Eidos volume 7 no. 3 (2023)
A JOURNAL FOR PHILOSOPHY OF CULTURE

DOI:10.14394/eidos.jpc.2023.0030

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Quantum Meta-physics: Nonlocality and Limits of Determinism

Abstract:
This essay aims to show that the recent development of quantum theory may provide us with an answer to one of the most compelling metaphysical problems, namely the problem of determinism. First, I sketch the conceptual background and draw the distinction between metaphysical and epistemological determinisms. Then, on the ground of the analysis of the problem of determinism in quantum mechanics, I argue that (1) metaphysical determinism is independent of quantum-mechanical formalism, and (2) that quantum nonlocality makes epistemological determinism impossible. I also try to show that metaphysical determinism should be regarded as a Kantian regulative idea which sets the horizon for scientific inquiry but which at the same time lacks what Kant calls "objective validity." The main conclusion is that metaphysical determinism should be regarded as an idealization – a formal, cognitive principle that we *a priori* assume and not something that we discover through scientific inquiry.

Keywords:
determinism, quantum mechanics, nonlocality, free will, Kant

For we can avoid ineptness or emptiness in our assertions only by presenting the model as what it is, as an object of comparison – as, so to speak, a measuring-rod; not as a preconceived idea to which reality must correspond. (The dogmatism into which we fall so easily in doing philosophy.)

Wittgenstein, *Philosophical Investigations*, thesis no. 131

Introduction

The main aim of this paper is to show – in a Wittgensteinian, and as I believe Kantian, manner – that determinism as a metaphysical claim is one of such dogmatic philosophical convictions and, what is more, one can find a good argument supporting this claim through philosophical reflection concerning quantum mechanics (QM). I intend to show that in the light of QM, on the one hand, what I call *epistemological* determinism is simply false, and on the other, that *metaphysical* determinism is rather a formal, cognitive principle that we *a priori* assume and not something that we discover through scientific inquiry.

So, the main focus of this paper lies on determinism which by itself seems to refer to science alone, without any explicit impact on religion. However, what is shown by almost the whole of Western philosophy, determinism has always walked hand in hand with free will. Probably the main reason the problem of determinism is so compelling is that it seems to exclude the possibility of the existence of free will[1] – what most obviously is a very disturbing consequence. Especially disturbing for people of different religions, Christianity in particular. There are numerous reasons for that but one of the most apparent ones is that without free will (and accountability associated with it) any genuine morality (goodness, love, etc.) would be impossible. As C. S. Lewis expresses it in *Mere Christianity*: "free will, though it makes evil possible, is also the only thing that makes possible any love or goodness or joy worth having. A world of automata – of creatures that worked like machines – would hardly be worth creating."[2] In this paper, I will not cover the (by the way fascinating), issue of the relationship between quantum mechanics and free will, however, I presume that by trying to limit determinism I will at the same time make room for the possibility of the existence of free will.

In the first section, I will sketch a conceptual framework for my further considerations with a few general remarks on determinism. Then, I will focus on the matter of determinism in quantum theory. The third section I will devote to the issue of nonlocality and its influence on the question of whether determinism is true. I shall end the whole essay with a few summarizing conclusions.

1. Determinism

1.1. Metaphysical and Epistemological Determinisms

There are several types of determinism and even several typologies concerning this heavily charged concept. To keep my further considerations as clear and straightforward as possible, let me start with a very simple typology that differentiates between *metaphysical* and *epistemological* determinisms. Presumably, the most general formulation of the thesis of metaphysical determinism (MD) would be:

(MD) the world is in itself determined.

At this point, when bringing out this very broad intuition which underlies all other sorts of determinisms, we should not specify what kind of determination is involved. Although – as Poręba notices – "[t]here is a close connection between the idea of reality as something fixed and determined and the idea of there being

1) It is important to note that there are various compatibilist accounts which argue that free will indeed can be reconciled with determinism (or even that determinism is a necessary condition for the existence of free will). However, in this paper, I will not delve into the compatibilism-incompatibilism debate and I will work on the assumption that determinism does exclude free will. Notwithstanding, I want to thank one of the anonymous reviewers of this paper for bringing my attention to this matter.

2) Lewis, *Mere Christianity*, 48.

a kind of mechanism securing this fixed status of reality,"[3] it is important to note that metaphysical determinism does not have to be a *causal* determinism which we usually have in mind in the scientific context.

Let us now consider what this "in itself" means. We can understand this expression in many ways but in order to juxtapose metaphysical with epistemological determinism let us assume that it stands for "independently of our knowledge." Thus, another formulation of MD would be:

(MD*) the world is determined independently of our knowledge.

As opposed to the metaphysical, epistemological determinism ought to take our knowledge into consideration. The most pronounced account of this type of determinism is to be found in the famous thought experiment called the "Laplace's demon:"

> An intelligence knowing all forces acting in nature at a given instant, as well as the momentary positions of all things in the universe, would be able to comprehend in one single formula the motions of the largest bodies as well as the lightest atoms in the world, provided that its intellect were sufficiently powerful to subject all data to analysis; to it nothing would be uncertain, the future as well as the past would be present to its eyes… . All of the mind's efforts in the search for truth tend to approximate the intelligence we have just imagined, although it will forever remain infinitely remote from such an intelligence.[4]

Hence, the original formulation of Laplace's account of determinism (LD) could be interpreted as a conditional:

> (LD) if one knew the exact state of the world at a given moment as well as the laws that govern its evolution in time, then she could determinately predict the state of the world at any other moment.

It is important to stress that this implication as a whole can be true regardless of whether the antecedent can be realized.[5] But from the viewpoint taken in this paper, such a conditional is a *metaphysical* statement, in the sense that its truth conditions are independent of our knowledge about the world. Whether this implication is true does not depend on our epistemological capabilities – for instance, it is true with reference to Laplace's demon whose cognitive powers transcend ours.

The question I intend to address in this paper is not whether it is metaphysically possible for some imagined entities to determinately predict the future, but whether it is epistemologically possible. I will focus on whether this is possible considering certain limitations of our cognition – limitations which Kant tried to bring to light and which (what I want to show), make themselves visible in QM. This is why, what I will be referring to as epistemological determinism (ED) is the above implication (LD) coupled with the assumption of the antecedent. Furthermore, my strategy in fighting ED will rest on the critique of the antecedent, as I will argue that

3) Poręba, "Reflective Judgements," 70.

4) Earman, *A Primer*, 7. This English translation of the passage from Laplace's *Essai philosophique sur les probabilities*, Earman quotes from Nagel. Ernest, *Structure of Science,* 281–82.

5) I owe this insight to one of the anonymous reviewers of this paper.

there are certain necessary cognitive limitations to the possibility of acquiring knowledge which is needed to determinately predict the future state of certain quantum systems.[6]

Let us note what Laplace adds at the end of this thought experiment: this perfect predictability, necessarily (mind the word "forever"), lies beyond the limits of our cognitive capacities. (By the way, that is the reason why later on in his paper, Laplace introduces the notion of probability as a tool for acquiring knowledge without certainty). On the other hand, Laplace also claims that our knowledge can approximate such intelligence.

What is, then, the status of this imagined intellect with the ability to determinedly predict the future? This question becomes more appealing when we realize that "[d]epending upon what power we endow the demon with, we get different senses of determinism"[7] and moreover, that the issue of whether determinism is true may depend on this matter. As Earman continues: "[e]ndow the demon with God-like powers and … the demon will be able to foresee the future … but this foresight may be a reflection of its precognitive abilities rather than any deterministic feature of the world."[8]

The two features of Laplace's deterministic vision, namely, that (a) it lies beyond our cognitive capacities, but at the same time (b) we can approximate this intellect, can be associated with the essential features of Kant's concept of regulative ideas.[9]

1.2. Kant's Regulative Ideas

My aim here is not to reconstruct the original views of Kant but rather to try to make use of the concept introduced by him. This is why I will only very briefly sketch his account and, while doing so, I may go beyond the letter of his philosophy.

Kant introduces the concept of regulative ideas in reference to Plato's forms which he regarded as "archetypes of things"[10] lying beyond the world of appearances and possible experience. As Kant puts it: "we can have no acquaintance with an object that corresponds to an idea, even though we can have a problematic concept of it."[11] "Problematic" in the sense that it is not decided whether something real corresponds to such a concept. The essential tenet of Kant's system in his *First Critique* is the claim that if any single cognition is to be objectively valid, it eventually has to refer to possible experience. This is why, at the theoretical level,[12] Kant denies the objective validity (or, simply, reality), of ideas.

At the same time, they should not be seen as mere illusions since they play a significant role in our cognitive architecture. In the case of three *transcendental* ideas, Kant even claims that they are some of the conditions of the possibility of experience (i.e. they are necessary formal constructions that are inscribed into the

6) In the formulation of LD I spoke of "the state of the *world*," to do justice to Laplace's original formulation. Further, my argument will rest upon the point that it is impossible to determinately predict the future state of *certain quantum systems* (which evince some nonlocal features). But as long as we consider these quantum systems as parts of the world, that should be enough to show that ED formulated in such a way is false.

7) Earman, *A Primer*, 7.

8) Ibid.

9) See Kant, *Pure Reason,* B 367–96, 670–96. When referring to Kant's *Pure Reason*, I give the pagination of the second original edition (B), (i.e. *Kritik der reinen Vernunft).*

10) Kant, *Pure Reason*, B 370.

11) Ibid., B 397.

12) In his *Practical Reason*, Kant argues that on the grounds of practical philosophy, the existence of three transcendental ideas (God, the world, and free will), can be justified. But let me leave it only as a footnote. Throughout this essay, I restrict myself to Kant's theoretical philosophy presented in the *First Critique*.

a priori structure of the cognitive subject). As he writes about ideals in general: "they provide an indispensable standard for reason, which needs the concept of that which is entirely complete in its kind, in order to assess and measure the degree and the defects of what is incomplete."[13] We need ideas – certain pure, imagined idealizations – to guide us in our empirical investigations.

Just like the vision of an absolutely determined world – the world as seen by Laplace's demon – ideas are (a) unknowable, but at the same time (b) they set the horizon to which our cognition can approximate.

There is another crucial feature of Kant's account of ideas worth mentioning in this context: they can be the cause of one transgressing the limits of cognition. The wrong use of transcendental ideas Kant calls the "transcendental illusion" and devotes almost the whole *Critique of Pure Reason* to trying to save us from it. He claims that ideas can only play a regulative, not constitutive, role in our cognition. They prescribe certain principles that should guide (regulate) the empirical use of all other concepts. Therefore, they should be used only "immanently" (i.e. inside the limits of possible experience), not "transcendently" (outside the empirical world). Let us note that this danger of a wrong use of idealizations – a *dogmatic* use – is also expressed in the above quotation from Wittgenstein.[14]

2. Determinism in Quantum Mechanics

I do not wish to cover this vast topic in a few paragraphs. Let me then sketch only a very general and simplified picture of the matter, with a focus on the issues relevant to the purposes of this essay.

2.1. Two Answers to the Schrödinger's Cat Paradox

We all are probably familiar with the story of Schrödinger's cat which, due to the indeterminacy of the state of the quantum system, remains dead and alive at the same time. This thought experiment was introduced by Schrödinger to show that the so-called Copenhagen interpretation of QM leads to paradoxes or even contradictions. The whole issue boils down to the question of how we should interpret the quantum state (in the form of the wave function) which before the measurement is given by a *probability* function and so without any definite value. For instance, the state concerning the position of a given particle can contain information that there is a 50% chance that after performing a measurement we will find the particle in place "A" and a 50% chance that we will find it in place "B." Additionally, after the measurement, the particle is to be found always in one definite place. The question arises: where was this one definite object before the measurement? Was it, for the whole time, in one definite place without us knowing? Was it in two places at the same time?

John Stewart Bell describes how two different fundamental answers to this problem (called "the measurement problem") give rise to two main types of interpretations of QM:

> [Schrödinger] thought that she [the cat] could not be both dead and alive. But the wavefunction showed no such commitment, superposing the possibilities. Either the wavefunction, as given by the Schrödinger equation, is not everything, or it is not right.[15]

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13) Kant, *Pure Reason*, B 597–98.

14) See Wittgenstein, *Investigations*, thesis no. 131.

15) Bell, "Quantum Jumps?," 201.

If we claim that it is "not everything" (i.e. it does not give a complete description of physical reality), we go to the "hidden variables" camp and need to postulate certain (hidden) variables which determine the physical properties of the system regardless of any measurement whatsoever. The second alternative gives rise to the so-called "collapse theories" which are more elaborate descendants of the Copenhagen interpretation.[16]

Below, I will focus on the former, let me then say just a few words about the latter. Collapse theories, as the name suggests, refer essentially to the concept of the *collapse* of the wave function which is an instant process that takes place at the moment of measurement. At this very moment, the state of the system rapidly shifts from indefinite (i.e. given by a probability function) to definite value in the process that *cannot be predicted* on the grounds of QM. Thus, collapse theories are plainly indeterministic in the epistemological sense.

What about hidden variable theories? May they let us maintain the idea of determinism regardless of these quantum peculiarities? I am going to argue that even though when it comes to metaphysical determinism they may do so, that is not the case with the epistemological one.

2.2. Hidden Determinism?

The "hiddenness" of hidden variable theories boils down to the fact that we can only postulate that "something-out-there" determines the physical properties of the system independently of our knowledge. But, this could mean that we cannot ever get to know this hidden reality, which plainly, is a serious problem. In other words, such reality would rather be postulated than ever discoverable by experiment. Therefore, in the case of hidden variable theories, determinism is postulated on a metaphysical level, but whether it could be maintained on the epistemological still remains an open question. On the other hand, I believe that the underlying conviction behind the mindset of the hidden variable theorists is that, although we may not be able to determine these variables on the grounds of our *current* theory, a *future* physical theory will be able to do so. For the time being, let me just bring your attention to this disputable conviction and come back to it later.

What is important for now is the very fact that a deterministic hidden variable theory (compatible with the experimental results of QM), is at all possible and moreover that it has been formulated.[17] It is the so-called pilot-wave theory, first introduced by de Broglie and then enhanced by Bohm (which is why it is sometimes referred to as the "de Broglie-Bohm theory").

This fact shows that both indeterministic collapse interpretations and deterministic hidden variable interpretations are compatible with quantum-mechanical formalism. *This means that the formalism (i.e. the theory) itself does not provide a definite answer to the question of whether determinism is true*. Put in other words, the issue of determinism is independent of quantum-mechanical formalism and depends on the choice of an interpretation. However, this is true only about metaphysical determinism and in order to discuss the status of epistemological determinism we need to take a closer look at the issue of quantum nonlocality.

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16) Commenting on this passage from Bell, Maudlin (see his *Quantum Theory*, 173–74), introduces also a third answer – the "many-world interpretation" – which, so to say, does not see this thought experiment as a genuine problem in the first place. For the sake of simplicity, however, I decided not to take it into consideration in this short paper.

17) See for example Bell, "Pilot Wave."

3. Nonlocal Indeterminacy

3.1. Locality as a Limitation of Knowledge – Kant and Einstein

Spatiotemporal locality was given a proper formulation by Einstein on the ground of his Special Relativity, but one may track its roots as far as to Kant's philosophy. Kant regarded space and time as the transcendental forms of the subject's senses, respectively: the outer senses and the inner sense. At the same time however, I am in favor of the interpretation of Kant's account which regards space and time as not only the forms of subjective perception but also of the objective world.[18] The crucial issue which I want to emphasize here is that according to Kant our cognitive limitations come from the fact that all knowledge is mediated by senses.[19] We cannot directly know things as they are in themselves. We only perceive them as they are in relation to our senses, (i.e. indirectly, as phenomena).

This spatiotemporal limitation can easily be spotted when we consider that being at a certain point in space and a certain moment in time one can empirically (i.e. through one's senses) examine only what is in one's direct contiguity. To give a trivial example (which nevertheless expresses this fundamental intuition), sitting at the desk in my room I cannot immediately know what at the same time is happening in the kitchen. To discover it by myself empirically I simply need to stand up and go there, that is, change my position in space. (Analogous examples can be constructed in reference to time).

Kant juxtaposes human cognition, limited by space and time, with an imagined cognition that would be unlimited and unmediated. An intellect endowed with such capacity would directly know the things as they are in themselves, (as noumena).[20]

Connecting this with the above considerations, we can say that this unlimited, "noumenal" cognition should be regarded as a regulative idea – it is the mode of cognition of Laplace's demon to which our knowledge can only approximate.

In Einstein's Special Relativity, the intuitions concerning this limiting nature of space and time turn out to be the consequences of the first postulate of the theory: the invariance of the speed of light. We all have probably heard that nothing can move faster than light: no object, no physical interaction, and no information. As a result, no causal interaction can propagate faster than this definite speed. This is the crux of Einstein's principle of locality.[21]

In the language of Special Relativity, the thesis of causal determinism could be encapsulated in the statement that the so-called "absolute past" of a given event (which is defined by the "light cone" in spacetime built of pointwise events), must determine the physical properties of this event.[22] The principle of locality cuts out from the whole spacetime, the area that is causally accessible for a given event or object. Analogously, in the case of the Kantian cognitive subject, it is the forms of space and time that limit what is cognitively accessible for a given subject.

18) This "objective" interpretation is based primarily on Kant's argument in the "Refutation of Idealism" in his *Pure Reason*, B 274–94.

19) With this regard, Kant shows his radical empiricist position.

20) See "On Distinction into Phenomena and Noumena," in Kant, *Pure Reason*, B 294–315.

21) See Bigaj, *Non-locality*, 24.

22) I speak of events to do justice to the conceptual framework of this theory, but this statement could easily be translated to the language of objects, particles, whatsoever.

3.2. Nonlocal Laplace's demon

Let us consider a borderline case of Laplace's demon: an omnipotent demon, an all-knowing intelligence, which traditionally has been identified with God. Such an intellect could know things directly, as they are in themselves, (i.e. noumenally). God in his cognition is not limited by space or time. It was already pointed out by Boethius who argued that, because God sees all the times as if they were present to him, his knowledge does not entail necessity and therefore does not limit our freedom. Let me reconstruct this argumentation in the Kantian framework. According to Kant, without temporal sequence we cannot think of any causal relation – as he writes: "[t]ime is in itself a series (and the formal condition of all series)."[23] Moreover, without a causal link between the objects of experience, we cannot think of *any* necessary connection between them. Therefore, if objects of God's knowledge are not given to him in time, his knowledge about them – his "cognitive connection" to them – does not entail necessity. This means that his knowledge about our future actions does limit our freedom. We can put it differently and say that because God's way of acquiring knowledge is not causal (as opposed to human – empirical – knowledge which always requires some causal interaction)[24] it does not in any way interfere with the objects of his perception.

When discussing Laplace's thought experiment, we saw that Earman casts doubts on the significance of this deterministic vision when it comes to answering the question of whether the objective world is deterministic.[25] In my interpretation of epistemological determinism, one of its assumptions is that in order to predict the future evolution of the world, one has to know the exact state of the world at a given moment in time. Cognitive locality, as described by Kant and Einstein, drastically limits the possibility of acquiring such knowledge. From our human perspective it is impossible to at an instant get to know all the physical properties of all objects in the universe. To that one could say that we do not have to know the properties of all there is, we could just restrict ourselves to a region of the universe that we want to examine. But here we stumble upon two quantum-mechanical obstacles that make a complete knowledge of relevant physical properties impossible (even in the case of very simple quantum systems).

The first one is Heisenberg's uncertainty principle whose consequence is that even in case of examining only *one* quantum object it is impossible to know exactly all the relevant (with regard to the desirable prediction), physical properties (e.g. position and momentum),[26] let alone knowing them for a system composed of a number of quantum objects which constantly interact with each other! It of course is an unsettling difficulty for the supporters of epistemological determinism, but below I want to focus on the obstacle more relevant to the discussed issues, which concerns the problem of nonlocality.

As an introduction, let me draw your attention to the problem of completeness. Put in general words, the discussed assumption of epistemological determinism states that one has to acquire a complete[27] knowledge of

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23) Kant, *Pure Reason*, B 438-39. Cf. ibid., B 232–56.

24) By the way, Heisenberg's and Bohr's interpretation of the quantum-mechanical uncertainty principle were based on a very similar observation that any act of measurement (which is a form of acquiring empirical knowledge), requires an interaction between the measuring devices and the object under investigation. They would present their understanding of this fundamental principle on an example known in the literature as the "Heisenberg's microscope" (see Hilgevoord and Uffink, "The Uncertainty Principle," section 2.2). In short, this sort of thought experiment is constructed so as to show that because any act of measurement requires an interaction between the measuring devices and the object under investigation this interaction always disturbs the state of the object in a way that is impossible to predict *a priori*.

25) Cf. Earman, *A Primer*, 7.

26) See for example Hilgevoord and Uffink, "The Uncertainty Principle."

27) "Complete" in the sense that it provides all the relevant information so as to determinately predict the future (or past) state of the system at any given moment.

a system to be able to predict its future evolution. Then, we shall say that completeness is a necessary condition for predictability and, therefore, a necessary condition for epistemological determinism as well. Schematically, we can express this in an implication:

(1) epistemological determinism completeness,

which is logically equivalent to:

(2) incompleteness epistemological indeterminism.

This means that if one does not acquire a complete knowledge, they cannot make an accurate prediction nor can they precisely determine the future evolution of the system.

At the same time, the considerations concerning the nonlocal Laplace's demon were aimed to show that cognitive, spatiotemporal locality limits the possibility of precise prediction and eventually leads to epistemological incompleteness. Let us keep in mind this observation:

(3) cognitive locality epistemological incompleteness.

3.3. Quantum (in)Completeness

The completeness of QM was called into question in the famous article "Can Quantum-Mechanical Description of Physical Reality be Considered Complete?" published by Einstein, Podolsky, and Rosen in 1935 (thus the popular name of the argument presented in this article: the "EPR argument"), which was analyzed in great depth by Bell.[28] There is no room here to reconstruct this argument in detail, this is why I will restrict myself to presenting its assumptions and conclusions relevant to the purposes of this essay.[29]

The authors' answer to the question posed in the title is negative. Their argument is aimed to show that quantum-mechanical formalism allows special-case systems (called the "entangled systems") where one can observe certain statistical correlations between the wave functions describing different parts of the system, no matter how remote they are from each other.[30] With much simplification, it seems that in an entangled system of, for instance, two particles, measurement performed on one somehow *influences* the state of the other regardless of the distance between them – as if the space between them did not exist. According to the authors, these correlations suggest that there has to be "something-out-there" that determines the values of physical properties before any measurement. It is not the measurement that triggers the change of the state of the second particle. For the whole time the state of both of them has been perfectly determinate, but – the argument follows – QM cannot see it. Therefore, they conclude that QM formalism is *incomplete*, (i.e., to use Bell's expression "the wavefunction is not everything"). (Later, Einstein would insist that there has to be a more complete theory than QM which is still to be discovered and which then became known as the "hidden variable theory").

Around 30 years after the original paper, Bell cast huge doubt on their conclusion. In short, he succeeded in showing that what has been proved by the argument is not the alleged incompleteness of QM but the real

28) See Bell, "Einstein-Podolsky-Rosen Paradox."

29) For more details see for example Bigaj, *Non-locality,* 23–67; Maudlin, *Quantum Theory*, 25–29.

30) See Bell, "Einstein-Podolsky-Rosen Paradox," 20.

existence of a nonlocal, quantum interaction.[31] The correlations between remote parts of the system described by QM come from nonlocal interaction between these parts. Moreover, Bell showed that any theory (including the hidden variable theory promoted by Einstein), which reproduces the predictions of QM, must be nonlocal.[32] It is important to note that this "reproduction of the predictions of QM" is more than desirable since QM predictions have been empirically confirmed numerous times. In other words, if we want any theory to accord with experiments (or simply with empirical reality), we have to accept that it must be nonlocal – in the sense that it allows the existence of interactions which violate Einstein's principle of locality. Long after Bell, this fact has been even better justified by a number of theoretical arguments as well as experiments. One of the examples is the so-called "Hardy case" and as Bigaj writes in his recent paper "Non-local Character of Quantum Mechanics: 20 Years Later": "the current argument [concerning the 'Hardy case'] proves, beyond a reasonable doubt, that reality itself is non-local."[33]

For the purposes of this paper, it is also worth noting that the best known and the most elaborate hidden variable theory – namely "pilot-wave theory" – "has indeed a grossly non-local structure."[34] It is, so to say, even *more nonlocal* than the standard QM (which with some simplification can be seen as an example of a collapse theory). Let us recall that hidden variable theories were introduced to maintain the deterministic vision of the world in itself. Hence, it seems that in order to claim determinism is true, one has to accept "more nonlocality." Surprisingly, this accords with purely philosophical considerations described above. Reflecting on the cognitive spatiotemporal limitations, one can see a connection between determinism and nonlocality. To be able to determine the state of the world at a given moment, an intellect would have to go beyond the limitation of locality – like God, it would have to be able to know things *directly* as they are in themselves.

Conclusions

As a summary, let us come back to the implications described earlier:

(2) incompleteness epistemological indeterminism,
(3) cognitive locality incompleteness,

and next, combine them:

(4) cognitive locality incompleteness epistemological indeterminism.

Thus, it follows that:

(5) cognitive locality epistemological indeterminism.

In the section about Kant's and Einstein's views on locality, I tried to show that cognitive locality is a necessary limit of the human mode of cognition. If we accept it as a premise, from (5) it follows that *we are forced to accept epistemological indeterminism*. This means that we have to recognize that in the empirical world there exist

31) See ibid.

32) See ibid., 14.

33) Bigaj, "Quantum Mechanics," 69.

34) Bell, "Einstein-Podolsky-Rosen Paradox," 14.

certain phenomena – (i.e. nonlocal phenomena) – that will always remain outside the limits of our cognitive capacities. In other words, there are certain phenomena which we will never be able to determinately predict.

What about metaphysical determinism? As I argued above, my claim is that we should regard it only as a regulative idea that by itself does not tell us anything meaningful about empirical reality. The statement that reality is determined independently of our knowledge might set the goal for scientific inquiry but it is not a part of it. It is assumed rather than discovered. It is but "an object of comparison – as, so to speak, a measuring-rod; not as a preconceived idea to which reality must correspond."[35] Recall that QM itself does not decide whether quantum reality is in itself determined or not. The freedom of interpretation regarding collapse and hidden-variable theories shows that one can choose whether she wants to believe that metaphysical determinism is true or not – and this fact, in my opinion, renders the thesis of metaphysical determinism much less meaningful.

I believe the thesis of metaphysical determinism should be reformulated into a problematic, hypothetical assumption – which is the basis of any novel scientific investigation – that although in the world we can still observe certain phenomena which have not yet been explained and "determined" by science they possibly can be embraced by future scientific inquiry. Such an assumption has to be made if we want science to progress. But, again, this assumption is only problematic and "ideal" – it sets the direction for the expansion of the domain of human knowledge but in itself lies beyond it.

The last thing – which, however, may be the most important – is to ask: what do these considerations have on the problem of the existence of free will? In this paper, I wanted to follow the Kantian strategy of critique of the transcendental illusion: first, examine the limits of knowledge and then show that the discussed issue lies beyond them. I have argued that quantum nonlocality sets the limit for our attempt for a deterministic description of the world. And, so far as determinism and free will are essentially intertwined, I believe this conclusion makes room for the possibility of the existence of free will (as a part of this world). If we cannot prove that determinism is true then we cannot prove that free will does not exist and, therefore, we still can rationally believe that it does.

But could we, on the grounds of quantum mechanics, *prove* that free will does exist? Unfortunately, this is something that I believe we are not yet competent to answer. The only thing we could say is that in order to answer this question we should first examine the relationship between free will and nonlocal quantum phenomena. For now, we may just wander being careful not to fall into philosophical dogmatism.

35) Wittgenstein, *Investigations*, thesis no. 131.

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