heisenberg, explained with some details that one is not bound to assume that quantum phenomena have no cause; only that the causes are not defined in the absolute but only *relative* to the very circumstances of the production of the phenomena.

Even more precisely, P. Destouches-Février demonstrated that any predictive theory bearing on phenomena defined *relative* to possibly incompatible experimental contexts is "essentially indeterminist."[82] Indetermination in the sense of unpredictability is here a direct consequence of the relativity (or context-dependence) of phenomena.

To summarize, a plausible positive teaching of the dialectic of determinism and indeterminism is that microphysical knowledge is contextual, relational, or participatory at the deepest level. At any rate, this is the teaching one is likely to draw from this dialectic if both an absolutist defence of one thesis and a nihilistic reaction to the lack of proof of any thesis, are to be avoided[83].

8-Relational knowledge

It is not precise enough to say that the Madhyamaka and the neo-Kantian philosophies of science are similar in their focus on relations or on relational knowledge. They are also similarly specific about relations. Both of them put relations before (or on the same footing as) the *relata;* both of them share a non-polar conception of relations, and for all that they do not reify relations.

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[79] This is the case, admittedly, in Bohm's hidden variable theory.

[80] K. Popper, *The postscript to the logic of scientific discovery, II The open universe,* Hutchinson, 1982, §22

[81] G. Hermann, "Die naturphilosophischen Grundlagen der Quantenmechanik", *Abhandlungen der Fries'schen Schule,* Sechster Band, 2. Heft. 1935. French translation and extensive comment in: G. Hermann, *Les fondements philosophiques de la mécanique quantique* (Présentation par L. Soler), Vrin 1996

[82] P. Destouches-Février, *La structure des théories physiques,* Presses Universitaires de France, 1951, p. 260-280

[83] The idea of a participatory universe, presented by J.A. Wheeler, is defended in a Buddhist context by: B.A. Wallace, *Choosing reality,* op. cit. Chapters 14, 15. See also: M. Ricard & Trinh Xuan Thuan, *Le moine et le scientifique,* (Forthcoming).

When Nagarjuna equates mutual dependence with emptiness[84], or lack of inherent existence, this clearly shows that he has not the slightest temptation to think that the *relata* precede the relation. He even insists that something which is "(...) due to a cause and which does not exist in lack of such" is like a "reflection"[85], or like "foam, bubbles, illusion, (...)."[86] The relation is what makes the *relata* emerge (as non-inherently existing phenomena), just as much as the other way round. Yet, no ontology of relations is asserted: "Neither connection, nor connected nor connector exist."[87] Indeed, asserting the existence of relations to the detriment of that of the *relata* would involve the use of an opposition (relation-*relata)* and the solidification of one of its terms, whereas the two terms of this opposition *also* arise in dependence.

As for the Neo-Kantian philosophers, they are very careful to put function before substance (to paraphrase the title of a book by E. Cassirer), and relations before their *relata.* According to P. Natorp, Plato's most important discovery in the *Sophist,* at the end of his lifelong discussion about being and not-being, is that they somehow mutually ground each other[88]. The applications of this discovery came much later, especially in Kant's conception of the synthetic power of thought. But as soon as it was clearly understood, it underwent radical developments.

The most prominent neo-Kantian philosophers pointed out that the basic shortcoming of metaphysics consists in "(...) separating correlative standpoints within the field of knowledge itself, *and thus transforming what is logically correlative into an opposition of things."*[89] They then quickly reinterpreted Kant in this spirit, by showing that his basic method of transcendental deduction[90] was precisely aimed at avoiding such an unwarranted transformation. Thus, notwithstanding Kant's original formulations, H. Cohen and P. Natorp claimed that transcendental deduction *should not* be interpreted as an attempt to return to some absolute foundation of knowledge. According to them, there can be no static relation between an epistemic ground (the forms of thought) and something grounded (objective knowledge), where a dynamical process of mutual accomodation is involved[91]. What is expressed by each special instance of transcendental deduction is only a "constraining reciprocity, in which there is neither *prius* nor *posterius."*[92] In other words, what a transcendental deduction reveals is a perfectly symmetrical *relation of co-production.* Yet, here again, no well-rounded ontology of relations emerges: only a tireless study of ever-developing relational cognitive acts.

As previously noticed, the special feature of neo-Kantian philosophies, when compared to the Madhyamaka, is that they are explicitly aimed at the justification of science, and especially of physics. They tend to apply their basic relational insights to the clarification of the nature of

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[84] Nagarjuna, Mulamadhyamakakarika, XXIV, 18, in: J. Garfield, *The fundamental wisdom of the middle way,* op. cit. p. 304

[85] Nagarjuna, *Lokatitastava,* in: C. Lindtner, *Nagarjuniana,* op. cit. p. 129

[86] Nagarjuna, *Acintyastava,* in: C. Lindtner, *Nagarjuniana,* op. cit. p. 147

[87] Nagarjuna, Mulamadhyamakakarika, XIV, 8, in: J. Garfield, *The fundamental wisdom of the middle way,* op. cit. p. 219

[88] E. Cassirer, H. Cohen, & P. Natorp, *L'école de Marbourg,* op. cit. p. 220

[89] E. Cassirer, *Substance and function,* Dover, 1953, p. 271. Italics are mine.

[90] According to C. Taylor's simple definition, a transcendental deduction is "(...) a regression from an unquestionable feature (...)" of our knowledge to "(...) a stronger thesis as the condition of its possibility". Ch. Taylor, *Philosophical arguments,* Harvard University Press, 1995

[91] See C. Schmitz, "Objectivité et temporalité", in: M. Bitbol & S. Laugier (eds.), *Physique et réalité, un débat avec Bernard d'Espagnat,* Editions Frontières, 1997, p. 273

[92] E. Cassirer, H. Cohen, & P. Natorp, *L'école de Marbourg,* op. cit. p. 55

scientific knowledge, and they therefore complement the Madhyamaka in which these insights are predominantly used to promote existential disabuse[93].

If applied, say, to the deduction of Newtonian mechanics by Kant (in his *Metaphysical foundations of natural science),* the neo-Kantian construal of transcendental deduction yields an important epistemological teaching. The very fact that part of this physical theory *can* be transcendentally deduced shows that it must not be interpreted as a reflection of some inherent feature of external reality, but rather as an expression of the *mutual constraints* between the two co-dependent terms of the cognitive relation[94]. More specifically, the extensive use of differential calculus by classical mechanics shows, according to most neo-Kantian thinkers, that only (infinitesimal) relations are accessible, and that no monadic foundation of these relations, no absolutized *relata,* can ever be grasped by physics[95].

In quantum mechanics, the relational structure of knowledge is only enhanced. "(Quantum mechanics) exaggerates the relative character of the description of nature. It abandons the representation according to which the structures of relations are univocally determined by certain connections of things in space and time, and shows their being dependent on the way an observer takes cognizance of the system"[96]. Using the vocabulary of section 3 (point 4), this sentence is to be understood as follows. In quantum mechanics we can no longer content ourselves with describing "lateral" relations between spatio-temporal objects, thus behaving *as if* the "transversal" cognitive relations did not exist or were irrelevant; we have somehow to take into account the multiple cognitive relations between the microphysical domain and the measuring apparatuses. Indeed, due to complementarity (or to the commutation relations), the multiple microdomain-apparatus relations *cannot be reduced to one* and then pushed away in the background. This remark recurs in current neo-Kantian interpretations of quantum mechanics, and in some other interpretations as well[97].

J. Petitot,[98] moreover, insisted that the transversal cognitive relation is represented by the formalism of quantum mechanics in such a way that its "subjective" pole (and also, in all likelihood, its "objective" pole) is not made explicit. Just as in Kant's interpretation of Newtonian mechanics the spatio-temporal structure implicitly conveyed the relational nature of macrophysical knowledge, in a neo-Kantian reading of quantum mechanics the Hilbert space structure implicitly conveys the relational nature of microphysical knowledge while involving no

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[93] Moreover, the neo-Kantian philosophers mostly owe their insights to a free play of ideas, rather than to direct stabilized experience of a disabused outlook.

[94] Of course, the cognitive relation can change, and its terms as well, in the course of the development of experimental research. This is enough to explain that science is liable to revolutions, notwithstanding the possibility of transcendentally deducing its structure at a given stage of its development. Here, the spurious eternalist connotations of Kant's *a priori* should not be allowed to impose on us a foundationalist reading of his transcendental deduction of Newtonian mechanics. Once this is recognized, nothing can prevent us from looking for a (similarly non-foundationalist) transcendental deduction of Quantum mechanics. A sketch of this deduction is provided below.

[95] G. Hermann, *Les fondements philosophiques de la mécanique quantique* (Présentation par L. Soler), op. cit. p. 116; also: H. Cohen, *Le principe de la méthode infinitésimale et son histoire* (French translation by M. de Launay), Vrin, 1999.

[96] G. Hermann, *Les fondements philosophiques de la mécanique quantique* (Présentation par L. Soler), op. cit. p. 119. Also: E. Cassirer, Determinism and indeterminism in modern physics, Yale University Press, 1956, p. 131, 182.

[97] V. Fock, quoted in: M. Jammer, *The philosophy of quantum mechanics,* John Wiley, 1974, p. 202; M. Davis, "A relativity principle in quantum mechanics", *Int. J. Theor. Phys. 16*, 867-874, 1977; M. Mugur-Schächter, "Space-time quantum probabilities II: relativized descriptions and Popperian propensities", *Foundations of physics,* 22, 235-312, 1992

[98] J. Petitot, "Objectivité faible et philosophie transcendantale", in: M. Bitbol & S. Laugier (eds.), *Physique et réalité, un débat avec Bernard d'Espagnat,* op. cit. p. 207-208

description of the two *relata*. From this standpoint, the (non-local) hidden variable theories are to be understood as desperate attempts at pointing towards an inaccessible world of *relata* behind the relational network of standard quantum mechanics.

This feature of quantum mechanics gave rise to interesting developments about the notion of non-supervenient relations, namely relations that do not depend on hypothetical monadic properties of the *relata*[99]. But it was already latent in many earlier discussions on the measurement problem, and on the *entanglement* of state vectors. If one recognizes the purely relational status of the state vector, that is, its being an expression of the propensity for phenomena under activation conditions, the measurement problem reduces to a problem of transition from relativities to monadic properties. It is a problem of breaking the chain of relations expressed by the entangled state vector of the system (object+apparatus), thus jumping to non-relational determinations of both the apparatus and the object. Now, a fascinating proposal for a solution to *this* problem has been given in the framework of Everett's original *"relative state"* interpretation[100]. The solution consists in remarking that, if the experimenter herself partakes of the network of relations, things may *appear* to her *as if* well-defined non-relational determinations arose from the measuring interaction. In short, a state *relative to her* appears *from her standpoint* as a well-determined feature of something substantial. This is a good summary of how reifying (or "absolutizing") illusions may arise.

In addition, it can easily be shown that taking into account this deeply relational character of microphysical processes is nearly enough to derive the basic structure of quantum mechanics[101]. In other words, it can be shown that one may formulate a kind of "transcendental deduction" of quantum mechanics. Of course, the type of transcendental deduction that has to be used to derive the overall structure of quantum mechanics is much more general than Kant's. In this general sense, a transcendental deduction is not a regression from objective knowledge to its conditions of possibility, as in Kant's *Critique of pure reason*. It is a regression from a set of minimal requirements about the scientific process of anticipation of phenomena, to a strong anticipative structure as the condition of possibility for these requirements to be satisfied. Now, taking into account *two* requirements, namely (i) that the anticipation must bear on *contextual* phenomena, and (ii) that the predictive tool must be *unified* under the concept of a *preparation,* the basic anticipative structure of quantum mechanics arises. As J.L. Destouches and P. Destouches-Février[102] argued convincingly, the formalism of vectors in a Hilbert space, together with Born's correspondence rule, is the simplest predictive formalism among those that obey the constraint of *unicity* in a situation where de-contextualization cannot be carried out. Even the general form of the (Schrödinger or Dirac) equations of evolution can be obtained this way, by a series of direct or bridging transcendental arguments[103].

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[99] P. Teller, "Relational holism and quantum mechanics", *British Journal for the philosophy of science,* 37, 71-81, 1986

[100] H. Everett, "'Relative state' formulation of quantum mechanics", in: B.S. De Witt & N. Graham, *The many-worlds interpretation of quantum mechanics,* Princeton University Press, 1973. Here, it is especially important not to mix up Everett's original *relative state* formulation and its later reading in terms of *many-worlds*. See e.g.: Y. Ben-Dov, "Everett's theory and the 'many-worlds' interpretation", *American Journal of Physics,* 58, 829-832, 1990.

[101] M. Bitbol, "Some steps towards a transcendental deduction of quantum mechanics", loc. cit. See section 6 of the present paper.

[102] J.L. Destouches, *Corpuscules et systèmes de corpuscules,* Gauthier-Villars, 1941; P. Destouches, *L'interprétation physique de la mécanique ondulatoire et des théories quantiques,* Gauthier-Villars, 1956

[103] A bridging transcendental argument establishes a *bridge* between the specific form of transcendental deduction which was used by Kant within the direct spatiotemporal environment of mankind, and the generalized sort of transcendental deduction needed in domains of scientific investigation which may go beyond the human *Umwelt*. An

This being granted, typical features of microphysical phenomena such as wave-like distributions and quantization, which are predicted by the quantum theory, no longer appear as contingent aspects of nature. In view of the previous derivation, they rather appear as a necessary feature of any *activity* of production of contextual and mutually incompatible phenomena whose level of reproducibility is sufficient for its outcomes to be embeddable in a unified system of probabilistic anticipation. Of course, this does not mean that quantum mechanics could have been obtained by mere armchair philosophizing. Only that the structure of quantum mechanics has *retrospectively* revealed its deeply relational nature to the philosophical inquiry. As was the case for Kant's deduction of Newtonian mechanics, the very *possibility* of a transcendental deduction of quantum mechanics teaches us something important about the status of this theory. It suggests that quantum mechanics should not be construed as a reflection of some (exhaustive or non-exhaustive) aspect of a pre-given nature, but as the structural expression of the *co-emergence* of a new type of experimental activity and of the "factual" elements that constrain it[104].

Here again, these results and reflections are easily available in the literature. They were strongly promoted by the neo-Kantian trend in philosophy of science. But in order to become widely accepted, in order to be articulated into a new coherent participatory conception of the world, they will need to overcome the Western urge for foundations, and for reification of the pragmatic categories of everyday life. This can occur only through their integration within a higher-order axiological and existential operator (not to say within an alternative *form of life)* of which the Madhymika dialectic and soteriology is likely to be the central element.

9-Conclusion

What is the use of this article, beyond its philosophical content? It does not pretend to be a substitute for the best spiritual writings of the Mahayana Buddhist tradition, nor even to add the slightest contribution to them. Even less can it alone induce the self-transformation of other human beings. But it may weaken the intellectual ground of those who still (roughly one century after the alleged fading of scientism) take science as the modern equivalent of the late religious dogma. It may also, more importantly, help those who are already engaged in a process of self-transformation not let themselves be impressed, at an intellectual level, by the substantialist tales of the majority of physicists. It may above all give them a hint as to how to integrate the many strata of their life and thought in our modern culture. These effects having, hopefully, been obtained, the present article is to be thrown away as any other step in the Wittgensteinian ladder towards what really matters.

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example is Bohr's correspondence principle, which ensures a connection between the basic thing-like organization of everyday life and classical mechanics, and the contextual organization of quantum mechanics. See M. Bitbol, "Some steps towards a transcendental deduction of quantum mechanics", loc. cit

[104] See F. Varela, E. Thompson, & E. Rosch, *The embodied mind,* op. cit. for similar remarks in the general framework of the cognitive sciences.