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FROM QUANTUM MECHANICS TO QUANTUM REALITY

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Throughout the 20th century, quantum mechanics was celebrated as the ultimate proof that modern science is leaving behind deterministic mechanical materialism and admitted that it is dealing with non-material entities; moreover, the notion that our reality takes place through being observed opens up to a subjectivist denial of objective reality. Some quantum scientists themselves claimed that the only way to account for our entire universe is to presuppose a global external observer (i.e., God). The text rejects not only this direct theological solution but also the traditional "realist" stance which secretly relies on a divine dimension (the divine status of natural laws). It proposes a reading of the ontological implications of quantum physics which opens up the way for a consequent materialism, even if, from a traditional reading, this may appear to be an odd materialism without matter.

Keywords: Quantum mechanics – Bell's Theorem – Niels Bohr – Experimental metaphysics – Counterfactual definiteness

I. How Can Reality Itself Be Wrong?

When a philosopher deals with quantum physics, the first thing to avoid is the common temptation to elevate its paradoxical results into a universal world-view, a formula that applies to all possible domains. Niels Bohr himself occasionally fell into this trap and argued that his notion of complementarity has wide applicability: from Kabballah (complementarity between God's love and God's justice), between life and physics, between energy and causation, between knowledge and wisdom. Did he thereby not come close to a kind of universal metaphysics that contains all of reality, in clear contrast to his repeated insistence that quantum mechanics is just a way we describe reality, with no ontological implications?

Closer to the spirit of our time, one should also reject the cultural historicization of superpositions and complementarity in quantum physics, perceiving them as one of the manifestations of the turn in the predominant ideology around 1900 (the reverse of the mechanistic-determinist materialism with its "naïve" notions of "objective reality"; the idea that, in new scientific advances, "matter is disappearing"; the passage from realism to modernism in the arts with the accent on multiple subjective perspectives; general doubt in rationalism and social progress). The theories of relativity and quantum mechanics are supreme scientific achievements which cannot be reduced to or accounted for in the terms of the social and ideological circumstances that gave birth to them. Yes, quantum mechanics emerged in a specific historical constellation, but this does not relativize its truth. As Marx already put it, certain categories (his example is the universal notion of labor) which are valid for all times can only appear as such, in their universality, in modern capitalist society in which labor becomes universal in the experienced social situation itself (workers are aware that they can pass from one to another kind of labor since they are paid for it by money, the universal equivalent of all values). In capitalism, I experience myself as a human being who is for contingent reasons engaged in one or another activity to survive. I am a universal being also for myself.

A little bit more pertinent, although still problematic, is to locate quantum mechanics in the shift between appearance and reality that took place at the same time. The gap that separates the quantum level from our ordinary perceived reality is *not* a gap between the ultimate hard reality and a higher-level unavoidable-but-illusory hallucination. On the contrary, it is the quantum level which is kind of "hallucinated," not yet ontologically fully constituted, floating ambiguously, and it is the shift to the "higher" level of appearances (our perceived reality) that turns it into a hard reality. Therein resides the embarrassing paradox encountered by the 20th century "hard" sciences: in (among others) quantum physics, the "appearance" (perception) of a particle determines its reality – the very emergence of "hard reality" out of the quantum fluctuation through the collapse of the wave-function is the outcome of observation, i.e., of the intervention of consciousness. This premise of the ontological superiority of appearances is difficult to accept – a difficulty that does not concern only the ideological misuse or philosophical interpretation of a science: it is a difficulty that haunts science itself.

As is clear from this last example, I approach quantum mechanics from the standpoint of the struggle between materialism and idealist or outright religious spiritualism. Throughout the 20th century, quantum mechanics was celebrated as the ultimate proof that modern science itself is leaving behind deterministic mechanical materialism and admitted that it is dealing with non-material entities; moreover, the notion that our reality takes place through being observed opens up to a subjectivist denial of objective reality – does the primacy of appearances not imply an observer to whom things appear? Some quantum scientists themselves claimed that the only way to account for our entire universe is to presuppose a global external observer (i.e., God). I am thoroughly opposed not only to this direct theological solution, but also to the traditional "realist" stance which no less secretly relies on a divine dimension (as Einstein explicitly stated). This is only (what I consider) a correct reading of quantum physics which opens up the way for a consequent materialism (even if, from a traditional reading, this may appear to be an odd materialism without matter).

This difficulty is what we will focus on, taking as our starting point Lee Smolin's *Einstein's Unfinished Revolution*, a book wonderfully characterized by George Dyson as "the best explanation yet of what has yet to be explained" (Smolin 2019, quoted on the book's cover). Smolin doesn't provide a new Theory of Everything. After bringing out the limitations of quantum mechanics, he just very cautiously formulates a series of conjectures of how "what lies beyond quantum" would look. To go to the end, Smolin's starting point – quantum mechanics is the most successful theory ever formulated, the only problem with it is that it is wrong – should be supplemented: what if the solution is not to make a big step into some unknown universe of hidden variables that would provide a full view and explanation of reality, what if the deadlocks of quantum mechanics point towards the odd fact that, measured by the standards of our reality, the "reality" of which quantum mechanics speaks is in some sense *in itself "wrong"*?

In *what* sense, exactly? In the sense that the universe of quantum waves described by science is incompatible with our intuitive notion of reality: science concerns only measurable quantities, but it cannot give an intuitive picture of what goes on at atomic scales. So is complementarity not a notion reflected into itself? It is not just the complementarity of qualities we measure (say, particles and waves, or position and momentum), but also the complementarity of the observed and the observer, of the quantum phenomena and the ordinary reality in which all measurements take place. This is why I find problematic Smolin's claim that, "however weird the quantum world may be, it need not threaten anyone's belief in commonsense realism" (Smolin 2019, 205). The least one can add is that "commonsense realism" implies a belief in the substantial reality of things which cannot be resolved in or reduced to a network of relations, and further that space is an irreducible aspect of our commonsense notion of reality, in contrast to Smolin's own idea that

> to extend quantum mechanics to a theory of the whole universe, we have to choose between space and time. Only one can be fundamental. If we insist on being realists about space, then time and causation are illusions, emergent only at the level of a course approximation to the true timeless description. Or we can choose to be realists about time and causation. Then, like Rovelli, we have to believe that space is an illusion (Smolin 2019, 204).[1]

Quantum mechanics thus immanently raises a fundamental ontological question: what is the status of its object? If it is not a part of our spatio-temporal reality, is it a part of another reality or just a theoretical fiction? But we should also turn the question around: is what we call "philosophy" still able to account for what quantum mechanics is dealing with?

[1] But is this really Rovelli's position? What about his idea – we'll deal with it later – that "time is an effect of our overlooking of the physical microstates of things. Time is information we don't have. Time is our ignorance." (Rovelli 2017, 222 – 223).

II. Bell's Theorem

At the very beginning of his bestselling *The Grand Design*, Stephen Hawking triumphantly proclaims that "philosophy is dead" (Hawking, Mlodinow 2010, 5). With the latest advances in quantum physics and cosmology, the so-called experimental metaphysics reaches its apogee: metaphysical questions about the origins of the universe, etc., which were till now the topic of philosophical speculations, can now be answered through experimental science and thus empirically tested. Upon a closer look, we, of course, soon discover that we are not yet quite there – almost, but not yet. Furthermore, it would have been easy to reject these claims and demonstrate the continuing pertinence of philosophy for Hawking himself (not to mention the fact that his own book is definitely not science, but its very problematic popular generalization): Hawking relies on a series of methodological and ontological presuppositions which he takes for granted.

But we should nonetheless not ignore the philosophical implications of quantum mechanics; even when quantum mechanics may seem to indulge in wild speculations, its claims are getting empirical confirmation. The Nobel Prize for Physics in 2022 was given to Alain Aspect, John F. Clauser and Anton Zeilinger for discovering the way that unseen particles, such as photons or tiny bits of matter, can be linked to, or "entangled" with, each other even when they are separated by large distances. Clauser said:

> Most people would assume that nature is made out of stuff distributed throughout space and time, and that appears not to be the case.… Quantum entanglement has to do with taking these two photons and then measuring one over here and knowing immediately something about the other one over here, and if we have this property of entanglement between the two photons, we can establish a common information between two different observers of these quantum objects. And this allows us to do things like secret communication, in ways which weren't possible to do before (Johnston 2022).

The obvious question that arises here is: could there be a more complete description of the world, with quantum mechanics reduced to just one of its parts? For example, could particles be carrying hidden information about what they will show as the result of an experiment, so that measurements display the properties that exist exactly where the measurements are conducted? Bell discovered that there is a type of experiment that can determine whether the world is purely quantum mechanical, or whether there could be another description with hidden variables. If his experiment is repeated many times, all theories with hidden variables show a correlation between the results that must be lower than, or at most equal to, a specific value – this is called Bell's inequality.

However, quantum mechanics violates this inequality: it predicts higher values for the correlation between the results than is possible through hidden variables.

The implications of these experiments are not only practical (they point towards the direct exchange of information at long distances) but also philosophical. Today the wave of critiques directed against the Copenhagen orthodoxy is rising. Bohr's formulations are dismissed as a theory which prohibits any theory, as variations on the theme of "Shut up and calculate!"[2] For example, Sabine Hossenfelder's return to realism is clearly opposed to Hegel's idealism: there is a chaotic thickness ("ugliness") of reality that cannot be generated by means of formal (logical, mathematical) "beautiful" articulations. But while the demand to confront the big "metaphysical" question about the reality that sustains quantum phenomena is totally legitimate, one should not too easily "domesticate" the basic paradoxes displayed by the quantum measurements: not only is a kind of realism disproved by them, i.e., not only do we have to abandon the notion that a theory simply registers what goes on in independent "objective" reality. The properly Hegelian dimension of the elimination of hidden variables resides in the fact that this elimination does something that appears impossible for a common sense: it proposes a procedure to demonstrate rationally and experimentally not the presence of something behind the phenomenal appearances but its absence, the fact that there is nothing behind. The inaccessibility of hidden depth is not just epistemological, but it can be proven that it is part of reality itself – therein resides the basic reversal of the Hegelian dialectical process, and so we need to formulate a philosophical version of Bell's theorem. Critics of Bohr accuse him of irrationally prohibiting any speculations about what kind of reality there is behind the phenomena we measure and translate into mathematical formula. But what if, since the ontological question persists, we should transpose the limit that prohibits us to grasp as it is reality-in-itself into this reality, conceiving this reality itself as something that is "barred," traversed by an irreducible impossibility?

The experimental testings of Bell's inequality thus provided the first clear case of what is usually called "experimental metaphysics": the result – the rejection not only of the hidden variables critique of quantum mechanics but also of its "orthodox" Copenhagen interpretation – has crucial ontological implications about the nature of time and space and about the general interconnectedness of reality. Bohr was a stubborn everyday-life realist: he was never tired of repeating that only our reality exists and that all that happens in quantum physics experiments is part of our common reality (apparatuses we use for experiments are part of this reality, the results of experiments are numbers that appear on a screen) – we never see wave

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[2] For a simple but concise report on this critical wave, see Becker (2018).

oscillations or other quantum entities, the entire edifice of quantum mechanics is just a mathematical construct we use to account for the connection between the phenomena we observe in our reality, but it does not point to another sphere of reality beyond or beneath our common reality. The paradox is that, although the experiments which confirmed Bell's hypothesis (a link between particles faster than the speed of light) were taken as a victory of Bohr against Einstein's insistence on hidden variables, they renewed the debate about the ontological status of quantum phenomena. In an anti-Bohr spirit, Bell spoke of "beables" as opposed to "observables": reality is not a chaotic mess waiting for observers to "collapse" into observable objects, it is something that should be analyzed the way it is in itself. The link between two particles that connects them faster than light means that at a certain level of reality, the time/space dimension functions in a way that is fundamentally different from the time/space of our reality: either information can move faster than light or there is another level of space where what appears to us far away is next to us. We should be careful to note here that the results of experiments which tested Bell's theorem do not exclude hidden variables as such, they only exclude *local* hidden variables, i.e., hidden variables which operate within our time-space in which the greatest speed is the speed of light. So the question remains: how are two correlated particles connected beyond our space-time since it seems that a signal passes between them faster than the speed of light? David Bohm's pilot wave theory which tries to explain this implies precisely such non-local hidden variables.

In quantum mechanics, counterfactual definiteness (CFD) is the ability to speak "meaningfully" of the definiteness of the results of measurements that have not been performed (i.e., the ability to assume the existence of objects, and properties of objects, even when they have not been measured). The term "counterfactual definiteness" is used in discussions of physics calculations, especially those related to quantum entanglement and to the Bell inequalities. In such discussions "meaningfully" means the ability to treat these unmeasured results on an equal footing with measured results in statistical calculations.[3] How far do we go here? Bell's violation demonstrates an absence, not a presence. Does then entanglement not imply a kind of counterfactual definiteness? If one element goes up, we know without measurement that the other one goes down? Becker quotes David Deutsch who brought out the best argument for the many worlds interpretation of quantum mechanics:

> The Everett [many worlds] interpretation explains well how the [quantum] computer's behaviour follow from its having delegated subtasks to copies of

[3] See Counterfactual definiteness [online]. Available at: https://en.wikipedia.org/wiki/Counterfactual_definiteness

> itself in other universes…When the [quantum] computer succeeds in performing two processor-days of computation, how would the conventional interpretations explain the presence of the correct answer? *Where was it computed?* (Becker 2018, 253).

The task is to define this place "where it was computed" not as another reality like ours, but as another virtual-but-effective place. Bell's theorem shows a path to this with its three key features: contextuality, imperfection, and counterfactual definiteness. In quantum mechanics, contextuality is the dependence of an observable's outcome on the experimental context, i.e., on the system-apparatus interaction, which means that *the order in which measurements are made matters*, or, to evoke the standard example of a conversation between Anna and Beth: "the answers Anna gives depend on the choice of which questions Beth is asked" (Smolin 2019, 55). "Contextuality occurs in situations in which our system is described by at least three properties, which we can call A, B, and C. A is compatible with both B and C, so A may be measured simultaneously with either B or C. But B and C are not compatible with each other, so we can measure only one at a time" (Smolin 2019, 56). So we can measure A and B or we can measure A and C, and the paradox is that "the answers to A depend on whether we chose to measure B or C along with A. The conclusion is that nature is contextual" (Smolin 2019, 56).

Probabilistically, complementarity means that the joint probability distribution does not exist: one has to operate with contextual probabilities. The Bell inequalities are interpreted as the statistical tests of contextuality, and hence, incompatibility. For context-dependent probabilities, these inequalities may be violated.[4] However, what is the ontological status of such context-dependent probabilities? Is it not clear that they cannot stand on their own, or, as Smolin put it, that "any system quantum mechanics applies to must be a subsystem of a larger system" (Smolin 2019, 26) – why? Because (for Bohr) it doesn't cover the ordinary reality in which we measure quantum phenomena: observers and measuring systems are not part of the system being studied, and quantum mechanics cannot cover the gap that separates the two. Smolin tries to imagine a solution here by way of stepping "beyond the quantum." To designate the basic elements of the universe, Smolin proposes a neologism "nads" (Leibniz's "monads" minus "mo"), in the spirit of Democritus' neologism "den" (he subtracts the negation "me" from "meden," the term for nothing) – in this sense, nads are also in a way something that is less than nothing. Unlike (the standard reading of) Democritus' atoms, Smolin's nads are not substantial entities but a network of relations. Originally, these interactions occur in time only, not limited by the speed of light – this limit emerges only with the appearance of time-space. How, then, does space arise out of

[4] See Khrennikov (2022).

spaceless temporal events and their intermingling? “Space arises as a coarse-grained and approximate description of the network of relationships between events,” and quantum nonlocalities are “remnants of the spaceless relations inherent to the primordial stage, before space emerges” (Smolin 2019, 236). Smolin advocates a theory of decoherence from the lack of clones: large objects are unique, they have no clones, so they bring about a collapse into single reality: macroscopic systems which have no copies anywhere in the world don’t obey quantum mechanics. But all of reality cannot be “sublated” into our spacetime, so “quantum physics arises from nonlocal interactions left over when space emerges” (Smolin 2019, 240) – in my terms, quantum phenomena bear witness to the fact that God itself (the big Other) is deceived, that some things elude its grasp. I am, of course, by far not qualified to pass a judgement here, since this topic is very complex: how does decoherence relate to collapse of the wave function in a measurement? Are they the same? Obviously not directly, since the way Smolin describes decoherence, it happens “objectively.” Moreover, how does observation differ from “views” that characterize every nod? Are such views not a more basic mode of observation? This brings us back to the key ontological problem of quantum mechanics avoided by Bohr: how to account for the split between observed/measured phenomena (quantum waves) and the entire complex machinery of observation (not only observers but also the instruments we use to do the measurements) which is firmly located in our reality? The first thing to do is to take note of the fact that “every way of drawing a boundary splits the world into two incomplete parts. There is no view of the universe as a whole, as if from outside of it. There is no quantum state of the universe as a whole. If relational quantum theory had a slogan, it would be ‘Many partial viewpoints define a single universe’” (Rovelli 2017, 197). Rovelli gives to such relational quantum mechanics a specific spin: “reality consists of the sequence of events by means of which a system on one side of the boundary may gain information about the part of the world on the other side.… This reality is dependent on a choice of boundary, because what is a definite event – something that definitely happened for one observer – could be part of a superposition for another” (Rovelli 2017, 198).

Apropos Schroedinger’s cat, our observation decides if the cat in the box is dead or alive, but we can also posit the cat itself as the observer of the signal from the detector, etc.: “if it doesn’t make sense for us to exist in a superposition, it surely doesn’t for the cat either” (Rovelli 2017, 53). Such a view also enables us to reject the Everett theory of multiple universes: it implies that we can occupy a godlike position from which we can posit that the infinity of branches really exists: “But we are not godlike, we are observers living inside the universe, we are part of the world that the wave function describes. So that external description has no relevance for us or for the observations we make” (Rovelli 2017, 165). Note, again, the mention of God at this crucial point. Here, however, one has to add that a vision of the universe of wave functions in which nads interact through "viewing" each other ("viewing" in the abstract sense of limited links which connect a nad with its environment), and in which gaps between observers and observed emerge continuously, doesn't allow us to posit relational reality as an all-encompassing reality within which gaps emerge: there has to be a void, a limitation beyond which there is nothing, in wave reality itself – reality itself is non-all, "feminine." Not simply without boundary, but with an empty boundary which makes it non-all. "Masculine" is the gap of decoherence, with the exception of the observer. Theology provides here a false solution: reality can be conceived as All through God as universal observer.

This paradox enables us to explain why Bell's theorem is so revolutionary: as Becker pointed out, it implies a move from perfection to imperfection: "Bell's stroke of brilliance was to consider imperfection, rather than perfection" (Becker 2018, 151). *This* is why Bell's theorem is "the most profound discovery of science" (Rovelli 2017, 141): it provides a formula (of the result expected if there is no faster-than-light interconnection) *in order to refute it*. Imperfections usually serve to demonstrate that other (hidden) variables must be at work – in the case of Bell's theorem, they serve the opposite end: they prove that there is *nothing* behind.

III. A Deceived God

In the debate between theology and atheism we encounter a similar problem: the usual argument of religious theorists is that it is possible to (pretend to) explain reality without reference to God, i.e., that God is a hypothesis we don't need (as Laplace famously replied to Napoleon), but it is not possible to prove that something does not exist. However, a true materialist does exactly this, which is why s/he has to pass through religion. To make this point clearer, let's take a closer look at Napoleon and Laplace – when Napoleon visited Laplace, he asked him: "They tell me you have written this large book on the system of the universe, and have never even mentioned its Creator." Laplace replied: "Sire, I had no need of that hypothesis." Religious commentators claim that this reply is "constantly misused to buttress atheism":

> Of course God did not appear in Laplace's mathematical description of how things work, just as Mr. Ford would not appear in a scientific description of the laws of internal combustion. But what does that prove? That Henry Ford did not exist? Clearly not. Neither does such an argument prove that God does not exist. Austin Farrer comments on the Laplace incident as follows: "Since God is not a rule built into the action of forces, nor is he a block of force, no sentence about God can play a part in physics or astronomy. We may forgive Laplace – he was answering an amateur according to his

> ignorance, not to say a fool according to his folly. Considered as a serious observation, his remark could scarcely have been more misleading. Laplace and his colleagues had not learned to do without theology; they had merely learned to mind their own business" (Lennox 2007, 44 – 45).

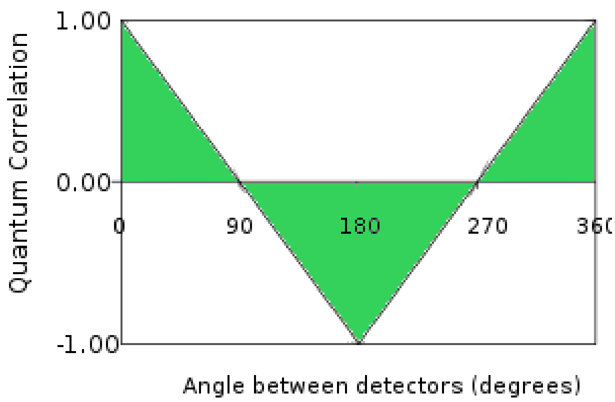
The religious side makes here a worthwhile point: the fact that natural scientific explanation of the universe does not need to evoke God is true since it is basically tautological: in the space of natural determinism (even if it admits an irreducible contingency), there is no place for entities like God, free will, etc. But this does not prove that there is no God. God can still be conceived as a transcendent cause of the entire cosmos. So here a reference to Bell becomes crucial: Bell's genius resides in the way he succeeded in demonstrating that something (hidden variables) *does not* exist, and a true atheist materialist should do the same for God – not just prove that we don't need God to explain reality, but to prove that God cannot exist.

The problem is that most of the practitioners of the quantum mechanics avoided this path. Becker claims that "every interpretation has its critics (though the proponents of basically every non-Copenhagen interpretation are usually agreed that Copenhagen is the worst of the lot)" (Becker 2018, 287). I agree, but my reaction to it is a variation of Churchill's well-known quip about democracy (which he took from someone else): "democracy is the worst form of government – except for all the others that have been tried." Yes, Copenhagen orthodoxy is the worst imaginable – it is not an argument at all, just an outright prohibition to raise the very ontological question of the status of quantum phenomena. However, all others – solipsism of the observer, hidden variables, Bohm-realism, many worlds interpretation – are worse because they fill in the ontological gap kept open by the Copenhagen interpretation. So instead of filling in this gap by way of proposing its positive explanation, we should just displace it, posit it into the very heart of reality itself. If a rumor that Bohr was an avid Kant reader is true, one should accomplish here a move from Kant to Hegel. Bohr limits reality to what Kant calls the space of transcendental constitution forever separated from the In-itself, and Hegel challenges us to transpose this separation into the In-itself – or, as they say in quantum theory, what if the imperfection implied by complementarity "is a feature and not a bug" (Becker 2018, 89)?

To put it in yet another way, Bell's theorem "is significant not because of what it is, but what its *negation* implies: a violation of Bell's theorem in experiment is proof that quantum mechanics *cannot* be described by hidden variables, and thus by classical mechanics."[5] Here is a simple description of the experiment that I took from Paul Mainwood:

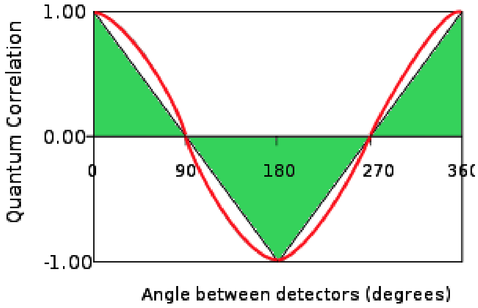
[5] Quoted from online forum post at *Quora*: https://www.quora.com/What-does-Bells-inequality-mean-in-laymans-terms

I am going to allow my two electrons to communicate as much as I want in advance of their being emitted from the source. Now they are emitted by the source and fly apart, each to their own detector. I am going to set things up so that I ban them from all communication once they are in flight. I am also going to allow my detector operators a free choice as to the angles they choose to set their detectors and ban all communication between them too. *How much correlation can there be between the readings of spin ("positive" and "negative") that I get from the two detectors?* The answer to the question depends on the relative setting of the angles of the two detectors. Let's start with the case where the two detectors are set at the same angle as one another. For the case where the two detectors measure in the same direction, here's an easy plan that can give you full 100% correlation. But now, what if the detectors are not set at the same angle? For example, if we placed the detector angles at 90 degrees to one another and use the same rules, it is straightforward to see that we'd get zero correlation: half the time, the demons in each of the two electrons will shout the same word, and half the time they'll shout opposite words… But what happens if *the "demons" don't know what angles the detectors will be set at*? As long as there is no communication between the electrons once in flight, and so long as the angles of the detectors are set independently, then any scheme has a limit on the correlation value that is shown by the green areas here.



But what if you get to quantum mechanics, and you set up exactly this setup with two real electrons that are entangled with one another?

Quantum mechanics predicts that these two electrons will give *more* correlation in their spin measurements than this limit – here's the quantum line in red.



This gives us Bell's theorem: no local (= no communication between the electrons/detectors), realistic (= any kind of machinery or demon-thing that contains state assignments or probability distributions for measurement outcomes) model can reproduce the predictions of quantum mechanics – there is too much correlation predicted by quantum mechanics for any local, realistic scheme to work.[6]

Incidentally, in popular explanations of this experiment, the imagined situation often used is the one of Bob and Alice, two roulette players interacting in a complex set of two triple roulettes. From a superdeterminist position, we can of course question the status of Alice's and Bob's "contingent" decisions: are they really contingent, or even free? Are they not also parts of the determinist reality into which they intervene? Plus, the comparison with Alice's and Bob's card cheating connotes sexual difference (woman versus man), but the term "cheating" points in the right direction of how quantum reality "cheats" the laws of our reality.

Now we can return to our basic question of materialism and quantum physics: quantum physics is truly materialist insofar as it allows such ontological "cheating." In his advocacy of hidden variables which are needed to explain quantum measurements, Einstein produced a pure formula that the "subject is supposed to know" by way of providing a clear formulation of what Lacan called "knowledge in the real": "Somebody must know, the photon must know…."[7] When asked about the basis for

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[6] Quoted from online forum post at *Quora*: https://www.quora.com/Quantum-Mechanics-What-is-an-explanation-of-Bells-Theorem-in-plain-language

[7] Is the limitation of such "knowledge in the real" not clearly discernible in the confusions caused by global warming? We often get high temperatures already in February, and then another cold wave takes place in late March or April. Nature (whose "knowledge" tells it that warm weather comes with spring) "misreads" the hot February as the beginning of spring and begins to come into flower, but the new cold wave then destroys the premature blooming and disturbs the entire reproductive cycle.

his realist stance, he explained: "I have no better expression than the term 'religious' for this trust in the rational character of reality and in its being accessible, at least to some extent, to human reason" (Einstein 1993, 119). But it is precisely this "knowledge in the real" that is shattered in quantum physics: quantum phenomena bear witness to the fact that nature "does not know" how to act, that its laws are not all-inclusive.

Bohr is quoted as saying: "There is no quantum world. There is only an abstract quantum physical description. It is wrong to think that the task of physics is to find out how nature *is*. Physics concerns what we can *say* about nature" (Petersen 1963, 12). This vaguely positivist statement was echoed by Heisenberg: "[W]e have to remember that what we observe is not nature in itself but nature exposed to our method of questioning."[8] (No wonder that Heisenberg as a German formulates a version closer to hermeneutics.)

Bell proposes here a third way: the universe of quantum waves is not just our description of reality, but rather it uncovers a new reality which obeys different laws than those of our ordinary spatio-temporal reality with linear time and three-dimensional space. In short, the link between the two correlated particles appears as a "spooky action at a distance" only if we stick to the standard notion of space, of spatial distance – what if we introduce the notion of heterogeneous spaces? This is why we stumble here (again) upon a spiritualist temptation: what if the non-local link is a simultaneous-atemporal spiritual bond of everything, an indication of a reality different from our spatio-temporal materiality? Again, this is the pseudo-solution we should unconditionally reject: yes, photons are in themselves massless, so they do not move in time or space, everything happens among them instantaneously – but this matter-less other space nonetheless remains real. If we look for some kind of spiritual dimension, it is present in Einstein and not in Bohr: the fact that Einstein (who did not believe in a personal God) talks about God when evoking the universal laws of nature confirms that God is the ultimate figure of the big Other, and that Descartes was right when he claimed that only a non-deceiving god can sustain our knowledge about reality:

> In order for science (true knowledge) about the external world as well as about ourselves as *res extensae*, that is to say, as bearers of sensible properties, to constitute itself, it is necessary to presuppose/demonstrate the existence of a god who is not deceiving us, who created eternal truths and, as Descartes put it, planted them like seeds into our souls. This god is not a god of religion but a god of philosophers and scientists (to follow Pascal's differentiation between the "god of Abraham, Isaac and Jacob," and the "God of philosophers and scientists.") A human can become a subject of knowledge who dominates the world, but only as a depositary of the truths of the Other (Zupančič 2023, 57).

[8] See Heisenberg (1958, 58).

But, as Lacan pointed out, the passage from universal doubt through certitude to *cogito ergo sum* (as a *res cogitans*) is not as smooth as Descartes' deduction implies. Anxiety arises when my trust in everyday reality breaks down, when I see that I cannot rely on any figure of the big Other, that the big Other is not just deceiving but deceived itself, inconsistent. The paranoiac vision of a *genie malin*, a deceiving god which is a fantasy reaction to the true anxiety: it reestablishes the big Other who controls things, although in the evil form – the big shift happens here, my belief in a big Other who controls things is restored. Then comes the third moment, the proof that god cannot be a cheating deceiver but must be truthful. So the first form of certitude is not simply the certitude that I exist even if all objects of my thoughts are hallucinations; it is the negative certitude that I cannot rely on anything or anybody. This certitude "is the opposite of the certitude of being, it could rather be formulated in this way: I know (that the Other is inconsistent, that it can cheat me, and that, for this reason, my knowledge provides no solid ground), *therefore I am not.* We are dealing with the certitude of non-being" (Župančič 2023, 58).

Even before God enters, there is a subtle shift from "I doubt about everything" to "when I doubt, I think, know this, so I am": at the high point of anxiety, when I am certain of my non-being, I am a pure void of a subject, because I am (as a subject) only insofar as the Other is inconsistent. "I am not" means that I am barred from being a subject – the moment I say "(I know that) I am," I am no longer a subject, I transpose myself into the domain of objective reality where I am one among the existing things which are the object of science. This is why Lacan can claim simultaneously that the subject of modern science is the Cartesian subject, *and* that modern science forecloses the subject. Modern science is grounded in the Cartesian radical doubt which shatters our everyday life-world, undermines our "being-in-the-world," our trust in reality – in other words, modern science is grounded in the experience of pure substanceless subjectivity, a void of non-being. However, in its functioning, modern science forecloses this dimension and simply ignores its position of enunciation, reducing its discourse to talking about external reality towards which we maintain a safe distance – "subject as nothing" becomes "no subject," science is supposed to be objective. One can mobilize here the difference between the two German terms, *Zweifel* and *Verzweiflung*, used already by Hegel. *Zweifel* means a simple doubt: from the safety of my subjective stance, I doubt about things outside of my space. *Verzweiflung* means that my subjective position is also threatened: it implies subjective despair.

IV. Space or Time

So what has all this to do with quantum physics? Quantum physics provokes anxiety, ontological uncertainty, its implication is that the big Other itself is deceived, that there is a lack/inconsistency in the big Other. The subject is here not foreclosed, excluded as in objective science, it returns as the "observer" which makes measurements and thus causes the collapse of quantum waves into objects of our "normal" reality. However, this "observer" is not the pure subject but already an agent as part of "normal" external reality. Consequently, the Copenhagen interpretation advocated by Bohr and others obfuscates the most radical dimension, the "ontological scandal," of quantum physics, by way of reducing it to "the way we speak," with no ontological implications. Bohr was not too skeptical (about external reality), quite the opposite, by constraining science to "the way we speak" about phenomena of our ordinary reality (which is the only reality there is), he protected this reality from all doubts and uncertainties.

As we have already seen, Einstein refused the chance aspect of quantum theory, famously telling Niels Bohr: "God does not play dice with the universe." Einstein's other favorite saying – that the Lord is subtle but not malicious – is related to the same conviction of rationality: "Nature hides her secret because of her essential loftiness, but not by means of ruse." It is not enough to counter Einstein's statement with the opposite claim that god does deceive us – this still leaves unscathed the figure of god as an agent who manipulates us but knows what he is doing, and his own integrity remains intact. We should apply to god himself the line from 1 John 1:8: "If we say that we have no sin, we deceive ourselves, and the truth is not in us." God deceives himself, which is why there is sin in him and the truth is not in him. But even this figure of self-deceiving god is not enough: god is deceived not simply by himself but by something that is "in himself more than himself" – how are we to understand this crazy claim? First, we should conceive god here as the ultimate figure of the big Other, the symbolic space which registers everything there is and thereby confers on it symbolic existence; then, we should take into account the lesson of quantum physics: particles appear and vanish before being registered by the big Other, floating in a sphere outside what God notices.

Imagine that you have to take a flight on day x to pick up a fortune the next day, but do not have the money to buy the ticket; but then you discover that the accounting system of the airline is such that if you wire the ticket payment within 24 hours of arrival at your destination, no one will ever know it was not paid prior to departure. In a homologous way,

> the energy a particle has can wildly fluctuate so long as this fluctuation is over a short enough time scale. So, just as the accounting system of the airline "allows" you to "borrow" the money for a plane ticket provided you pay it back quickly enough, quantum mechanics allows a particle to "borrow" energy so long it can relinquish it within a time frame determined

> by Heisenberg's uncertainty principle.… But quantum mechanics forces us to take the analogy one important step further. Imagine someone who is a compulsive borrower and goes from friend to friend asking for money.… Borrow and return, borrow and return – over and over again with unflagging intensity he takes in money only to give it back in short order.… a similar frantic shifting back and forth of energy and momentum is occurring perpetually in the universe of microscopic distance and time intervals (Greene 1999, 116 – 119).

This is how, even in an empty region of space, a particle emerges out of nothing, "borrowing" its energy from the future and paying for it (with its annihilation) before the system notices this borrowing. The whole network can function like this, in a rhythm of borrowing and annihilation, one borrowing from the other, displacing the debt onto the other, postponing the payment of the debt – it is really like the subparticle domain playing Wall Street games with the futures. A minimum of time always elapses between a quantum event and its registration, and this minimal delay opens up the space for a kind of ontological cheating with virtual particles (an electron can create a proton and thereby violate the principle of constant energy, on condition that it reabsorbs it quickly enough, i.e., before its environs "take note" of the discrepancy. *This* is how God himself – the ultimate figure of the big Other – can be deceived; by a swarm of "ones" which escape its grasp. This is how one should read the notion of "half-God" introduced by Lorenzo Chiesa[9]: god who is not fully the demiurge of all there is, god to whom a whole layer of things escapes, or, as Lacan put it: "it is not so much a question of knowing whether he is not a deceiver but, what Descartes does not bring up, whether he is not deceived."[10]

Another paradox (for our common sense) of this notion of "borrowing" energy from the future and paying for it (with its annihilation) before the system notices this borrowing, is that it seems to involve a minimum of backwards time travel.[11] Are closed causal loops in which A is both the causal future and causal past of B really to be excluded? Retrocausality allows us to explain the faster-than-light link between particles without violating speed of light as the fastest possible movement: when two entangled particles are split, information from one particle first travels (with the speed

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[9] Personal communication.

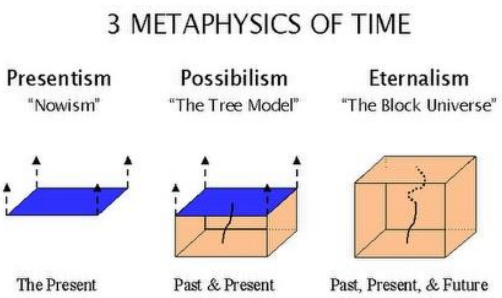
[10] Lacan, Seminar XII, lesson of 3 February 1965 (here, quoted from the yet unpublished manuscript of Lorenzo Chiesa).

[11] Quantum physicists have now performed the first measurement of time reflection: they have managed to reverse time on a quantum level, and even to showcase how time reflections happen. We cannot but wait and see what will follow… See Cartlidge 2023.

of light) back in time to the moment of their split and then travels forward to the other particle, so that their link appears simultaneous. We do not necessarily need to posit the general reversibility of time: the basic direction of time remains forward, from the past to the future, and the occasional detours through the past just complicate the overall movement. (Is there a parallel in the nature of the time structure described by Jean-Pierre Dupuy?[12] At what level can we say that natural processes do not just develop obeying linear causality, that they may also involve a vision of the future and react to it?) Dupuy points out the homology between his notion of projected time in which different futures coexist and the basic idea that future is necessary:

> There are no alternative possible futures since the future is necessary. Instead of exclusive disjunction there is a superposition of states. Both the escalation to extremes and the absence of one are part of a fixed future: it is because the former figures in it that deterrence has a chance to work; it is because the latter figures in it that the adversaries are not bound to destroy each other. Only the future, when it comes to pass, will tell (Dupuy 2023).

And Dupuy is aware of a link with quantum mechanics: "I arrived at the concept of superposition of states by a line of reasoning that owes nothing to quantum theory. Even so, there are unmistakable affinities, at the very least, between the metaphysics of projected time and some of the basic concepts of quantum mechanics" (Dupuy, 2023). So what kind of notion of time (in its contrast to space) does such a notion of universe rely on? The three major rival metaphysical views of time are Presentism, Possibilism, and Eternalism.[13]



Presentism is the ontologically austere view: only the present exists, the past has been but is no longer, while the future will come to be but is not yet. Then we have the tree

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[12] See Dupuy (2023), here, quoted from the manuscript.
[13] See Savitt (2021).

model which is closest to our commonsense view: the past and the present form a stable block of what really took place or is taking place, while the future is open to chance and to our freedom. The block universe is philosophically most interesting, it basically reduces time (temporal change) to space: everything there is exists in an eternal present, and the flow of time is just the illusion due to our limited view constrained to the present. The purest version of the block universe in which time is reduced to a secondary dimension was recently deployed by Rovelli who

> posits that reality is just a complex network of events onto which we project sequences of past, present and future. The whole Universe obeys the laws of quantum mechanics and thermodynamics, out of which time emerges. He argues that our perception of time's flow depends entirely on our inability to see the world in all its detail. Quantum uncertainty means we cannot know the positions and speeds of all the particles in the Universe. If we could, there would be no entropy, and no unravelling of time.[14]

Rovelli spells out clearly the ontological implications of this view: what we experience as our temporal reality "is not a fundamental constituent of the world," it only appears to us

> because the world is immense, and we are small systems within the world, interacting only with macroscopic variables that average among innumerable small, microscopic variables. We, in our everyday lives, never see a single elementary particle, or a single quantum of space. We see stones, mountains, the faces of our friends – and each of these things we see is formed by myriads of elementary components. We are always correlated with averages: they disperse heat and, intrinsically, generate time.… Time is an effect of our overlooking of the physical microstates of things. Time is information we don't have. Time is our ignorance (Rovelli 2017, 222 – 223).

What this means, at the level of ontology, is that "we must not confuse what we know about a system with the absolute state of the same system. What we know is something concerning the relation between the system and ourselves" (Rovelli 2017, 223). What really exists out there, reality in itself, "the absolute state of the system," is composed of quantum events and their interactions which take place outside time, and we should strictly distinguish this reality-in-itself from the way reality appears to us due to the limitation of our view – the classical metaphysical difference between reality and appearances returns here with a vengeance, and Parmenides wins over Heraclitus.

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[14] Quoted from Jaffe (2018).

No wonder Einstein viewed with sympathy the idea of a block universe and played with it – this idea is not a crazy extrapolation but a necessary implication of a fully deterministic view of the universe. Consequently, the only way to really save time – in whatever form – is to conceive reality as not-all, as incomplete, and in this sense as open towards the future. What this means is that what Rovelli calls the "absolute state" of reality, its complete description, is not only out of reach to us, finite limited observers, but it is in itself a meaningless notion that should be abandoned. The "ignorance" that separates us, our view, from the absolute state of reality is immanent to reality itself – reality is "in itself" barred, traversed by an impossibility. Usually idealists privilege time (our thoughts happen in time but cannot be located in space), while materialists insist on the irreducible character of space (even our thoughts have to be located in the spatial reality of our brain); but we should turn this privileging around.

So which of the three models should we adopt? Not that of a tree ("possibilism") with past and present determined and an openness just towards the future, but a fourth one: the *historicity of block-universe itself*. Each "now" – say, every historical epoch – reconstructs its own vision of the past and of the future, and when a true change happens, not just a repetition of the same, the whole block-chain is transformed. The past itself is open towards the future, that is, it is not simply "what really happened" but full of cracks, of alternate possibilities – the past is also what failed to happen, what was crushed so that "what really happened" could have happened.

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