

Contemporary Science Between Theoretical and Practical Reason: A Transcendental-Pragmatic Approach to Quantum Theory

PATRICIA KAUARK-LEITE¹

Abstract

The aim of this paper is to show that in the contemporary context of quantum theory, the Kantian radical distinction between theoretical and practical reason can no longer be held. I argue that the theoretical and a priori subjective conditions of experience, as represented in quantum mechanics, are inexorably connected to the *a priori* conditions of communication between agents in the world. Therefore, theoretical reason cannot be detached from practical reason, as Kant holds, but on the contrary we now have one unified capacity for reason that is at the same time theoretical *and* practical, and, in that sense, *transcendental-pragmatic*.

Keywords: theoretical reason, practical reason, transcendental pragmatics, quantum theory.

La ciencia contemporánea, entre la razón teórica y la práctica: una aproximación trascendental-pragmática a la mecánica cuántica

Resumen

El propósito de este trabajo es mostrar que la radical distinción kantiana entre razón teórica y razón práctica no puede ya mantenerse en el contexto contemporáneo de la teoría cuántica. Sostengo que las condiciones de la experiencia subjetiva, teórica y a priori, tal como están representadas en la mecánica cuántica, se encuentran inexorablemente conectadas con las condiciones *a priori* de comunicación entre agentes en el mundo. Por lo tanto, la razón teórica no puede ser desvinculada de la razón práctica, tal como Kant afirma, sino que por el contrario tenemos ahora una capacidad racional unificada que es al mismo tiempo teórica y práctica, y, en este sentido, *pragmática-transcendental*.

Palabras clave: razón teórica, razón práctica, pragmática-transcendental, teoría cuántica.

In Kant's Critical philosophy, pure reason plays specific and independent roles in the theoretical and practical domains. In the third chapter of the "Doctrine of Method" in the first *Critique*, the "Architectonic of Pure Reason", Kant discusses the contrast between theoretical and practical reason. Here he points out:

[Theoretical reason] contains all rational principles from mere concepts (hence with the exclusion of mathematics) for the theoretical cognition of all things; [practical reason], the principles which determine action and omission *a priori* and make them necessary (A841/B 869).

Reason, as a faculty completely independent of the sensibility, is initially presented as the source of metaphysical illusion, in its claim to know objects that are not given in empirical intuition and therefore can never be known. Although by the end of the "Transcendental Dialectic", theoretical reason is also presented as the source of valuable and positive regulative principles for both the

¹ Universidade Federal de Minas Gerais.

human conduct of scientific theoretical inquiry and also practical reasoning, nevertheless it is only practical reason that can justify our non-cognitive belief, or faith (*Glaube*), about God, freedom, and immortality. In this sense, the *Critique of Practical Reason* will be able to justify a certain non-cognitive use of theoretical Ideas as ‘postulates of practical reason’. These Ideas of reason regarding non-empirical objects can have a legitimate real use that may be validated by moral considerations. So pure reason has a real use, that is not merely regulative, only as practical reason.

This entails a strong division between theoretical and practical reason. The former is concerned only with objectively valid cognition (*Erkenntnis*) carried out by theorizing human subjects, and the latter with the rational capacity for deliberating about actions by practical human agents. In this regard, Newtonian laws of nature are fully justified in the theoretical domain of pure reason, and moral laws in the practical domain of pure reason.

Nevertheless, in the contemporary context of quantum theory, this radical distinction between theoretical and practical reason can no longer be held. Following Niels Bohr’s and Michel Bitbol’s interpretation of quantum theory, and also inspired by Jürgen Habermas’s and Karl-Otto Apel’s transcendental pragmatics, I will argue that the theoretical and a priori subjective conditions of experience, as represented in quantum mechanics, are inexorably connected to the *a priori* conditions of communication between agents in the world. If this is correct, then it follows that theoretical reason cannot be detached from practical reason, as Kant holds, but on the contrary we now have one unified capacity for reason that is at the same time theoretical *and* practical, and, in that sense, transcendental-pragmatic.

The novelties introduced by Bohr’s interpretation of quantum theory lead us to consider his ideas in the context not only of one of the most radical scientific revolutions that occurred in the 20th century, but also of the transcendental-pragmatic ‘linguistic turn’ in 20th century philosophy. As we will see, in Bohr’s pragmatic conception of quantum theory, the Kantian sharp distinction between theoretical and practical reason becomes blurred, and is ultimately rejected and replaced by a different and more unified conception of reason.

The transcendental-pragmatic linguistic turn is part of a more general movement known as the linguistic turn. As is well-known, the label ‘linguistic turn’ first occurred in the title and Editor’s Introduction of a highly influential collection of essays about the foundations and genesis of Analytic philosophy, edited by Richard Rorty, and first published in 1967. By means of this label, he wanted to describe the most essential feature of the philosophical movement initiated by G. Frege (1884/1974, 1892/1980) and B. Russell (1911, 1912, 1914, 1924), namely the transformation of all philosophical problems into ‘problems of language’, which in turn becomes the new primary focus of philosophical investigation. In Rorty’s words: “I shall mean by ‘linguistic philosophy’ the view that philosophical problems are problems which may be solved (or dissolved) either by reforming language, or by understanding more about the language we presently use” (Rorty, 1992: 3). According to Karl-Otto Apel (1989), the linguistic turn is triggered on the one hand by early Wittgenstein’s *Tractatus Logico-Philosophicus* (1921), and on the other hand by constructive logical semantics, as developed by Carnap (1928) and Tarski (1944). According to Apel, the linguistic turn is characterized by the philosophical adoption of fundamental ‘logico-linguistic concepts’ instead of ‘mentalist concepts’ such as ‘consciousness’, ‘judgment’, ‘thought’ or ‘intentionality’. In the *Tractatus*, Wittgenstein added to this basic linguistic turn a transcendental-semantic twist, whereby the Kantian supreme principle of all synthetic judgments in the Transcendental Analytic, which says that “the conditions of the *possibility of experience* in general are at the same time the conditions of the *possibility of the objects of experience*, and on this account have objective validity in a synthetic judgment a priori” (Kant 1998: 283; A158/B197) was replaced by an equivalent logico-linguistic postulate. This postulate expresses the idea that the logico-transcendental conditions of pure language are the conditions of the possibility of all actual and possible atomic and molecular facts in a describable

world. Apel (1989: 21) considers this principle, that he called ‘principle of the onto-semantic autonomy and methodological non-transcendability of language’, as the irreversible standard of twentieth century philosophy and the major criterion of the linguistic turn.

It was Wittgenstein himself who first recognized the essential connection between the problems of ‘the limit of language’ as revealed by his philosophy, and the transcendental solution given by Kant:

The limit of language manifests itself in the impossibility of describing the fact that corresponds to (is the translation of) a sentence without simply repeating the sentence. (We are involved here with the Kantian solution of the problem of philosophy). (Wittgenstein 1998: 13; MS 110, 61: 10.2.1931)

I follow Robert Hanna (2015) here in his analysis of the relation between Wittgenstein and Kant. According to him, “Wittgenstein’s conception of human language is essentially the same as Kant’s Critical conception of human rationality”. In this sense, the early Wittgenstein carries out a linguistic turn from a specifically *transcendental* point of view. As Apel (1989) points out, the linguistic transcendentalism of Wittgenstein presupposes at least three things: 1) the idea of a ‘pure language’, or logically deep structure of all possible languages, that constitutes the underlying ontological structure of the describable world; 2) that meaningful language should consist only of propositional sentences whose only function is to represent states of affairs, or actual or possible facts; and 3) the reference of the signs to real objects must be guaranteed by the structure of language itself. The first of these assumptions was abandoned by Carnap (1950) and replaced by a plurality of linguistic frameworks playing a quasi-transcendental function in relation to which various descriptions and scientific explanations of the world of experience can be meaningful.

However, even despite their important similarities, there is also a radical methodological difference between Kant’s *Critique of Pure Reason* and Wittgenstein’s *Tractatus*. Instead of seeking to establish the limits of pure reason, as Kant did, Wittgenstein proposes instead to establish the limits of meaningful discourse. In this sense, the linguistic turn is centered on the transformation from an analysis of conscious intentionality, to an analysis of language in which the logico-semantic conditions of language play the role of Kantian a priori forms of cognition. Wittgenstein’s investigation of the limits of propositional meaningfulness replaces Kant’s investigation of the limits of cognitive meaningfulness and knowledge. Thus for Wittgenstein in the *Tractatus*, metaphysical propositions cannot be ‘said’, but only ‘shown’, and strictly speaking are nonsensical; whereas for Kant in the first *Critique*, synthetic a priori metaphysical propositions are always at least thinkable, and if they express the conditions of the possibility of human experience, then they are not only thinkable and fully meaningful, but also scientifically valid. For Wittgenstein, however, the scope of scientific meaningfulness is much narrower. For meaningful propositions such as those found in the natural sciences, the incompatibility of language and description does not hold, provided that they can be reduced to pictorial representations of facts cashed out in observational terms. Nevertheless, if scientific propositions could not be reduced to descriptions in observational terms, they would be also nonsense and natural sciences would suffer the same fate as metaphysics. We will see that this very strict criterion of meaningfulness developed by early Wittgenstein in the *Tractatus*, which in turn heavily influenced Carnap’s logical empiricism, in fact becomes highly problematic when it is applied to the propositions of quantum mechanics.

Besides, according to Apel, the semantic theory that leads from Wittgenstein’s *Tractatus* to the syntactic-semantic frameworks deployed by Carnap and Tarski, suffers from a fallacious abstraction by not properly considering the transcendental-pragmatic dimension of language. In this way, the first phase of the linguistic turn concentrated on the logico-semantic boundaries of meaningfulness, but we must also recognize along with Habermas (1992: 57-86) and Apel (1989) that due to a certain abstractions, the logico-semantic phase of the linguistic turn, on its own, could not

solve certain essential philosophical problems and therefore a further turn to transcendental pragmatics is necessary. If we abstract away from the communication situation, from concrete contexts of speech, and from the actual use of language, then the investigation of syntax and semantics is restricted to the formal analysis of propositions. Therefore, a complete linguistic turn should consider the transcendental-pragmatic condition of the possibility of our intersubjectively valid discourse and discursive knowledge of the world.

The transcendental-pragmatic turn inside the larger linguistic turn involves, first, the later Wittgenstein's move towards a philosophy of ordinary language centered on the effective use of linguistic signs. And second, it involves the serious reconsideration of C.S. Peirce's semiotic and pragmatic transformation of Kant's transcendental logic. By transforming the single cognitive subject into an intersubjective community of interpreter-subjects, Peirce establishes the triadic function of the sign as a necessary mediation for the interpretation of the world and thus, as a condition of possibility of discourse and discursive knowledge about reality. Apel characterizes Peirce's semiotics as transcendental insofar as it seeks to provide the conditions of possibility of intersubjective valid discourse and discursive knowledge of the world.

Apel's and Habermas's transcendental-pragmatic approaches to the philosophy of language take into account the scientific contents of consciousness and intentionality not only in their representation of reality, but also and more fundamentally in their triple communicative relationship: they are (1) statements about things of the world, (2) that express the subject's intention, (3) for the linguistic community's members. The meaning of a scientific statement is then analyzed as a linguistic action used by the participants in communicative community.

In this perspective, both the propositional and also the performative dimension of language must be analyzed. This means that in the analysis of the meaning of any proposition whatsoever, whether it be scientific or practical/moral, two dimensions are entangled: that of the lifeworld and that of natural language. A valid proposition must both rely on the world of experience and also be rationally founded, that is to say that its scientific content must be fully defensible in the face of all possible counterargument. This in turn implies that the validation of any propositional content whatsoever must be 'discursively' decided. Or in other words, the necessarily intersubjective dimension of language must be taken into account. The Habermasian distinction between, on the one hand, 'language games' falling under the conditions of the possibility of objective experience, and on the other, the discussion of the reasons for the claim to validate arguments, leads us to consider, correspondingly, two dimensions of the a priori preconditions of scientific experience: (i) the a priori theoretical dimension of experience as a matter of representing how things are, and (ii) the a priori practical dimension of experience related to scientific discourse. This latter dimension presupposes a normative framework of science that is not reducible either to the descriptive or explanatory domain or to the realm of ethical values.

Let's now see how these pragmatic ideas arise in the context of quantum theory. According to Bohr, the activity of the human cognizer cannot be separated from the activity of the human agent who has to communicate his experimental outcomes to the other subjects within a scientific community. Both activities should be considered as parts of an interpretation process, where the purely formal symbols are related to intuitive concepts in a given experimental situation through the principle of complementarity.

It is precisely because the conditions of possibility of understanding are inextricably linked to the conditions of possibility of communication that we should characterize Bohr's philosophical view as both pragmatic and transcendental. It is pragmatic because, as Bohr points out, the activity of understanding cannot be included within a strict semantic perspective that relates scientific concepts to particular empirical intuitions by disregarding their communicative use by the members of

scientific community. And it is transcendental because Bohr's investigative approach to the conditions of possibility of understanding leads him to establish some a priori performative invariants, which cannot be lacking in any research activity.

Thus, following the later Wittgenstein, the supreme principle of all synthetic judgments of Kant's transcendental philosophy can be replaced in Bohr's framework by a transcendental-pragmatic thesis according to which the conditions of possibility experience in general are at the same time conditions of the possibility of an unambiguous communication of the results of an experiment to the members of a scientific community.

Bohr's transcendental-pragmatic approach is evident even when he recognizes that the roots of his complementarity principle lie in the fact that there is a quantum of action for microphysical phenomena. This has generated many misunderstandings in discussions of the interpretation of quantum mechanics and has led many philosophers of science to consider Bohr's position as empiricist or even realistic. Nevertheless, Bohr refuses to interpret the discovery of the quantum of action in a realistic way. On the contrary, he sees it as a discovery that highlights the performative dimension of scientific language, always hidden by traditional epistemological analyses (see Bohr 1937, 1949 and 1958). According to Bohr, this performative fact leads us to interpret the meaning of scientific language in different ways in the experimental context, depending on whether the quantum of action can or cannot play a significant value role. From this perspective, he construes the distinction between macroscopic and microscopic levels (or ordinary and quantum levels) not as a division between two levels of realities – macro and micro (as in the realistic approaches) – or even between the two levels of languages – observational and theoretical (as in the empiricist semantic approaches due to Carnap and other logical empiricists). Instead, this Bohrian macro/micro distinction has its full sense only if we construe it in a transcendental-pragmatic perspective, according to a meaningful use of scientific concepts that is always, at once, both theoretical and practical. So, for Bohr, the quantum of action is a quantum condition not referring to any kind of determination by a mind-independent reality, but rather to the attitudes of scientists in their practical use of concepts.

Unlike H. Folse (1978), who sees in Bohr's conception of the quantum of action the starting point of his empirical-realistic approach, therefore, I put myself on the side of J. Honner (1982), who considers the conception to be part of a broader program that seeks transcendental conditions of possibility for a valid scientific discourse and at the same time for a valid scientific experience.

In this perspective, the only sense that can be given to the ordinary role of scientific descriptions is limited to the macroscopic processes, where the semantic references can be unambiguously defined and where all the experimental situations take place. Consequently, all the attempts to attribute either mind-independent ontological reality, or a semantic description to microscopic entities as if they were unobservable phenomena, can lead to insurmountable confusion. As Bohr pointed out, the word 'phenomenon' should be reserved for what appears and therefore only for the macroscopic domain. So 'unobservable phenomenon' is a contradiction in terms. The problem then is how to show that the objectivity of physics is maintained in the face of the development of quantum experiments that go beyond our ordinary experience of everyday life. Following Bohr, my view is that the answer to the problem of quantum objectivity is not to be found in a referential semantics for unobservable objects but in a transcendental analysis of the conditions of the possibility for unambiguous scientific communication. As Bohr puts it: "By the word 'experiment' we refer to a situation in which we can tell others what we have done and what we have learned" (Bohr 1991: 207).

Insofar as Bohr identifies the conditions of objectivity with those of an unambiguous scientific communication, his argument, which has a distinctly transcendental character, should be directed to the search for the conditions of possibility under which physicists, as finite and rational human beings acting in the world and belonging to a linguistic community, use concepts. For Bohr,

the fact that the concepts of daily life are used even for processes that extraordinarily exceed the range of our ordinary experience is a transcendental condition of scientific communication. Nevertheless this is only a necessary but not a sufficient condition for solving the problem of the objectivity of quantum theory.

The project of specifying the use of scientific language according to different levels, in order to make unambiguous descriptions of experimental phenomena, does not however solve another much deeper problem, which is how to make comprehensive or exhaustive descriptions of the experimental phenomena. For Bohr, all the references to phenomena in quantum mechanics should be taken contextually. That is, what we call phenomena depends on the local, surrounding circumstances in which we observe them. In this sense, no sharp distinction can be made between the observed object and the experimental apparatus we use to observe it. In Bohr's words: "No sharp distinction can be made between the behavior of the [atomic] objects themselves and their interaction with the measuring instruments" (Bohr 1958: 61). Taking this contextuality condition into account, the solution for problem of the completeness of an exhaustive description of the quantum phenomena is given by the complementarity principle. Thus this principle plays a major transcendental role in Bohr's thought. As Bohr clearly pointed out: "Far from containing any foreign mysticism to the spirit of science, the notion of complementarity points to the logical conditions for description and comprehension of experience in atomic processes" (Bohr 1991: 288; 1958: 91). In this quotation 'the logical conditions' to which Bohr refers are best understood as 'transcendental conditions'.

In his paper, "Causality and Complementarity" (1937) and also in other texts, Bohr argues that the complementarity principle is quantum theory's substitute for the classical principle of causality. This Bohrian principle, in general terms, tries to establish the conditions of the possibility for the intelligibility of the quantum physical phenomena. Otherwise put, this principle is the answer to the transcendental question of 'how a theory that takes the quantum of action as a fact is possible?' This does not mean that we are denying the empirical conditions that are imposed by the quantum of action. On the contrary, by admitting it as a scientific fact, what Bohr is really doing is the same Kantian reflective project of seeking the transcendental conditions of the possibility of that fact, even though he does describe it in precisely this way. Thus, we find that for Bohr, the conditions of objectivity are determined, on the one hand, by the subjective conditions of our contextually enlarged sensitivity, that is to say our sensitivity amplified by the measuring instruments, and on the other hand the conditions of objectivity are determined by the intersubjective conditions of our language in unambiguously communicating scientific concepts and thoughts.

Here we have a similar situation to the Kantian doctrine of transcendental idealism, where the borderline between subjective and objective facts is quite fluid. Thus, for Kant, on the one hand the a priori conditions of subjectivity are also those of objectivity, and on the other hand, the a priori conditions of the objects of experience are also those of transcendental apperception (the 'I think'). Similarly in Bohr's view, the subjective conditions of our observer position and the intersubjective ones in its function of an unambiguously communicating scientific thoughts and applying scientific concepts are the conditions for objectivity 'complementarily' understood, that also satisfy the completeness requirement.

This new way of updating Kant's transcendental idealism also draws inspiration from Michel Bitbol's work, in which there is an attempt to develop an even more pragmatic approach, in which the a priori are associated with specific modes of practical activity. In critical response to representational approaches, which lead to insurmountable paradoxes when applied to microphysics, Bitbol develops a more coherent alternative that provides an explanation for the basic theoretical structure of quantum mechanics, by exhibiting the conditions of possibility of scientific research activity oriented towards quantum measurement results.

The special place that Bohr reserves in quantum physics for ordinary language and also for classical concepts, which for him are nothing more than refined every day concepts, has its fundamental explanation in his principle of complementarity. In quantum experimental contexts, the classical concepts do not have their ordinary referential function, but instead their complementarity-determined meaning depends on their application in specific experimental situation where the subject's act of observation of a quantum phenomenon is part 'of the phenomenon itself'. If we think of ordinary language practices as language-games, in Wittgenstein sense, that played by scientists in their activity of communicating an experimental outcome, we can derive a new sense of objectivity in physics. This objectivity is not 'subjectively' determined by a universal transcendental ego, as Kant (and also, in the 20th century, Husserl) thought, but is instead 'intersubjectively' determined, as Bohr clearly noticed in the context of the quantum mechanics, by the preconditions of language, which make possible unambiguous communication about experimental facts between the members of a scientific community. The essential philosophical meaning of Bohr's complementarity principle is the thesis that the theoretical activity of understanding cannot be separated from the practical communicative activity of scientists. So, similarly to the later Wittgenstein, Bohr's account of scientific thinking and scientific concepts requires a pragmatic factor for the determination of meaningfulness. Moreover, Bohr's semantic pragmatism is more adequately construed from a transcendental-pragmatic point of view than it is from a classical pragmatic perspective, as has been proposed by Manuel Bächtold (2008).

Putting transcendentalism and pragmatism together, then, we have an illuminating and adequate Kantian interpretation of Bohr's thought that is not 'strictly' Kantian. Briefly sketched, we have the following. At a constitutive level, scientific physical knowledge of the world tries to reconstruct the phenomenon in its logical-mathematical structure, but this logical-mathematical rationality is not sufficient. Beyond that, scientific knowledge presupposes a discursive plan in the light of which this knowledge can be elucidated and unambiguously communicated. In this sense, the mathematical structure of physical theory is a transcendently necessary condition, but not sufficient. Furthermore, discursive rationality must be presupposed. In this way, a performative level emerges beyond the propositional level of lifeworld propositions. Because the world, as represented, has this linguistic-pragmatic character, it has several meanings. If we consider the world as significant, our pre-understanding is a condition of possibility for all experiences and for our actions in the world. So, to the extent that Bohr's thought can be importantly compared to Kant's thought, it is not in the strict Kantian sense, but rather a transcendental-pragmatic derived from Kant-oriented contemporary philosophy.

Let me now try to summarize the fundamental thesis of this transcendental- pragmatic approach to Bohr's interpretation of quantum mechanics:

- i) To the extent that it is contextually dependent on observational conditions, physical knowledge of the world claims at a constitutive level to be able to reconstruct the phenomenon in its logical-mathematical structure;
- ii) and in quantum physics this logical-mathematical structure is identified for instance with the formalism of the wave function in Hilbert space and the bridge between the abstract structure and the experience is given by Born's rule;
- iii) but this logical-mathematical rationality however, as Apel and Habermas have pointed out, is not sufficient;
- iv) hence we need to presuppose a further discursive level of ordinary language, in the light of which the phenomenon with its measurable outcomes can be meaningfully described and unambiguously communicable.
- v) Both levels – the logical-mathematical one and the ordinary linguistic one – should be considered as parts of a single holistic process of interpretation, whereby the purely

formal symbols are linked with concepts that are subordinated either to the experimental activity of measurement or to the activity of speech.

- vi) Thus new transcendental principles must be found not only in the constitutive structure of experience but also in the performative intentions in reference to which the constitutive utterances are enunciated in order to obtain an unambiguous intersubjective understanding and agreement.

In these ways Bohr's interpretation of quantum mechanics and Bitbol's transcendental-pragmatic approach to quantum mechanics jointly allow us to assert that the performative dimension of quantum objectivity is irreducible and cannot be overlooked. It is no longer a question of thinking that this objectivity is caused by an unobserved reality, even if this reality is taken as unknowable or veiled. For the proper understanding of why this objectivity is acceptable in classical theory but no longer acceptable in quantum theory, a comparison can be made between 'things in themselves', in Kantian sense, and 'atoms in themselves' as non-perceptible things that have a real existence completely independent of minds like ours. In the classical theory of atomic structure, which lasted until the end of nineteenth century, atomic ontology was standard and atoms were broadly understood as mind-independent substances or unobservable Kantian material things-in-themselves. However, they could also be understood in other Kantian terms as regulative Ideas of reason, *i.e.*, as creations of our capacity for theoretical rationality, which are absolutely useful and necessary to extend, as far as possible, our understanding of the experiential domain. The atom was conceived in this sense as a 'transcendental object = X' that we took *as* 'if' it had its own existence independent of us. The problem is that quantum mechanics seems clearly to have decisively refuted this notion of objectivity, whether in fully realistic terms as a Kantian 'thing in itself', or as a heuristic Idea of theoretical reason as Kant conceived it in "Transcendental Dialectic". I think it is clear that Kant epistemologically established that the concept of an object cannot be wholly separated from the subjective conditions of sensibility and understanding. He had already given up the implicit noumenal-realist account of objectivity in classical physics, which presuppose the existence and causal powers of the object regardless of the way the subject know it. Nevertheless, the 'Kantian turn' in quantum mechanics is a more radical renunciation of the notion of objectivity in classical physics. Quantum mechanics introduces a new concept of possible experience that cannot be explicated in classically Kantian terms. Even more radical than Kant's 'Copernican revolution', in epistemology and metaphysics, the concept of an object in quantum mechanics cannot be understood without referring, on the one hand, to a priori formal theoretical conditions of objective representation, and on the other, to the context-dependent experimental conditions in which we interact with the object. But Kant's theory of experience does not take into account this kind of interaction in his semantic analysis of classical scientific judgments.

As von Weizsäcker pointed out, the quantum-mechanical wave function indicates the probability for each possible outcome of each possible experience of the experimental object. These two meanings of the word 'possible' in quantum experience outstrip the one defined by Kant and highlight the quantum-mechanical renunciation of Kantian notion of objectification. The first meaning, according to von Weizsäcker, expresses our ignorance regarding the causal intervention of any ultimately non-controlled physical process in the conditions of a possible experience. The second meaning expresses the possibility of willing and acting, that is to say our power to choose to carry out an experiment, or not. This second meaning of the word 'possible' is quite divergent from Kantian original notion of "possible" experience and emphasizes that the boundaries between theoretical reason and practical reason, or between knowledge and action, are fluid and not rigid.

In the *Critique of Pure Reason*, possible experience belongs to the domain of what is knowable by means of a theoretical reason that is transcendently separated from the domain of willing by means of practical reason. In the classical Kantian sense, what makes experience possible

are the a priori conditions of human sensibility and understanding, which are completely independent of material and also practical conditions for carrying out any sort of classical experiment. It is precisely this doubly-radical kind of ‘deobjectification’ that confers on the transcendental-pragmatic analysis of quantum mechanics a more original interpretation of philosophy in general and of Kant’s philosophy in particular.

By way of concluding this paper, I would like to stress that if we follow Bohr’s analysis of quantum theory, we should seriously consider the necessarily intersubjective character of objectivity, that only the pragmatic perspective allows us take to take fully into account. The objectivity of experience is thus understood ‘as what can be can be contextually-shared in an intersubjective way’. Objectivity is contextually-shared intersubjectivity. Quantum mechanics is the most exemplary case of the fact that the performative dimension of language partially constitutes objectivity itself, as this dimension is explored in Wittgenstein’s, Austin’s, Habermas’s, and Apel’s theories of the nature of experience, now explicitly including scientific experience. According to them, the propositions used to communicate experiments are themselves the expressions of intentional actions. Bohr’s and Bitbol’s interpretation of quantum theory, in turn, building on Austin’s, Habermas’s, and Apel’s transcendental-pragmatic turn, leads us to propose that the mathematical formalism of scientific rationality cannot be disengaged from the irreducibly practical situation of human intentional agents in the world.

Bibliography

- APEL, Karl-Otto: “From Kant to Peirce: the semiotic transformation of transcendental logic”, in BECK, L. W. (ed.): *Proceedings of the Third International Kant Congress 1970*, Dordrecht, Reidel, 1970, 90-104.
- APEL, Karl-Otto: *Understanding and Explanation: A Transcendental-Pragmatic Perspective*, G. Warnke (trans.), Cambridge (Mass.)/London, The MIT Press, 1984.
- APEL, Karl-Otto: “Linguistic meaning and intentionality: the compatibility of the ‘linguistic turn’ and the ‘pragmatic turn’ of meaning-theory within the framework of a transcendental semiotics”, in DELEDALLE, G. (ed.): *Semiotics and Pragmatics: Proceedings of the Perpignan Symposium*, Amsterdam/Philadelphia, John Benjamins Publishing Company, 1989, 19-70.
- APEL, Karl-Otto: *Towards a Transformation of Philosophy*, G. Adey and D. Fisby (trans.), Milwaukee, Marquette University Press, 1998.
- AUSTIN, John L.: *How to do things with words*, Oxford, Clarendon Press, 1962.
- BÄCHTOLD, Manuel: *L’Interprétation de la mécanique quantique: une approche pragmatiste*, Paris, Hermann éditeurs, 2008.
- BITBOL, Michel: *Mécanique quantique: une introduction philosophique*, Paris, Flammarion, 1996.
- BITBOL, Michel: *L’aveuglante proximité du réel: anti-réalisme et quasi-réalisme en physique*, Paris, Flammarion, 1998a.
- BITBOL, Michel: “Some steps towards a transcendental deduction of quantum mechanics”, *Philosophia naturalis* 35 (1998b) 253-280.
- BITBOL, Michel: “Relations, Synthèses, Arrière-Plans ; sur la philosophie transcendantale et la physique modern”, *Archives de Philosophie* 63 (2000a) 595-620.
- BITBOL, Michel: “Arguments transcendants en physique modern”, in CHAUVIER, S. and CAPELLÈRES, F. (ed.): *La querelle des arguments transcendants*, Revue philosophique de l’Université de Caen 35 (2000b) 81-101.
- BITBOL, Michel: “Anticiper l’unité : une méthode de connaissance”, in CAZENAVE, M. (ed.): *Unité du monde, unité de l’être*, Paris, Dervy, 2005.

- BITBOL, Michel: “Reflective Metaphysics: Understanding Quantum Mechanics from a Kantian Standpoint”, *Philosophica* 83 (2010), 53-83.
- BITBOL, Michel and OSNAGHI, Stefano: “Bohr's Complementarity and Kant's Epistemology”, Bohr, 1913-2013, *Séminaire Poincaré XVII* (2013) 145-166.
- BOHR, Niels: “The quantum postulate and the recent developments of atomic theory”, *Nature* (Suppl.) 121 (1928) 580–590.
- BOHR, Niels: “Introductory Survey (1929)”, in: *Atomic Theory and the Description of Nature*, 1-24, Cambridge, Cambridge University Press, 1934.
- BOHR, Niels: “Causality and Complementarity”, *Philosophy of Science* 4 (3) (1937) 289-298.
- BOHR, Niels: “Discussion with Einstein on epistemological problems in atomic physics”, in P.A. Schilpp (ed.): *Albert Einstein: Philosopher-Scientist*, The Library of Living Philosophers, Vol. VII, 201-24, Evanston (IL.), 1949.
- BOHR, Niels: *Essays 1958-1962 on Atomic Physics and Human Knowledge*, New York, Wiley & Sons, 1963.
- CARNAP, Rudolf: “Empiricism, Semantics, and Ontology”, *Revue Internationale de Philosophie*, 4 (1950) 20-40.
- CARNAP, Rudolf: *The logical structure of the world* (1928), R. George (trans.), London, Routledge & Kegan Paul, 1967.
- FOLSE, Henry: “Kantian aspects of complementarity”, *Kant-Studien* 69 (1978) 58-66.
- FOLSE, Henry: *The Philosophy of Niels Bohr: The framework of complementarity*, Amsterdam, North-Holland, 1985.
- FREGE, Gottlob: “On Sense and Reference (1892)”, M. Black (Trans.), in GEACH, P. and BLACK, M. (eds.): *Translations from the Philosophical Writings of Gottlob Frege*, Oxford, Blackwell, 1980 (3rd ed.).
- FREGE, Gottlob: *The Foundations of Arithmetic: A logico-mathematical enquiry into the concept of number* (1884), J. L. Austin (trans.), Oxford, Blackwell, 1974 (2nd revised ed.).
- HANNA, Robert: “Wittgenstein and Kantianism”, in GLOCK, H.-J. and HYMAN, J. (ed.): *Blackwell Companion to Wittgenstein*, Oxford, Blackwell, 2015.
- HABERMAS, Jürgen: *Postmetaphysical thinking: philosophical essays* (1988), W. M. Hohengarten (trans.), Cambridge (Mass.), MIT Press, 1992.
- KANT, Immanuel: *Critique of practical reason* (1788), in GREGOR, Mary J. (trans. and ed.): *Immanuel Kant: Practical Philosophy*, 133–272, Cambridge, Cambridge University Press, 1996.
- KANT, Immanuel: *Critique of pure reason* (1781/1787), GUYER, P. and WOOD, A. (trans. and ed.), Cambridge: Cambridge Univ. Press, 1997.
- KAUARK-LEITE, Patricia: “Transcendental philosophy and quantum physics”, *Manuscrito: Rev. Int. Phil.* 33 (1) (2010a) 243-267.
- KAUARK-LEITE, Patricia: “Classical Reason and Quantum Rationality: Transcendental Philosophy Face Contemporary Physics”, in BRYUSCHINKIN Wladimir N. (ed.): *Klassische Vernunft und Herausforderungen der modernen Zivilisation*, Bd. 2, 237– 246, Kaliningrad, Baltische Föderale Immanuel-Kant-Universität, 2010b.
- KAUARK-LEITE, Patricia: *Théorie quantique et philosophie transcendantale: dialogues possibles*, Paris, Éditions Hermann, 2012.
- KAUARK-LEITE, Patricia: “Redefining the Curvature of the Arc: Transcendental Aspects of Quantum Racionality”, in KAUARK-LEITE, Patricia; CECCHINATO, Giorgia; FIGUEIREDO, Virginia A.; RUFFING, Margit; and SERRA, Alice (eds.): *Kant and the Metaphors of Reason*, 561-577, Hildesheim, Olms, 2015.
- PEIRCE, Charles S.: *Philosophical writings of Peirce*, J. Bucher (ed.), New York, Dover Publications, 1955.

- PRINGE, Hernán: *Critique of the Quantum Power of Judgment. A Transcendental Foundation of Quantum Objectivity*, Berlin, De Gruyter, 2007.
- RORTY, Richard (ed.): *The linguistic turn: essays in philosophical method*, Chicago, The University of Chicago Press, 1967.
- RORTY, Richard (ed.): *The linguistic turn: essays in philosophical method, with two retrospective essays*, Chicago, The University of Chicago Press, 1992.
- RUSSELL, Bertrand: "Knowledge by Acquaintance and Knowledge by Description", *Proceedings of the Aristotelian Society* 11 (1911) 108–128.
- RUSSELL, Bertrand: *The Problems of Philosophy*, London, Williams and Norgate/New York, Henry Holt and Company, 1912.
- RUSSELL, Bertrand: *Our Knowledge of the External World*, Chicago/London, The Open Court Publishing Company, 1914.
- RUSSELL, Bertrand: "Logical Atomism", in MUIRHEAD, J. H. (ed.): *Contemporary British Philosophers*, 356–383, London, Allen and Unwin, 1924.
- TARSKI, Alfred: "The Semantic Conception of Truth and the Foundations of Semantics", *Philosophy and Phenomenological Research* 5 (1944) 341–376.
- WITTGENSTEIN, Ludwig: *Philosophical Investigations* (1953), G. E. M. Anscombe (trans.), Oxford, Basil Blackwell, 1958 (3rd ed.).
- WITTGENSTEIN, Ludwig: *Culture and value: a selection from the posthumous remains*, P. Winch (trans.), VON WRIGHT, G. H. (ed.), Oxford, Blackwell, 1998 (rev. 2nd ed.).
- WITTGENSTEIN, Ludwig: *Tractatus Logico-Philosophicus* (1921), C. K. Ogden (trans.), London, Routledge & Kegan Paul, 1981.