

Quantum Theory and Reality, What Reality *IS* (?)

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As all of you know, last century saw the rise of quantum physics, which constituted a truly dramatic advance in human knowledge. Indeed its axioms are by now to be found at the core, not only of atomic physics proper but also nuclear physics, solid-state physics, high energy physics, electromagnetism, the whole of chemistry and so on. The change quantum mechanics brought into physics was really enormous.

What was its most essential feature? Well, you know, the question looks simple but still, various answers are given to it. Some emphasize the new kind of mathematics it makes use of, others its basic use of probabilities, etc. Personally I think such considerations do not yet reach the core of the matter. As for me, I consider that, when all is said and done, the crucial change consisted quite precisely in this: pre-quantum physics - the physics we call *classical* - was meant to deal with **what exists** whereas quantum physics deals in fact with **what we shall see**.

Now, I must explain this. Classical physics is essentially the physics we first learned at school (incidentally, rightly so: it is the simplest, it lies at the basis of most technologies, and one should beware confusing issues). Clearly its purpose is to provide us with a description of reality *as it really is*. It states there *are* material bodies. It states there *are* electric and magnetic fields. To them it associates mathematical symbols, which, it claims, obey certain laws, the set of which is called a theory. From the said laws, experimentally testable consequences are then derived and tested experimentally. This latter stage of course is essential for ascertaining that the theory is valid, but still, it is external to the theory proper: in principle it is quite possible to present and explain the theory in question without bothering to describe the experiments that make it testable. When they have to do with a theory of this type, entirely grounded on the apparently obvious idea that the entities it deals with do really exist by themselves, quite independently of whether we can perceive them or not, philosophers - who rather like giving elaborated names to simple views - say it is consistent with *ontological realism*.

Clearly, despite its queer name ontological realism is so natural a conception that, at first sight, most people consider it quite obvious and inescapable. True, it rests on the postulate that human mind possesses all the concepts that "fit" reality. But up to the advent of quantum mechanics this assumption seemed validated: Indeed, for a long time theories could be expressed just in terms of simple, fully intuitive concepts: *space, position, motion, force* etc. And later on - when these concepts proved insufficient - theories such as general relativity could successfully make use of descriptive concepts such as "curved space", borrowed, this time, from mathematics.

On the advent of quantum mechanics it could therefore naturally be hoped that it too would prove consistent with ontological realism. And indeed this hope was entertained, not really by the "founding fathers" of the theory (Bohr, Heisenberg etc.) but by most of their immediate successors. But was it fulfilled? Well those of you who started quantum mechanics and studied such problems as the harmonic oscillator or the hydrogen atom, may feel inclined to answer "yes". For such eigenvalue problems are indeed qualitatively quite similar to the *classical* one of finding the possible frequency modes of a vibrating string or the electric field inside a cavity. However, as you know, quantum mechanics is a probabilistic theory: In some cases what it yields is only the probability that, *upon measurement of such and such a quantity, such and such value should be found*. And, at this place, quite a subtle riddle, with a distinctly philosophical flavor, appears: For when we say "should be found" we implicitly refer to **somebody** who finds, or to

some detection device **conceived of by human beings** for the **purpose** of detecting. True, our statement is still an objective one, since it's valid for anybody and at any time and place. But it is not expressed in terms an ontological realist would be happy with, since it involves *us* whereas an ontological statement should bear on what exists, not on what we see or intend to do. Statements of such a type - that are objective without being ontologically objective - I've taken the habit of calling "weakly objective".

"But - you may be tempted to say - this seems to merely be a question of wording! Instead of speaking of the probability **we** have of finding such and such value, why not simply speak of the probability that the measured quantity **has** this value. Same as, when we pull a card out of a pack, we speak of 'the probability that it **is**, say, a king!'. Alas ! In the quantum mechanics case this doesn't work ! The riddle I mentioned consists in that, when you naively try to systematically interpret quantum mechanics that way you soon are faced with insuperable inconsistencies. In other words standard quantum mechanics does not enjoy "ontological objectivity" or "strong objectivity" as I use to say. Of course this does not mean it is not objective ! Only, it is but "weakly objective" in the sense I explained. I'm not sure that all theoretical physicists are as sensitive as I am to the importance of this surprising feature. In my view it is essential.

Anyhow, this is one of the aspects through which we discover that quantum theory basically differs from classical science and is therefore truly puzzling. And it introduces us to a long story of brilliant physicists trying to, somehow, reconcile quantum theory with ontological realism. Now, this is not the proper place for us to review all the ingenious ideas that were - and still are - put forward in this field. They are highly technical and anyhow this would require a one year's course ! Here I am just trying to give you an indication as to the existence and the nature of the problem. As for its suggested solutions all I shall say is that most of them are very clever, very audacious also, that some of them constitute real advances, and that, in a sense, some do succeed in salvaging ontological realism, though it is always at the price of sacrificing either relativity theory, or the identity of the observer's ego, or some similarly basic view; but that - precisely for that reason - up to now none of them proved sufficiently credible to gain general acceptance.

Now, faced with these difficulties a remark may naturally come to our mind. It is that up to now, no great theory, not even Newton's one, proved eternal. Why should quantum theory be an exception? In other words, would it be possible to make it compatible with ontological realism and relativity, at the price of changing it a little bit? Of course all its experimentally verified predictions have to be kept but along with them it also suggests quite strange things, such as what we now call "entanglement-at-a-distance", which seems to signify that when two particles have once interacted they somehow remain linked together at a distance by some mysterious eternal bound. Einstein, already, found such an idea unacceptable. A priori the idea of a "future modified quantum mechanics" freed from such odd features seemed a very attractive one. And it could be hoped that ontological realism would then be recovered in addition.

Well, attractive as they may have been, these hopes were not substantiated. In 1964 John Bell proved that assuming (ontological) realism and "locality" (which essentially means that relativity theory is valid so that there is no such thing as a "mysterious bound at a distance")... Bell proved, I repeat, that assuming realism and locality implies that some inequalities between measurable numbers are satisfied; Whereas - he pointed out - they are **falsified** both by the quantum mechanical predictions and (as it turned out later) by experiment. This shows that we had better take quantum theory seriously, even when what it predicts seems almost unbelievable. And in particular it shows that the "mysterious, hidden bound" is there after all: In other words: that a certain type of holism, not straightforwardly perceptible but hidden in the equations, must

be taken into account.

All this is disconcerting. Still, quantum physics exists. Nay, so long as predicting observational or experimental outcomes is the matter it is inordinately successful as we saw. This is puzzling since we normally explain why a theory is predictively successful by considering that it describes things as they really are. It is however well worth noticing that the very notion "explanation" is not that clear. Some philosophers analyzed it thoroughly and came to the conclusion that "to explain" just mean to connect up a great many different facts by showing they come under the same general law. Now, if we adhere to this 'non-ontological' conception of what an *explanation* is, we may keep the notion of "explanation" without sticking to ontological realism. And then our source of puzzlement just simply vanishes. The very many different facts quantum mechanics successfully deals with are considered "explained" simply in virtue of the fact that they all come under the same general laws, namely the quantum mechanical axioms. And the Bell inequalities have no reason to hold good since they were grounded on realism (or at least on 'counterfactuality' which is a weakened form of realism). In other words, the strange correlations-at-a-distance that quantum mechanics predicts and that were indeed observed are no more a logical riddle of some sort. They are just manifestations of the normally well-hidden holism I mentioned.

Well, all this being considered I ask you: isn't the idea of dropping ontological realism worth considering after all? Of course, we must be aware of what it implies. Dropping ontological realism means that our scientific knowledge finally bears, not on reality-in-itself - alias "the Real", alias "the ground of everything" - but just on *empirical* reality, that is on the **picture** that, in virtue of its structure and finite intellectual capacities, human mind is induced to form of reality-in-itself. This may be resented as giving up too much. But note on the other hand that anyhow, in virtue of the hidden wholeness I mentioned we must quite drastically water down the commonsense view according to which objects, be they large or small, all enjoy, by themselves, separate existence at any time at some definite place in space without appreciably interacting when they are very far apart. To state that we see or apprehend them so because the structure of our senses makes us perceive the Real in this form seems to be nearer to the truth.

Admittedly this conception is not the one the bulk of the scientists' community favors. Note however that, still, it is shared by many people. In fact, surprisingly enough it meets with the views of outstanding contemporary neurologists specialized in cognition theory. And, besides, it obviously bears quite a definite relationship with the main Kantian views, which were adhered to by a great many philosophers as well as by some physicists such as Henri Poincaré. What I just showed you is that it also gets the - indirect - support of the most productive basic physical theory, which obviously imparts to it an even greater weight.

What we saw up to this point partakes either of factual science or (concerning Kantism) of a well recognized philosophy. But now, for the last part of this talk, what I'll say - while, I hope, remaining reasonable and likely to be true ! - still will be distinctly more personal and speculative. In a way, we leave science for philosophy.

My point is that, obviously, we know much more than Kant knew, so that the fact we agree with him on certain issues does in no way implies we should agree with him on *every* point. This seems particularly true concerning what he called "Reality-in-itself". True, in the conception we are considering "Reality-in-itself" - alias "**the Real** with a capital R", alias "the ground of things" - is not reachable by science, just as Kant said. But does it mean, as Kant seems to have thought, that it should not concern us *in any way* ? I think this is going too far. Scientists are deeply aware that their theories have to pass the test of experience; that they are not free to stick to any bright idea that comes to them; they (quite reasonably I think !) attribute these limitations, in the last

resort, to something that is independent of the human mind, hence that is more than just an appearance. In other words they attribute them to **the Real**. And they rightly feel therefore that between the Real and themselves there is a genuine, even if obscure, relationship. We thus naturally get to the view that we must take seriously the notion of a *ground of things*, that is supremely real and that, on the other hand, lies so much beyond our concepts, be they familiar or mathematical, that the phenomena - those we directly perceive as well as those science describes - do not enable us to decipher it. On it they provide us with mere **glimpses**, and very vague ones at that. This is why I called it **Veiled Reality** in my books.

At this point I'd like to draw your attention to the fact that, if true, this conception I sketched has two significant consequences.

One of them is that **if**, indeed, it is our mind that, due to its own structure, carves out **all objects** out of the "ground of things", obviously we cannot any more think of mind itself as emerging from (some class of) **objects**. If the notion "emergence" is here to be kept, we may only claim that mind emerges "from the ground of things". As we shall immediately see, the difference is far from being a negligible one.

For indeed - and this is nothing else than the second consequence I just mentioned - this "ground of things", this Real, quite obviously is not a thing. What we saw seriously suggests that it is not imbedded in space, and, maybe, not in time either. Let us call it "Being" if you like. Or "the One", following Plotinus. Since science cannot tell us anything precise about its nature it cannot rule out the possibility that also other forms of mind activity yield imprecise glimpses on it.

The latter point is important for it refutes the idea that there would exist, on the one hand science, qualified and solely qualified for gaining a knowledge of the ground of things, and on the other hand art, music, poetry etc. confined to the realm of pleasure. Intuitively most admirers of classical music, art or poetry always brushed aside the said idea. Indeed they have the strong feeling - nay, for some, the conviction - that, beyond mere pleasure, the emotions they feel on such occasions sort of open to them a window looking out on a "something" they somehow know is essential. Is this conceptualized knowledge? Of course not. I do not claim for a moment that, just because the listener to a Beethoven symphony feels such an emotion he acquires a knowledge comparable in nature to scientific knowledge. Moreover, artistic emotions essentially imply the impression of a *mysterious realm* which we may merely catch a glimpse of. Manifest is the difference with science, which, within its domain proper, does really dispel mysteries. But look here. Remember that according to the conception at hand the domain in question, the one of science, is not the *ground of things*. It is *empirical reality*, that is, the set of the *phenomena*: everything that we may or might observe by whatever means. Over **that** field science truly reigns. There, it and it only yields true knowledge. On the other hand, concerning the *ground of things* science has no such privilege. In this domain its positive contribution, just as the one of the other modes of approach I mentioned, consists at best of quite hazy indications, *not* of organized knowledge. It is true that, even there, it has quite an important function, since it convincingly invites us to discard too naive tentative representations of the said ground of things. But clearly this role is but negative.

Now, we are gathered here on the invitation of Rev'd Andrew Willson, *Chaplain* of Imperial College. Moreover, if I have the pleasure of being with you today it's because yesterday I was honored with the Templerton prize, and, as you know, the Templeton Foundation is interested in spiritual questions. For these reasons it seems appropriate that our final reflections

should bear on spirituality. Well, what we just saw concerning artistic or literary sensibility should make this relatively easy. For indeed spirituality is, same as artistic sensibility, grounded in part - but this part is quite essential - on affectivity or, in other terms, on emotion. Which entails that it does not go without mystery. And this is indeed one of its most important elements, and one that no great spiritual figure ever claimed we could make vanish. This was I think, the main source of the deep misunderstanding that prevailed between religious people and classical physicists since, in the eyes of the said physicists it was in principle possible to attain, be it only asymptotically, an objective knowledge of the ultimate nature of everything, so that anything having to do with mystery was doomed to final elimination. But this is precisely the point on which the conception we consider parts from theirs. For indeed in it, as we saw, the *ground of things*, alias, Being, lies beyond the reach of conceptualized knowledge, and mystery is not therefore something negative that has to be eliminated. On the contrary it is one of its constitutive element. The just mentioned source of conflict between science and religion therefore vanishes.

Sure, it is not for a scientist such as me, who spent his whole life juggling with equations, to speak on spirituality. I stand outside the temple, so to speak. Still I'd like to say why I consider that, even in this domain, science does shed light. In my view it does so mainly by rendering unbelievable any intellectual construction - of whatever nature - claiming to yield access to the ultimate ground of things with the sole use of the simple, somewhat trivial notions everybody has. In particular, it reminds us that, even though images are needed, the letter kills, so that in this particular field science finally incites us to primarily have resort to personal spiritual contemplation. Ultimately therefore its message in that realm is not so very different from the one we get from the most inspiring romanesque cloisters. True, spirituality takes up many different forms and some of them are definitely to be brushed aside. The worse, in that realm, verges the best. But the best exists. I consider I have sound reasons to believe in the *ground of things* I mentioned, lying beyond our ability at conceptualizing and which, from time immemorial, thinkers called "the Divine" or "the Sacred". I like conceiving it to be infinitely lovable and am therefore convinced that those among our contemporaries who believe in a spiritual dimension of existence and live up to it are, when all is said, fully right.

