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Veiled Reality

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ABSTRACT

Each of us, presumably, has his own way of looking at the problem of reality. I was kindly asked by Professor Laurikainen, when he organized this symposium, to describe to you my approach, leading to the notion of a veiled reality (which, I understand, has some similarity with Pauli's notion of reality). I am grateful for this nice opportunity. I shall do my best to comply with the request.

The concept of reality is basically a philosophical, not a physical, concept. Hence the subject of this talk lies, to some extent at least, outside physics, a fact which will be illustrated by the circumstance that I shall show you no equations. But the methods I shall apply are those of physics rather than those of philosophy. In particular, I shall try to define unambiguously the concepts I use. Also I shall not demand that some general view should be accepted from the start. Rather I want to proceed as we do in science, that is, by formulating some working assumptions and looking at their consequences. With the idea that we shall reject the assumptions if the consequences turn out to be wrong.

Preliminary remark

These assumptions make no claim at originality so that it would be pointless to invent new words to name them. Unfortunately the old words used here (realism etc...) all were given many acceptations in the literature. To avoid ambiguities let it be specified that in the present

lecture the words in question are always taken in one and the same sense, which is the one specified by the following set of definitions. I hope that in this way consistency, at least, will be preserved.□

1. THE STANDPOINT OF REALISM

Definition : it consists in considering that "something" exists, the nature of which (a set of material objects, an entity, God, or what not) is left for the time being completely unspecified. This "something" is assumed not to depend on the cognitive powers of mankind. But of course it influences decisively the results of our measurements.□

Henceforth this "something" will be called "independent reality" or, for short "reality".

Remark a

This definition is very weak in that only the existence, not the nature, of reality is postulated. Hence realism as here defined covers most of the great philosophies of the past. On the other hand the independence condition is very strong. I here reject even unavowed dependences on human cognitive powers, such as references to such notions as that of "systems incapable of being isolated", and the rest. For who, if not man, is supposed to "isolate" or to fail being able doing so ?□

Remark b

Many philosophers use the word "reality" to signify a concept partly defined by means of a reference to the abilities of men. This convention is unobjectionable as such. But by definition it is not the one made here. In my convention the concept in question, if used, should therefore be given another name.□

Is reality describable ? Opinions on this may and do differ. We must consider various views. Here I only formulate hypotheses corresponding to the answer yes.

2. THE HYPOTHESIS OF PHYSICAL REALISM

Definition : it consists in considering that reality (in the above sense of the word) can in principle be nonambiguously described by

physics (plus other "hard" sciences if necessary).□

As I said, this is but a working hypothesis. At the start I request neither that it should be accepted nor that it should be rejected : we must decide on the basis of a comparison with actual physics.

Now, to describe we need words, that is, concepts. Physical realism therefore implies that some at least of the concepts used in physics do label elements of reality. What are these concepts ? Here there are two possibilities that are a priori worth considering. Let them be expressed in the form of two alternative hypotheses.

2.1 The Hypothesis of Near Realism

Definition : it consists in considering that the concepts labelling the elements of reality are all familiar, everyday ones, such as very small solids (grains, tiny particles of substance), forces etc.□

Roughly speaking near realism identifies reality with things. That is, it reduces it to be a collection of localized objects such as electrons, quarks and so on, conceived of as being objects (in the popular sense, thus, localized) interacting by means of forces. We all know however that such a hypothesis cannot be upheld any more. Even though some physicists still deem it proper to use such a language when writing popular books, they all know that they thereby cheat (and, in my view, on an essential point). For example relativity has taught us long ago that it is definitely not by means of the familiar concepts of space and time that we can hope to describe reality. And elementary particle physics goes even much farther, with such phenomena as pair creation and annihilation and so on. Hence, already near the end of the "classical age" of physics, physical realism had taken, in the mind of its physicists supporters, the form of the alternative hypothese 2.2, below.

2.2 The Hypothesis of Mathematical Realism

Definition : independent reality cannot be described exclusively by means of familiar, everyday concepts. But it is nevertheless scientifically describable "as it really is". Its description must be made by means of nonfamiliar, noneveryday concepts, borrowed from mathematics.□

Let me just mention that this hypothesis has a long history associated with such names as Plato, Galileo, Descartes, Spinoza and, nearer to us, the Einstein of the later years. Let me also forcefully stress that according to this hypothesis physics does not merely describe a human point of views on reality. It describes reality as it is.

Being interested with the question of reality we shall have to examine how the consequences of these hypotheses compare with facts. But before that I must of course mention that neither the hypothesis of physical realism (near or mathematical) nor even the standpoint of realism were the only views that were considered, even by scientists. An alternative was proposed in the form of logical or empirical positivism, according to which both science and ordinary knowledge are indissolubly linked with human experience. So that their purpose can only be a description of the phenomena, that is, of things, events and so on, as they are perceived and combined by collective human experience.

Now, as you all know of course, the advent of quantum mechanics coincided with a great increase of the consideration given by physicists to the positivistic trend. This increase looks even more considerable if we appreciate it not on what these physicists said but on what they actually did. And indeed there were good reasons for the increase in question. The point can be made very clear if we compare classical and quantum probabilities. Let us, for example, compare the tossing of a coin and the passing of a spin 1/2 particle polarized along O_x through a Stern-Gerlach apparatus directed along O_z. In both cases, imagine that some time after the event took place we "look at the result" (directly or with the help of some other apparatus). In both cases, the probability that we observe a head (respectively a $S_z = + 1/2$ result) is 1/2. In both cases if we repeat the experiment a large number n of times, the number of favorable results is roughly n/2. But in the case of the coin we may interpret this by saying that just before we looked, each coin already was in the state (head or tail) in which we now find it, whereas in the spin case we may not (since a beam recombination would prove us wrong). In other words, in the quantum case we are deprived of the possibility of a naively realistic

interpretation that was straightforward in the classical case. We remain only, or at least so it seems at first sight, with the "positivistic" interpretation that physics only allows us to predict what we shall observe.

Hence there are some good grounds for the positivist-sounding statements of people like Bohr, Heisenberg, Wigner and the like. To make things short let me just show you a statement made by the latter.

> The laws of quantum mechanics only furnish probability connections between results of subsequent observations carried out on a system. It is true, of course, that the laws of classical mechanics can also be formulated in terms of such probability connections. However they can also be formulated in terms of objective reality. The important point is that the laws of quantum mechanics can be expressed only in terms of probability connections [between results of subsequent observations].

E. Wigner, Symmetries and reflections, Indiana University Press. The phrase inside square brackets, not present in the original text, is but a reiteration of the specification formulated in the first sentence, inserted here by me to make my claim even more transparent.

Now there are two points to be made with respect to this quotation. The first one is, in fact, just the one I produced it for. The quotation underlines the positivistic, or phenomenist nature of orthodox quantum physics. The second one is as follows. Nobody would seriously deny the fact that Wigner's main achievements lie in the field of mathematical physics. Hence the fact that he wrote this text shows in a specially clear way a fact that is extremely important. This fact is that mathematical realism is by no means the only conception that allows mathematics to play a basic role in physics. Indeed, contemporary theorists have developed what we might call a "mathematical positivism" whose mathematics are just as highbrow as those of the mathematical realism of, say, an Einstein. But they do not aim at a description of reality as such. Essentially their aim is to connect past and future observations. As usually described in advanced textbooks, algebraic quantum field theory is, I would say, a stronghold of this mathematical positivism.

There is, I think, a clear way of expressing the difference between mathematical realism and mathematical positivism. It is to distinguish between strongly objective and weakly objective statements. I am very much surprised that physicists practically never make this distinction, even when they discuss basic questions. They just say "science is objective". But this is a source of misunderstandings since the word objective has at least two senses. Some scientific statements are objective in the sense that they make no reference to the concept of observation, or measurement, as such. Hence they can be understood as bearing on reality. Such, according to Wigner's foregoing quotation, are the statements of classical physics (think, for example of Newton's gravitation law). These I call strongly objective. Other statements do make reference to the concept of observation or measurement. But they still may be called "objective" since what they assert is supposed to be valid for any observer. They are therefore unambiguous. Most of them take the form of rules : "if we do this we shall observe that". These statements I call weakly objective, or intersubjective. In this language we may say that what Wigner points out here is :

a) that a strongly objective statement can always be converted into a weakly objective one but that the converse is not always true.

b) that some at least of the quantum laws can only be expressed by weakly objective statements, leading to mathematical positivism.

Now the stage is set and we may start a discussion. I want to make it "from the bottom to the top" rather than conversely. This is because I am a physicist as you are. Contrary to professional philosophers, physicists like to proceed that way, namely by starting with rather concrete, down-to-earth ideas, like Galileo with his balls, and proceeding to more abstract ones only when their data force them to do so.

So we start with a man-in-the street idea, namely realism and even naive, or "near" realism. But this part of the discussion was already done, in fact. We know that near realism must be rejected, not on a priori grounds but because it is incompatible with the facts we learn from physics.

The next candidate is mathematical realism. Now I already sketched a criticism of this idea, but this was merely a sketch. I did not claim that the criticism was final. So, let us have a closer look.

When I, for one, have such a closer look I think I can distinguish three or four approaches by means of which mathematical realism is defended. The first one, I think, is simply not correct. It consists in focalizing on the considerable range and power of the mathematical formalism and in forgetting, or overseeing, the fact that, because of the existence of mathematical positivism, this does not at all prove that mathematical realism is true. Some very mathematically minded people believe they justify mathematical realism by pointing to the tremendous role of abstract mathematics in helping us to find out the elementary laws that, in field theory, superstring theory etc... play the same role as the Schrödinger equation in non-relativistic quantum mechanics. But they seem not to be aware of the fact that, already in nonrelativistic quantum theory, the Schrödinger equation is not the end of the story --and that the same is true in the relativistic case-- because the problem is "can we interpret the state-vector (or the density matrix or what not) as an element of reality ?". For quite a number of reasons the answer is no. Hence it cannot be said that the present mainstream of theoretical physics, (unification theories, superstring theory and so on) truly discloses what reality is.

The second approach is a variant of the first. It is based on the generalizations of the quantum formalism called "quantum logic" and "algebraic theories". It is quite a fascinating approach and one that I think leads naturally to an "empirical reality" concept to which we shall return in a moment. But I think that its most serious supporters would agree with what I shall now say : because of nonseparability (alias "EPR entanglement") the elements of this empirical reality, and in particular the localized objects, merely describe human points of view on reality as such. Hence such theories definitely fall outside what I called mathematical realism.

Another approach by which, if not exactly mathematical realism, at least a (somewhat weakened form of) physical realism is defended is macroobjectivism. The proponents of this approach grant that wave

functions and the like do not necessarily correspond to what is actually happening in the real world, but they try to save the idea that, at least, when we say that the pointer of an instrument lies in such and such a graduation interval we assert something that bears on independent reality. Well, time does not allow me to enter into a discussion of the measurement problem, especially since the subject is intricate. Let me just try to briefly make two points.

a) Some theorists assume that the instrument pointer can be attributed a wave function so that before we look at the pointer the wave function of the composite system (particle plus pointer) is (in the general case) a superposition of several macroscopically distinct states. After we have looked it is only composed of one of them, of course. But these theorists simply deny that there should be a problem there for, they say, the wave function collapse "is merely an increase of our information". Such a statement clearly implies that before we looked our information was not maximal. Indeed it implies more. It implies that our information could have been maximal under no conceivable conditions, not even if we then had known the exact wave function of the composite system (a theoretical possibility which is compatible with the initial assumption). The statement therefore conflicts with the assumption that quantum theory is complete. Hence I can accept it only in conjunction with a hidden-variables theory, which then ought to be made explicit and studied for its own sake (see below).

b) Most theorists do not treat instruments that way. But although I read several proposed solutions to the measurement problem that I found quite enlightening, nevertheless none of them made it possible for me to say that the localization of the pointer after it interacted with the particle is an element of reality. My main reason is that in all these theories a reference is made to human abilities, be it in a highly indirect way. Hence I can only grant that some of these theories nicely describe empirical reality, i.e. nicely account for the observed phenomena (see e.g. ref. 1).

Next let me come to the L. de Broglie, Bohm, Bell and others hidden-variables theory. And let me first of all specify that, as regards Bohm's work what I have in mind is not the content of his book,

but just that of his 1952 papers[2] and of his recent papers with Hiley. There, the situation is different. I do agree that this theory does meet the requirements of strong objectivity. In other words I do agree that, in Bohm and Hiley's words, it is a possible ontology. I do agree also that this is a big step since, thanks to it, we now see that there is no blunt contradiction between quantum physics (I mean its predictive rules) and physical realism.

If somebody tells me "as a physical realist I believe that such a theory does describe independent reality 'as it really is'"I shall not be able to prove to him that he is being inconsistent. But this does not imply that I, myself, share such a belief. The points are as follow. First there is no experiment showing that this is the right theory. This is significant since this theory has at least one competitor, namely Everett's relative state theory[3], which has its own weak points but which is also compatible with physical realism I would say. Next, there are, I think, difficulties with manifest relativistic covariance. For example, although a recent hidden-variables model by John Bell[4] operationally reproduces all the relativistic predictions, still its author was forced to base it on the idea of independently existing (but nonobservable) Euclidean space and Newtonian time. I do not know whether this particular difficulty is there to stay. But I think that the mere fact it appeared illustrates a feeling of artificiality that I, for one, also get when I am told about the existence of, for example, a swarm of empty wave packets and such things. If such theories are true, then whatever sophisticated instruments we use we shall always have access to but a very tiny part of the iceberg of independent reality and even that part will always be seen by us in a highly distorted way. Under these conditions it seems to me that we are very much over-ambitious when we try to reconstruct the whole of the non-observed part. For we must then water down very much a guiding rule that was most useful, for example, to Einstein, and which is to soberly model the basic features of our interpretation of the theory on the mathematical elements of our theoretical synthese of appearances, and to use Occam's rasor to cut away all other features...

For these reasons, while I willingly say "it is possible that independent reality be structured that way" I am very much reluctant at saying "it is structured that way" and even at saying "we may reasonably hope that in some future we shall have a scientific certainty that it is structured that way". Hence I do not consider that such theories meet or will ever meet the requirement of nonambiguity which is part of those of what I called "physical realism".

Well, on the occasion of explicating my standpoint with respect to the hidden-variables theories I hope I succeeded in conveying to you something of my balanced judgement concerning the hypothesis of physical realism. I do not strictly disprove it, but for a variety of a posteriori reasons, derived from physics and that I find quite convincing, I do not feel able to believe it.

What I still have to do is to try explaining to you my position as regards the standpoint of realism. This question splits in two parts,

a) should we retain the idea ?

b) if we answer yes, what can we say concerning our relationship with the reality in question ?

Let us look successively at these two points. As regards the first point, quite definitely my answer is yes. For example, when a theorist tells me that the wave function is just a measure of our information, I feel bound to ask "information on what ?", without being able to consider that the question is meaningless (if he answers "on a system", I must ask "what is a system ?"). I must grant of course that there is no way of proving realism in the way one proves a theorem or the truth of an empirical statement. My answer is yes nevertheless, mainly for reasons that are implicit in most people's mind, that have been stated by a number of philosophers and that I find quite convincing. They can be briefly sketched as follows.

a) the opposite assumption is that the verb "to be" does not apply to anything. But this is obviously wrong. I do not know whether I exist as an absolute existant, maybe I am only the dream of some superior Being, or what not, but I simply cannot say without indulging in a contradiction that nothing at all is speaking presently to you. So that, something at least "is". And it seems preposterous to me to think

that this "flicker of consciousness" should be the only existant.

b) As scientists, we know that there is a difference between building up a physical theory and deciding what will be the rules of a new game or the basic ideas of a new philosophy. In the cases of game and philosophy our freedom is exclusively limited by the non-contradiction principle. In the case of physics there are additional limitations. A theory can be fully self-consistent and yet entail consequences that are proved wrong by experiment, and in that case we are forced to reject it. In other words something offers resistance to us, so that it is not our own creation. There must therefore be "something" prior to us. I mean some basic element that is not under our control.

c) Finally we observe regularities in our impressions and we all agree on the elementary facts we observe. The usual explanation is because these things are due to some external reality that has a structure, and I think this "trivial" explanation is sound and should be kept. I grant that here I am not using the notion of a causal link in the manner in which it is used in science, since in science the cause and the effect should be of the same nature, that is, they should both be phenomena. But I do not think this is an objection. I simply say that while reality is not a cause-in-the-scientific-sense, it is nevertheless the explanation, the <<raison d'être>> of the observed phenomenological regularities, and of the intersubjective agreements as well.

Now let me come to the point about our relationship with reality. We already reached the conclusion that it is not fully knowable and we need not come back on this. But shall we say that it is utterly unknowable ? Instead I say that this reality is "veiled". Why, and what do I mean ?

To try to convey this to you let me first refer to Kant's idea concerning the "thing-in-itself". It is often said that Kant considered it to be utterly unknowable. But in fact I am not so sure. Somewhere he compares our relation with the thing-in-itself to that of a judge with respect to somebody who is brought up for trial. And Kant says that we force the thing-in-itself to answer questions in our own

language, pretty much as the judge obliges the defendant to answer the questions he asks. We see everything through the a priori structure of our own sensibility and intelligence so that we cannot know the thing-in-itself as it really is. This is often taken as an argument purporting to show that we know nothing about the latter. But I maintain that the analogy with the court does not go that far. It is true that the judge asks his own questions in his own way. But still he tries to be informed of something that is external to him. And he is quite convinced that this expectation is not a complete delusion. Similarly I maintain that while physics is admittedly but a human view on reality, still it is not an arbitrary human product but does convey, albeit in a distorted form, an undefinable "something" of the true structure of reality.

One point that comforts me in this opinion is the following one. Relativistic spacetime is obviously not an inborn concept. In Kant's time, physics was based on Euclidean space and universal time and it was possible to maintain, as Kant did, that these concepts were just inborn ; that they came not from the thing-in-itself but exclusively from us. Now, however, physics uses spacetime which, as I said is not an inborn concept. So it is more difficult now to maintain Kant's position in this matter. We are therefore more or less forced to consider that it is something external to us that forced upon us the use of relativistic spacetime. I do not say that spacetime as we know it is, as such, a property of reality. On the contrary I think it is not. But I think that indirectly it does reflect an uncontrollable "something" of the structure of reality. Similarly I consider that due to the Bell theorem we can assert with confidence that reality is not "local". More generally I would say that physics plays in the intellectual realm somewhat the same role as parables and some fables play in the moral realm : the role of conveying in a disguised form a truth that cannot actually be expressed otherwise.

So now I think I can make clear what I mean when instead of saying that reality is unknowable I merely say that it is veiled. What I mean is in fact two things.

First I consider that the standpoint of realism is correct and even unavoidable. The verb "to be" is meaningful. And at the same time I know --this time from contemporary physics-- something that the realists of yore could not know, namely that reality does not boil down to what is describable, that is to the phenomena. Object is not Being. Thus, just by putting these two things together, it seems I know that there is something beyond the phenomena. This, I think, is real knowledge and very important (especially since it contradicts the implicit idea of most nonphysicist scientists...).

Second, I consider, as I just said, that the great laws of physics, although they do not describe reality as it is, yet constitute a human point of view on reality and therefore do capture an undefinable something of its structure. For me this is a very important argument for rationally opposing scientific reductionism. For I say : if physics both fails at giving us a sure, exhaustive description of reality, and yet succeeds in capturing something of it, why other approaches, such as music, painting, poetry should not ?

Although "empirical reality" is not my subject, I must here say just one or two words about this concept, just for contrasting it with that of independent reality. As I mentioned, and as Professor Primas will probably tell us again, things are not elements of independent reality. Rather, they are views we take on it. They are phenomena in the etymological sense. Well, what I call empirical reality is just the set of all the phenomena. In a way, it is what we get when we reify the set of recipes that mathematical positivism consists of. And we are forced to proceed to this conceptual reification if we want to speak of objects at all ! Even if we want to speak of molecules. In my view it is to this empirical reality that ideas such as complementarity apply. It constitutes the stuff on which our actions bear and it is the very subject-matter of the rational knowledge called science. But it must not be confused with independent reality, the faithful description of which presumably exceeds the powers of human reason.

Returning then for the last time to independent reality, I would like to conclude by referring again to what I said just a moment ago,

namely that, as a result of the analysis we made, it now seems plausible that approaches other than science (I mentioned music, painting and poetry) should also, concurrently with science, be capturing some undefinable something of the structure of independent reality. In our age of totalitarian techno-science I think this is very important for a reenchantment of the world that has become necessary. And it is gratifying that science itself should give us indications along these lines.

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