

# KANTIAN A PRIORI LAWS OF NATURE AND QUANTUM DISCONTINUITY

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**Abstract:** Quantum physics has already been seen by its founders as the strongest argument against the idea of a Kantian type of transcendental idealism, i.e., against the idea that the mind gives laws to nature. Attempts to make this classical transcendental view compatible with quantum physics involve reinterpretations of its fundamental concepts. They show the extraordinary fruitfulness of Kant's philosophy but also fall into the pattern of Fichte's endeavor to free it from its internal contradictions, i.e., they abandon some of its central assumptions. The paper tries to synthesize some of the sources of the systematic difficulties that impede the original Kantian philosophy from explaining phenomena observed in quantum physics.

**Keywords:** Kant, metaphysics, abstraction, appearance, quantum particles.

There may be no other philosopher as often associated with discussions about science as Immanuel Kant. This is certainly not by accident because Kant was preoccupied with scientific knowledge and claimed to offer a definitive explanation of how science is possible. There are, of course, debates about whether this is what he ultimately endeavored to do or whether the solution he proposed is a tenable solution. If, by science, one understands certain or apodictic knowledge, I think we can agree that this was the most important goal in his critical period. However, if one understands only mathematics and the science of nature (or even logic) by *science*, things are no longer so easy to settle. They become much more complicated if one also tries to understand the Kantian claims from the background of the progress of these sciences after Kant. If we take into account Kant's testimony that he was a metaphysician at heart while also considering that the question concerning the possibility of science actually gravitates around the question of whether metaphysics is possible or not (as a science), then we might have a good "guiding thread" for these discussions.

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Kant believes that in an age dominated by skepticism concerning the possibility of metaphysics, if one acknowledges its everlasting importance for the human race, one must try to find out once and for all time whether metaphysics can offer what it claims or not: namely, a true cognition of its age-old objects (God, the soul, and the world). In this context, one must immediately question the reasons for the prevailing skepticism about metaphysics. It was not difficult for Kant to see that the reason for this skepticism was the perpetual disagreement of those involved with this kind of knowledge, which was all the more striking if compared with the success of other domains of human culture where a fruitful agreement between all those implicated ruled. Those domains were mathematics, logic, and the Newtonian science of nature. Why could there reign a complete agreement in those fields, whereas metaphysics was always a land where no one could ever conquer a definitive terrain?

The answer proposed by Kant is that those domains are based on and consist mainly of cognitions that are synthetic a priori judgments<sup>1</sup>. And, to some extent, even if one does not know anything about a specific type of knowledge, one could expect that it should consist of such judgments because knowledge, by definition, adds novelty to our understanding of something. Thus, it must always be synthetic. And since those disciplines contain knowledge that is valid independently of time, they certainly contain at least some a priori element, i.e., independent of experience. But this is exactly what metaphysics always claimed to provide, namely knowledge going beyond any human experience, as is the case with the question of the immortality of the human soul, for example.

Although Kant does not discuss it extensively, we can deduce from what he says that these well-established disciplines have a history intimately associated with the history of metaphysics. They needed a long time to find the 'secure path of science'<sup>2</sup>, and it might be that metaphysics is in the same situation. However, there is more than that: as a 'queen of all the sciences'<sup>3</sup>, it might not only have a much more valuable object but also could be involved in the development of the other sciences. Because of this involvement, the recognized sciences could also help to discover why metaphysics had not yet managed to become a science, namely, show why within them something that has a metaphysical character can work, whereas when treated apart from those sciences, the same elements could not build a self-sustaining science. We could then expect that the 'synthetic a priori judgments,' present both in those sciences and in metaphysics, might be the answer because they address something that exceeds the boundaries of direct experience. In other words, the fact that real sciences contain synthetic a priori judgments is not only a

<sup>1</sup> Imm. Kant, *Critique of Pure Reason*, translated by Paul Guyer and Allen W. Wood, Cambridge, Cambridge University Press, 1998, p. 143–145.

<sup>2</sup> *Ibid.*, p. 110 (BXV).

<sup>3</sup> *Ibid.*, p. 99 (A VIII).

model for how to create the new science, namely metaphysics, but also a clue or an indication of the content that this new science of metaphysics should contain.

In what consists the history of the recognized sciences? At first sight, Kant's answer is, as we know, that this history was a more or less lengthy process in which those disciplines managed to reach a moment when scientists understood that they did not have to follow nature blindly but to constrain nature to answer their hypotheses. In the case of these sciences, this process is similar to how Kant describes the history of metaphysics. Thus, we can say that in their history, as in the history of metaphysics, people

‘have long collected relevant cognitions haphazardly, like building materials and worked through them technically with only a hint from an idea lying hidden within.’

Initially, the bodies of these sciences

‘seem to have been formed, like maggots, by a *generatio aequivoca* from the mere confluence of aggregated concepts, garbled at first but complete in time.’<sup>4</sup>

In other words, in this process, we deal with a sort of natural process of abstraction that allows knowledge to separate itself more and more from the immediate environment where it was obtained and to be applied elsewhere too. During this process, a natural division or hierarchy of abstract cognitions was discovered, which advanced to the level of abstract cognitions with the most comprehensive generality and for which one could no longer show any empirical origin. Such cognitions have been called *principles*.

This process of abstracting made people aware of the particularity of knowledge as a form of our experience. Although it might seem that this abstraction is only the generalization of past experience, Kant claims that at the moment when recognized sciences found the secure path of science, they understood that there was much more than that, namely that in scientific knowledge, experience was not an authoritative teacher but, strangely, conformed to or followed principles; it followed cognitions that were not derived from experience. In other words, mathematics, logic, and the Newtonian science of nature were bodies of cognitions initially abstracted from experience, conceptual bodies that discovered how to order their cognitions logically under some ultimate principles. In this way, they also confirm Kant's statement that ‘although all our cognition commences with experience, yet it does not on that account all arise from experience.’<sup>5</sup>

<sup>4</sup> *Ibid.*, p. 692 (A834–835/B 862–863).

<sup>5</sup> *Ibid.*, p. 136 (B I).

Naturally, no science questions the condition of its principles; it is only involved in the activity of connecting any newly discovered or observed fact with the existing cognitions and principles.

Kant endeavors to replicate this procedure of those sciences in metaphysics, hoping the latter could transform thus into science. Kant's 'Copernican Revolution' as a 'transformation in our way of thinking'<sup>6</sup> is, therefore, from the beginning, something that was aimed at changing the way of thinking only in metaphysics. It had nothing to do with the other sciences that had already found their own secure paths.

Still, in this process of replication, one must not forget for a single moment that those sciences are abstractions, i.e., that however far from experience they seem to expand, they continue to be intimately related to it precisely because they are abstractions. In other words, even in the most abstract scientific cognitions, there is always something that was already present at the beginning of each scientific discipline, at the most concrete level of it. This is Kant's general view. Only thus is his statement intelligible that reason discovers in nature 'what it itself produces according to its own design.'<sup>7</sup> In other words, knowledge is, for Kant, a circle, or rather a process of distillation that starts and develops historically with all kinds of ideas regarding nature and the world, among which there is also the true content that reason itself plants into experience. This true content maintains itself and develops throughout the evolution of knowledge because it is the only thing that manages to build a non-contradictory body of cognitions about nature, whereas the rest of the ideas are abandoned due to their contradictory nature. The circle closes, or the distillation process ends, when the body of non-contradictory cognitions is conceived of as a unity deduced from the highest principles of knowledge (the ultimate 'seeds' of reason), i.e., when they transform into true a priori cognitions.

Similar to the conditions of the other sciences, metaphysics had its own history, from which it retained some undisputed ideas in Kant's days, whereas others were still exposed to sharp criticism. Therefore, metaphysics continued to remain in a 'rhapsodical' condition where there was still no unity and where, therefore, true ideas were mixed with false ones. Kant hoped that the condition of metaphysics could be changed through a kind of 'Copernican Revolution.' This revolution consisted of thinking of metaphysics as a body of cognitions of reason grounded in reason's own principles and not in foreign principles. In this respect, metaphysics needed to follow the 'dogmatic procedure,' 'for science must always be dogmatic,' says Kant, i.e., 'it must prove its conclusions strictly a priori from secure principles.'<sup>8</sup>

<sup>6</sup> *Ibid.*, p. 113 (BXXII).

<sup>7</sup> *Ibid.*, p. 109 (B XIII).

<sup>8</sup> *Ibid.*, p. 119 (BXXXV).

Kant considers that the old-fashioned way of thinking in metaphysics was to conceive of the principles of this science as being originated in a foreign source. (This is what later was called substantialism.) Such an approach was similar to that in which sciences were not yet aware of their true nature as disciplines grounded in their own principles. Therefore, he calls for a change in perspective, namely to abandon the assumption that metaphysical principles can arise from a source other than human reason itself. But strangely, with such an assumption, the character of the other sciences changes, too. Or rather, not their character but the character of the metaphysical components present within them. The abstracted cognitions of those sciences were no longer thought of as features of external material things but as expressions of the activity of reason that projects into those things its own structure. With this new assumption, everything thought of in the past as pure forms of things transformed into products of the human mind, i.e., forms originating in human knowledge.

The acceptance that the general framework of the *Critique of Pure Reason* is drawn by the intention to make metaphysics possible as science also facilitates the fact that an interpretation of science (of nature) that does not take into account the metaphysical interest of Kant could lead to ignoring aspects that are involved in the functioning of the other elements of this philosophy.

The highest metaphysical abstractions or generalizations must correspond or cohere with the other abstractions of the other sciences. However, the relationship between the other sciences and metaphysics is not as if metaphysics only abstracts from them, in the same way in which the science of logic did not evolve as an abstracting process from Newtonian physics or the other way around. Metaphysics also had its own evolution and history, in which particular a priori cognitions were developed that could not be found elsewhere. Such is, for example, the question of the immortality of the soul. A. N. Whitehead expressed this idea very eloquently:

In the first period when the speculative Reason emerged as a distinguishable force, it appeared in the guise of sporadic inspirations. Seers, prophets, men with a new secret, appeared. They brought to the world fire, or salvation, or release, or moral insight. Their common character was to be bearers of some imaginative novelty, relevant and yet transcending traditional ways.<sup>9</sup>

These a priori cognitions must be (made) coherent with the other a priori cognitions of the other sciences. Therefore, metaphysics has to be grounded in a new principle from which all other a priori cognitions that belong to it can derive and build a systematic unity, as in all other sciences. Besides, this principle should make possible the understanding of the possibility of a priori cognitions in all other sciences as a sort of a lower level of the same general system of human a priori knowledge. This principle is introduced by Kant as a hypothesis:

<sup>9</sup> A. N. Whitehead, *The Function of Reason*, Boston, Beacon Press, 1929, p. 66.

Hence, let us once try to determine whether we do not get farther with the problems of metaphysics by assuming that the objects must conform to our cognition, which would agree better with the requested possibility of an a priori cognition of them, which is to establish something about objects before they are given to us.<sup>10</sup>

This hypothesis will transform later into a principle, which, like scientific principles, would be proved through its application. Kant says in this respect:

In this *Preface* I propose the transformation in our way of thinking presented in criticism merely as a hypothesis, analogous to that other hypothesis, only in order to draw our notice to the first attempts at such a transformation, which are always hypothetical, even though in the treatise itself it will be proved not hypothetically but rather apodictically from the constitution of our representations of space and time and from the elementary concepts of the understanding.<sup>11</sup>

Transforming metaphysics into science would restore its dignity as a queen of sciences and take the first steps to unify all human knowledge. This unification happens first only with the other recognized sciences so that one could think coherently the metaphysical propositions about the immortality of the human soul and the mechanical formula for speed or any mathematical or geometrical theorem.

This new required ultimate principle of Kantian metaphysics is that things are appearances that conform to our faculty of cognition, and from this principle, all other cognitions of mathematics, logic, and the Newtonian science of nature (but also of metaphysics itself) must be deduced. Only in the light of this principle do Kant's statements about the analytic or synthetic character of mathematical or geometrical propositions become intelligible.

Kant cherished the idea that human reason – as the totality of the a priori parts of the human faculty – is the same across all humans and all their history; it builds a unity. As such a unity, everything within it must be logically consistent and cohere with everything else. The ultimate metaphysical principle that things are appearances expresses this idea of unity. The unity of reason is first of all proven by the unity of concrete experience, which supports the unity of sciences. The formal unity of experience is given by the activity of productive imagination, the 'Reason itself' as Hegel puts it later, when speaking about the Kantian productive imagination. Through its synthesis ('the mere effect of the imagination'<sup>12</sup>) and retention in memory, imagination builds concrete experience.

<sup>10</sup> Imm. Kant, *Critique of Pure Reason*, cited edition, p. 110 (B XVI).

<sup>11</sup> *Ibid.*, p. 113 (B XXII).

<sup>12</sup> *Ibid.*, p. 211 (A 78/B103)

Imagination has an essential role in building the experience and the appearances, but also in building knowledge through its reproductive character, which is in fact the first moment of abstraction, when the object is present to us but ‘without its presence in intuition’<sup>13</sup>. People can play around with their imagination and the abstractions it produces, but real knowledge is what corresponds to experience: in other words, what does not contradict it, what follows its in-built unity. Thus, roughly speaking, the cognitive dynamics of the human mind are given through the activity of the imagination, guided by the limiting principle of non-contradiction present in the general unity of experience, where – to quote Kant’s example – the red cinnabar remains red from one moment to another and does not change its color suddenly<sup>14</sup>. Thus, all abstractions of the human mind are products of reproductive (and productive) imagination, and therefore, they always are rooted somehow in experience.

Imagination combines – or, in the Kantian philosophical language, it synthesizes – its contents and abstractions in every possible way (perhaps therefore Kant describes imagination as ‘a blind though indispensable function of the soul’<sup>15</sup>), but without violating some fundamental data of experience (for example, by producing non-spatial shapes). Thus, in the history of human knowledge, this playing with the abstractions of imagination led to the highest ones, those that could no longer be made more abstract, i.e., mental contents from which one could no longer remove any of the existing features without destroying the mental abstraction itself. These are the principles of all abstractions of a given domain. For example, one cannot imagine a body without imagining it as endowed with spatial shape. And, of course, this shape is then built from lines, which become the geometrical principles on which all other geometrical shapes must be built.

Now, if we think of all these principles as products of imagination and imagination as being fundamentally a faculty of sensibility<sup>16</sup>, then, in all its products, sensibility must somehow be present. That is to say that there cannot be any principles of human knowledge (and understanding) that are not somehow connected to imagination and, through it, to sensibility.

If sensibility is involved in all abstractions, then its a priori forms must also be involved in them. Thus, space and time as priori intuitions are a necessary part of every piece of knowledge, no matter how abstract it is. This is precisely what the section dedicated to the Analytic of the principles of intellect in the *Critique of Pure Reason* aims to show.

Kant’s language can sometimes be misleading. This is what happens with the term *understanding*. Very often, he uses this term, meaning, in fact, a mixture of what he properly calls understanding *and* imagination. In this respect, the specific

<sup>13</sup> *Ibid.*, p. 256 (B 151).

<sup>14</sup> *Ibid.*, p. 229 (A 100).

<sup>15</sup> *Ibid.*, p. 211 (A 78/B 103).

<sup>16</sup> *Ibid.*, p. 256 (B 151).

meaning of the term *understanding* in Kant is that of being only a faculty of recognition in a concept<sup>17</sup>. However, a concept in general is, again in his language, a rule of ‘synthetic unity’<sup>18</sup>, i.e., a scheme, and schemes are always products of imagination<sup>19</sup>. What is not imagination in a concept is the act of recognition of that scheme as being something, i.e., its recognized unity. Even the so-called principles of understanding involve rules or broader schemes (broader in comparison to the schemes of the categories) of imagination. Therefore, in these principles, the a priori content of sensibility cannot be missing either.

Kant’s statement that the understanding prescribes laws to phenomena can also be misleading because it can be understood in two ways. Within Kantian philosophy, these two ways are certainly related. However, if we ignore the fact that understanding also includes imagination (both productive and reproductive), this can lead to important errors when trying to build on Kant’s ideas. Those two ways of interpreting the statement that the understanding prescribes laws to phenomena are: first, that the understanding, together with the imagination, create the original structure of all appearances and the entire concrete experience. But, secondly, also that within a science, the theory that explains phenomena, through its explanation, prescribes laws to them. In Kant, the second meaning can be true only because science and theory are ultimately abstractions, and therefore, they are rooted in experience and the, initially, ‘obscurely’<sup>20</sup> given ‘original seed’<sup>21</sup> of reason. Now, this second meaning – that in science, understanding prescribes laws to phenomena – was sometimes detached from the first meaning – that understanding originally makes up the phenomena. And this detachment is what allows the attempts to make quantum phenomena compatible with Kantian philosophy. Such detachment can also easily be associated, for example, with Karl Popper’s view about the fallibility of science in general and of science as a model of things, a model that can be replaced by another one if newly discovered facts falsify an existing scientific model<sup>22</sup>.

If, in Kant, then, science is a product of abstraction and the combinations of abstractions mediated by the principle of non-contradiction, it is certain that the results of its activity can never contradict the general conditions that make our human experience possible.

Werner Heisenberg’s attempt to give a practically realist reinterpretation of Kant’s understanding of the a priori is very much akin to Popper’s view of science. Following Carl Fr. von Weiszacker’s suggestion, he states that we could save, to

<sup>17</sup> *Ibid.*, p. 230 (A 103).

<sup>18</sup> *Ibid.*, p. 232 (A 106).

<sup>19</sup> *Ibid.*, p. 273 (A 140/B 179).

<sup>20</sup> *Ibid.*, p. 145 (B 17).

<sup>21</sup> *Ibid.*, p. 692 (A834–835 /B 862–863).

<sup>22</sup> Karl Popper, *The Logic of Scientific Discovery*, London and New York, Routledge, 2005, p. 60.



some extent, the Kantian view by making an analogy between the thing in itself and quantum phenomena:

Therefore, practical realism is a natural part of the reinterpretation. Considering the Kantian ‘thing-in-itself’ Kant had pointed out that we cannot conclude anything from the perception about the ‘thing-in-itself.’ This statement has, as Weizsacker has noticed, its formal analogy in the fact that in spite of the use of the classical concepts in all the experiments a non-classical behavior of the atomic objects is possible. The ‘thing-in-itself’ is for the atomic physicist, if he uses this concept at all, finally a mathematical structure; but this structure is – contrary to Kant – indirectly deduced from experience.<sup>23</sup>

Thus, we may use the classical concepts of physics and of what Heisenberg called ‘dogmatic realism’ for the experiments and the measuring devices used in them, leaving then room for the non-classical behavior to the quantum particles. Kant certainly was a theoretician of ‘dogmatic realism,’ to which Einstein himself fell prey. However, what Heisenberg proposes is not a reinterpretation of Kant’s understanding of a priori, and it cannot be. Heisenberg uses only one of the meanings of a priori, namely that of ‘preceding experience,’ which, in Kantian philosophy, is rather a secondary or indirect meaning. In this respect, then, a historical a priori, as of the kind proposed by Heisenberg, would mean the totality of conditions that each historical epoch builds between it and reality, understanding thus ‘reality’ only through the lenses of these historical conditions:

In the discussion of the Copenhagen interpretation of quantum theory it has been emphasized that we use the classical concepts in describing our experimental equipment and more generally in describing that part of the world which does not belong to the object of the experiment. The use of these concepts, including space, time and causality, is in fact the condition for observing atomic events and is, in this sense of the word, ‘a priori.’ What Kant had not foreseen was that these a priori concepts can be the conditions for science and at the same time can have only a limited range of applicability.<sup>24</sup> [...] The synthetic judgments a priori thereby have the character of a relative truth.<sup>25</sup>

Despite its similarity with the Kantian theory, views like that which Heisenberg proposes ignore the other meaning of a priori in Kant, namely universality and especially necessity. A historical a priori cannot be, by definition, universal and necessary because then it would have to involve all cases and, as a consequence, eliminate historical differences. The Kantian transcendental approach, with all the

<sup>23</sup> W. Heisenberg, *Physics and Philosophy. The Revolution in Modern Science*, New York, Harper & Brothers Publishers, 1958, p. 91.

<sup>24</sup> *Ibid.*, p. 90.

<sup>25</sup> *Ibid.*, p. 91.

concepts that make it up, maintains its meaning only if understood as being based on abstractions rooted in human *universal* experience. An a priori understood within the framework of 'practical realism' certainly ruins every attempt at transcendental idealism, or in general, at idealism, because transcendental idealism, in its Kantian form, is not only about the grounds of science but mainly about metaphysics as an integrative science in which as, a consequence, all other sciences can acquire their places. But it also ruins the meaning of a priori and, consequently, introduces a new ontology of the human being, too, incompatible with the Kantian concepts. It was not by accident that, after Kant, in German idealism, philosophy claimed to be able to unite the whole of human knowledge into a single system.

Also, the analogy between the quantum level and the thing in itself, however natural it seems, is far from being tenable. This is because, nolens-volens, one applies the a priori intuition to the behavior of quantum particles and also the categories (one speaks about the 'motion' of a quantum particle, or about 'one' such particle).

In the case of Heisenberg's uncertainty principle, we deal with phenomena that have a certain constitution and which do not follow the common rules of the human intellect. In other words, here we deal with a structure of phenomena that are devoid of any cause, although they can be mathematically predicted, namely statistically. The fact that we can know only statistically where the particle lands on a screen makes it impossible to calculate its speed (momentum), or, when we know the latter, to establish where it lands. This lack of precision or accuracy, or inexactness (as Heisenberg also called it), is against the principles of Kantian philosophy (except, of course, if we adopt the Einsteinian understanding of quantum physics, namely as an incomplete theory).

In Kant, a phenomenon is a spatial and temporal content or presence of sensation. As such, it follows the principle of continuity (the anticipation of the intellect). This continuity implies also that in order to cover a distance, an object must go through all points of space, and all moments of time must be passed through or covered. Now, knowing the distance and the time necessary to get to a certain point makes it possible to calculate where the moving object was at the beginning of its motion. Nevertheless, this is possible only under the assumption that if we repeat the trajectory or the motion of the object, we get the same results, however often we repeat the experiment. This is the meaning of universality, and, of course with it comes that of necessity. Where there is universality, we state also that things cannot happen differently, they are absolutely constrained to behave in that way and not in another one.

Now, in quantum physics, there cannot be any such universality and necessity, since we cannot exactly establish the correspondence relationship between the spatial place and the temporal moment. In Newtonian physics an object is set in motion and, without being exposed to any other causal force, it will continue indefinitely its straight motion in space. This Kant also explains in his

*Metaphysical Groundwork of the Science of Nature.* Now, in quantum physics, since the result, the establishing of the moment of the end point of motion can be established only statistically, we cannot know precisely what the trajectory of the motion of that particle is. And, since it cannot be exactly predicted and established, it follows that while it is not detected it can be anywhere, both in time and in space, or, as Richard Feynman puts it, it can have any history:

Feynman's way of doing things is original and daring. At a recent conference, Feynman's colleague Freeman Dyson recalled his first impressions of this unusual approach to quantum theory: 'Thirty-one years ago, Dick Feynman told me about his "sum over histories" version of quantum mechanics. "The electron does anything it likes," he said. "It just goes in any direction, at any speed, forward or backward in time, however it likes, and then you add up the amplitudes and it gives you the wave function." I said to him "You're crazy." But he isn't.'<sup>26</sup>

Here we clearly deal with a violation of the classical causal principle, because we deal with a trajectory that is fluctuating but for which fluctuation we cannot identify any clear cause, as Newton's law of inertia (and Kant's principle of the intellect) demands. In other words, we deal with an effect for which we cannot give any cause and this is against the structure of the human transcendental subject. If this is true, if there are effects without causes, then clearly Kant's transcendental philosophy cannot hold any longer. Of course, this is something that Heisenberg emphatically states too, but while using concepts of Kant's philosophy hoping to make more intelligible quantum phenomena, in fact, he contradicts himself because he continues to cherish a (historically refashioned) Kantian view of the human subject and his knowledge thinking that this is possible when the world in which this subject exists changes.

The problem is not that we do not apply these transcendental features to quantum phenomena; the problem is that they cannot be applied in the same way as happens within ordinary human experience, while we still can interact with them and therefore relate to them as to some kind of 'phenomena.' That is to say, at this level, we no longer can speak about the *unity* of experience and about the *unity* of human knowledge or reason, as Kant demanded. Here, space disconnects from time (indeed, we no longer can talk here about the space-time continuum), and categorical determinations are perplexing (something being simultaneously a wave and a particle, for example, however not as thought-possibility but as different results of experiments). In this respect, Einstein's skepticism concerning quantum physics, skepticism that Heisenberg considers to be rooted in a 'dogmatic realism,' is not a metaphysical attitude like that of Kantian philosophy towards the thing

<sup>26</sup> Nick Herbert, *Quantum Reality. Beyond the New Physics*, New York, Anchor Books, p. 53.

in itself. In the Kantian metaphysical assumption, none of our (knowledge) instruments can work in order to grasp at will something from the realm of the unknown thing in itself, whereas in quantum physics, this absolute limitation transforms into a partial one, because our measuring devices can grasp some sequences of this indeterminacy. This is why quantum physics remains a science with a predictive power even greater than classical modern science, although, according to Einstein, quantum physics is an incomplete theory:

‘Quantum mechanics is certainly imposing,’ wrote Einstein in one of his letters to Born. ‘But an inner voice tells me that it is not yet the real thing. The theory says a lot, but does not really bring us closer to the secret of the ‘old one’. I, at any rate, am convinced that He is not playing at dice.’<sup>27</sup>

As a ‘sample’ of Einstein’s ‘dogmatic realism,’ we may quote the following recollection of Abraham Pais:

I recall that during one walk Einstein suddenly stopped, turned to me and asked whether I really believed that the moon exists only when I look at it.<sup>28</sup>

The incompleteness of quantum mechanics consists in its incapacity to secure the unity (i.e., continuity) of knowledge with the real object at its level. Such unity, for Heisenberg, corresponds to ‘dogmatic realism’:

Especially in physics the fact that we can explain nature by simple mathematical laws tells us that here we have met some genuine feature of reality, not something that we have – in any meaning of the word – invented ourselves. This is the situation which Einstein had in mind when he took dogmatic realism as the basis for natural science. But quantum theory is in itself an example for the possibility of explaining nature by means of simple mathematical laws without this basis. These laws may perhaps not seem quite simple when one compares them with Newtonian mechanics. But, judging from the enormous complexity of the phenomena which are to be explained (for instance, the line spectra of complicated atoms), the mathematical scheme of quantum theory is comparatively simple. Natural science is actually possible without the basis of dogmatic realism.<sup>29</sup>

That incapacity also translates into its statistical and, therefore, almost strictly mathematical character.

<sup>27</sup> M. Born, *The Born-Einstein Letters 1916–1955*, translated by Irene Born, London, Macmillan, 1971, letter from the 4<sup>th</sup> of December 1926, p. 91.

<sup>28</sup> A. Pais, ‘Einstein and the Quantum Theory’, in *Reviews of Modern Physics*, Vol. 51, No. 4, October 1979, p. 907.

<sup>29</sup> W. Heisenberg, *Physics and Philosophy*, pp. 82–83.

But this knowledge contains the uncertainty which is brought about by the interaction between the nucleus and the rest of the world. If we wanted to know why the  $\alpha$ -particle was emitted at that particular time we would have to know the microscopic structure of the whole world including ourselves, and that is impossible.<sup>30</sup>

Kant's transcendental philosophy, aiming at presenting the unity of reason, is also essentially opposed to Bohr's principle of complementarity. At the time of the initial development of quantum physics, among physicists, Bohr was also considered a philosopher due to his intuitive approach in explaining physical processes and experiments<sup>31</sup>. Perhaps as a consequence of this feature of his personality, he rejected the possibility of developing a quantum ontology, considering that the understanding of quantum mechanics, as well as of any other fundamental physical theory, must be expressed and communicated using the common language<sup>32</sup>. But common language always refers to common experience. This is why he argued that the principle of complementarity holds not only in quantum physics but describes the necessary pluralistic interaction between man and reality in general. In this respect, Bohr's fundamental (and wider) claim is that knowledge, in general, is discontinuous, not only within quantum physics but also in other areas of human existence:

'In general philosophical perspective,' writes Bohr, 'it is significant that, as regards analysis and synthesis in other fields of knowledge, we are confronted with situations reminding us of the situation in quantum physics. Thus, the integrity of living organisms and the characteristics of conscious individuals and human cultures present features of wholeness, the account of which implies a typical complementary mode of description. Owing to the diversified use of the rich vocabulary available for communication of experience in those wider fields, and above all to the varying interpretations, in philosophical literature, of the concept of causality, the aim of such comparisons has sometimes been misunderstood. However, the gradual development of an appropriate terminology for the description of the simpler situation in physical science indicates that we are not dealing with more or less vague analogies, but with clear examples of logical relations which, in different contexts, are met with in wider fields.'<sup>33</sup>

<sup>30</sup> *Ibid.*, p. 90.

<sup>31</sup> M. Flonta, *Filozofia cercetătorului. Înțelegerea fizicii cuantelor la Niels Bohr și Werner Heisenberg*, București, Humanitas, 2022, p. 194.

<sup>32</sup> *Ibid.*, p. 201.

<sup>33</sup> N. Bohr, 'Quantum Physics and Philosophy. Causality and Complementarity', in *Essays 1958–1962 on Atomic Physics and Human Knowledge*, New York, London, Interscience Publishers, 1963, p. 7.

However, there is no such discontinuity in Kant. For the latter, human knowledge is grounded on a transcendental structure that secures the unity of human knowledge throughout history, even when such a unity is not yet visible. Therefore, all past attempts to understand reality, even when not yet scientific, involve, in Kant, some features at work of that structure. On the other hand, a theory or science that cannot ground the unity of knowledge as a unity of human thought and experience goes far beyond Kant's transcendental philosophy. It's not a reinterpretation of it but a wholly different philosophy. A reinterpretation maintains the fundamental premises of the reinterpreted theory while changing or adding something to the way the consequences have been understood.

Although apparently similar to the Kantian philosophy – in that Bohr's theory of complementarity states that the observed object depends on the observing system – the fact that here the observing system is contextual, that it cannot function as a *universal* referring system (as was the case for the relationship between the thing in itself and the phenomena whose structure was immutable in Kant, forcing the thing in itself always to get the same phenomenal expression) makes Bohr's theory ultimately incompatible with Kant's ontology. Indeed, Bohr's main mistake was to believe that quantum phenomena do not necessitate an entirely new kind of quantum (based) ontology.

In Kant we deal with a discontinuity between reality 'in itself' and the human mind, while facing a unity of human experience as a phenomenal totality. By contrast, in the framework of the complementarity theory we deal with a discontinuity of the human experience itself, which entails the necessity of developing a very different understanding of the nature of human being itself and, of course, of the whole world, too.