HOW TO LOSE YOUR GRIP ON REALITY?
AN ATTACK ON ANTI-REALISM IN QUANTUM THEORY

by

Raymond D. Bradley

Emeritus Professor of Philosophy

Simon Fraser University

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[Abstract: Anti-realism – the denial that reality exists apart from our conceptions of it – is rampant, not just among Postmodernists and other *literati*, but also among many of the leading spokesmen of orthodox quantum theory – from Born, Bohr, and Heisenberg to Wheeler and Wigner. Undoubtedly they've done good physics. Why, then, do they indulge in bad metaphysics? This paper offers some answers.]

Anti-realism as a "virus of the mind".

It is no secret that anti-realism – the denial that there is a way the world really is as distinct from our perceptions or conceptions of it, or even the denial that a real world exists at all – is rampant in the social sciences and among those thinkers who call themselves "Postmodernists". What is less well-known is that anti-realism is also endemic among quantum physicists. Needless to say, the literati seize upon quantum antirealism as experimental confirmation of the views. I propose to stop this myth-making in its tracks.

In this paper I don't hide the fact that I regard anti-realism as a virulent form of philosophical error – a veritable "virus of the mind" as Richard Dawkin would put it. My aim is to explain how and why it is that so many quantum theorists have become infected by it.

First, an admission. I am neither a physicist nor a mathematician, merely a philosopher. Confront me with a cyclotron and I wouldn't know what it was unless told. Show me John Bell's non-locality theorem and I wouldn't even recognize the mathematical symbols, let alone know what they meant, let alone be able to follow the proof. So the question naturally arises: By what right do you presume to pass judgment on the claims of researchers outside your own area of competence?

My answer can best be expressed in the words of the American philosopher, Sidney Hook, who in 1957 wrote:

> Normally I should be reluctant to speak of the principle of indeterminacy in the presence of physicists, but having recently read what eminent physicists have written about philosophy, I feel absolutely shameless.[1]

Sidney Hook's targets were many of the most eminent proponents of orthodox quantum theory, those who take their cue from the so-called Copenhagen interpretation. He questioned the unsophisticated philosophizing which took them from Heisenberg's Indeterminacy Principle to a dismissal of causality and determinism and thence to the assertion that quantum indeterminacy was the source of free will.

My targets in this paper will be many of the very same quantum physicists, along with others of the same general persuasion.

Statements of metaphysical antirealism.

Here, then, are some paradigmatic expressions of the kind of metaphysical anti-realism that seems to be accepted within the prevailing interpretation of quantum mechanics.[2]

Werner Heisenberg:

> Some physicists would prefer to come back to the idea of an objective real world whose smallest parts exist objectively in the same sense as stones or trees exist independently of whether we observe them. This however is impossible.

Niels Bohr:

> There is no deep reality.
>
> *There is no quantum world*. There is only an abstract description.

John Wheeler:

> No elementary phenomenon is a real phenomenon unless it is an observed phenomenon.

Eugene Wigner:

> It is not possible to formulate the laws of quantum mechanics in a fully consistent way without reference to the consciousness . . . It will remain remarkable in whatever way our future concepts may develop, that the very study of the external world led to the conclusion that the content of the consciousness is an ultimate reality.

N. David Mermin:

> We now know that the moon is demonstrably not there when nobody looks.

And, summing up the antirealist position:

Bernard d'Espagnat:

> The doctrine that the world is made up of objects whose existence is independent of human consciousness turns out to be in conflict with quantum mechanics and with facts established by experience.

Many of these claims – especially the last four – might easily be mistaken for the rhapsodies of latter-day New Agers, or for the loose talk of those who, like Fritjof Capra and Gary Zukav, are intent on reconciling Western science with Eastern mysticism. But they are neither. Rather, they are pronouncements of sober, hard-headed, physicists and mathematicians of quantum-mechanical orthodoxy, many of whom would feature in any pantheon of the greatest scientists of the twentieth century. Nor are the proponents of these views indulging in hyperbole as a kind of intellectual publicity stunt. All the evidence is that they mean exactly what they say and believe that what they say has vast metaphysical import.

Yet there is an obvious logical gap between reports of physical data – what d'Espagnat calls "facts established by experience" – and the metaphysical dogma of antirealism. So, how do the proponents of quantum mechanical orthodoxy get from the one to the other? I'll offer some answers in Part II of this paper. Then I'll go on to argue in Part III that the anti-realism which they embrace is scientifically as well as philosophically repugnant.

Before that, in Part I, I want to take up some of the conceptual issues raised by a debate which, historically speaking, has been regarded as almost inextricably related to that between realists and antirealists. This is the debate over determinism versus indeterminism.

PART I: THE ALLEGED DEMISE OF DETERMINISM IN QUANTUM MECHANICS.

Anyone reviewing the history of the dispute between realist and antirealist interpretations of quantum phenomena could not but note that, almost without exception,[3] realists have been determinists while antirealists have been indeterminists.

Why should this be? The reason, in brief, is that most metaphysical realists – like Max Planck, Albert Einstein, Erwin Schrodinger, Louis de Broglie,[4] and David Bohm,[5] and John Bell – have also been scientific realists. That is to say, not only have they believed that there is such a thing as a real world that is largely independent of how we observe it or conceive of it; they have

believed that the whole purpose of science is to describe this world. And, almost without exception, they have believed, further, that a complete description of the world at the microphysical, quantum level, will reveal the causal mechanisms that determine its behavior.

By way of contrast, metaphysical antirealists – like Heisenberg, Bohr, Wheeler, and the other antirealists listed above – have seen the purpose of science in quite a different way. For them a scientific theory is nothing more than a mathematical model we make to describe our observations, and the question whether the observed phenomena can be explained in terms of underlying substratum of causal mechanisms is meaningless. Since they deny the existence of an independently existing microphysical world, they deny also that there can be any strictly causal or deterministic explanations of what goes on in that world. For them it suffices to report the results of quantum experiments in purely statistical and probabilistic terms.

The writings of Einstein, in particular, epitomize the standpoint of metaphysical-cum-scientific realists. As Einstein put it, "Reality is the business of physics". He believed, to the end, that the goal of science was to discover the way the world really is as opposed to our perceptions and conceptions of it; that orthodox quantum theory had not only failed to achieve such a goal but had prematurely abandoned any such quest; that the statistical data yielded by quantum-mechanical experiments were not "irreducible" but might someday be explained in terms of our ignorance of hitherto undiscovered or "hidden" variables; and that quantum theory would remain incomplete until such a deterministic substratum was discovered. In his words:

> I am . . . firmly convinced that the essentially statistical character of contemporary theory is solely to be ascribed to the fact that this theory operates with an incomplete description of physical systems.[6]

And again, in his autobiography:

> I still believe in the possibility of a model of reality – that is, of a theory which represents things themselves and not merely the probability of their occurrence.

As for the contrary, indeterministic, beliefs of the Copenhagen theorists, he wrote:

> The Heisenberg-Bohr tranquilizing philosophy – or religion? – is so delicately contrived that, for the time being, it provides a gentle pillow for the true believer from which he cannot very easily be aroused. So let him lie there.

Einstein wasn't alone in his scientific realist expectation that quantum mechanics would eventually go beyond a mere mathematical description of observables and find an explanation in the form of deeper causal mechanisms. His views were shared by a few other notables: Planck,

Schrodinger, de Broglie, and – much later – Bohm. Louis de Broglie expressed their common viewpoint especially aptly when he wrote that he expected a time to come when:

> . . . we will be able to interpret the laws of probability and quantum physics as being the statistical results of the development of completely determined values of variables which are at present hidden from us. . . . The idea of chance . . . comes in at each stage in the progress of our knowledge, when we are not aware that we are on the brink of a deeper level of reality which still eludes us.[7]

He was claiming that the concepts of randomness and chance are purely epistemic, having to do with our knowledge – or, rather, our lack of it – and should not be taken as having ontological import, i.e., as having any implications for the nature of the world itself.

My own views on all this are very much in accord with those of Einstein et. al. As a metaphysical realist I believe that there is indeed a real world "outside of me", so to speak. As a scientific realist I believe that it is indeed the business of physical science to reveal the nature of this world at the microphysical as well as the macrophysical level. And I share their hope and expectation that physics will eventually demonstrate the truth of our commonsense belief that nothing happens without a cause even in the quantum world.

Nevertheless, I have to admit that there is no a priori reason why either a metaphysical or a scientific realist should be a determinist. Neither form of realism actually entails determinism. Perhaps God does play dice with the cosmos after all. That the universe should be indeterministic – that events at the microphysical level, in particular, should be uncaused – is entirely conceivable.

On the other hand, the idea of universal determinism can't be dismissed as mere dogma. The history of scientific discovery has created a presumption in its favor; and that presumption is in no way weakened by the arguments that orthodox quantum theorists have advanced against it.

For the fact is that most, if not all, of these arguments are philosophically inept and betray a lamentable failure on the part of their proponents to understand the concepts with which they are dealing. I, as a philosopher, might be lost in the physical space of a laboratory. But equally, these physicists seem to be lost in the conceptual space of a philosophical argument.

Some of their arguments don't deserve to be taken seriously: for instance, Max Born's argument to the effect that quantum indeterminacy is needed to save mankind from the Marxist hordes and their doctrine of historical inevitability; or Niels Bohr's argument to the effect that quantum indeterminacy is needed in order to provide a safe niche for the concepts of free will and moral responsibility. But two of their arguments do deserve consideration.

Argument 1: Determinism presupposes absolute precision of measurement. But such precision is impossible. Hence determinism must be abandoned, not only at the microphysical level of quantum mechanics but also at the macrophysical level of classical mechanics.

This is Born's argument. Born links the notion of determinism with that measurement and then with that of mathematical continuity. He writes:

> Determinism presumes that the initial state is given with absolute precision. Given the smallest margin of uncertainty, there will be a point in the development of events from which prediction will become impossible. The concept of absolute precision of physical measurements is obviously absurd, a mental abstraction created by mathematicians to simplify the logic of their systems of thought. It belongs as little to physics as all other statements which are in principle not verifiable.[8]

Elsewhere, he argues:

> I maintain that the mathematical concept of a point in a continuum has no direct physical significance. It has, for instance, no meaning to say the value of the coordinate x of a mass-point, or of the center of mass of an extended body, has a value represented by a real number (like x = square root of 2 inches or x = pi cm.).[9]

And again (in a letter to me, dated 5 August, 1960):

> Two real numbers (each represented by an infinite decimal fraction, e.g., 1, 3, 5, 7, 8, ...) are equal if and only if all decimals coincide. But if these two numbers represent a physical quantity there is no way to decide whether they are actually equal.

Born's conclusion is that:

> . . . determinism is out of the question in the original sense of the word, even in the simplest classical science, that of mechanics. This conclusion does not depend on the special assumptions of quantum mechanics. In this way the whole idea of determinism vanishes.

Born's argument can be faulted on two main scores.

First, he claims that the truth of determinism presupposes what he calls "absolute precision of measurement." But a moment's reflection should show that this is wrong. Since the practice of measurement – whether precise or imprecise – presupposes the existence of measurers, it would follow, on his account, that no possible universe could be considered to

be deterministic unless and until it contained measurers making absolutely precise measurements.

But worse is to follow. His conclusion effectively defines determinism as a mathematical impossibility in any universe whatever, even ones in which accurate measurers do exist. Born has set the criterion for being deterministic so high that no conceivable system could satisfy it. In order to satisfy his demand for accuracy in measurement we would have to be able, in certain cases, to count to the end of an infinite series of real numbers. But it is mathematically impossible that there should be an end to such a series. Not only are Born's criteria for accuracy absurdly high; if his argument for rejecting determinism were sound, then quantum physics would not deserve its reputation as having made a revolutionary break from classical physics with respect to its newly discovered commitment to indeterminism.

Born was not the only one who seemed not to understand this. As he saw it, his measurement argument had carried the day for indeterminism and against determinism. Writing to me about the issue on 5 August 1960, he claimed:

> Returning to my last correspondence with Einstein about reality and determinism, his objections to the statistical interpretations of quantum mechanics led me to reconsider the traditional conviction that classical mechanics is deterministic. If it should turn out that this is not the case the whole aspect of indeterminism in quantum theory would be changed.

And a little later:

> It is easy to see that determinism in classical mechanics can be reduced to the problem of continuity, and I have shown that it is just a historic relict from the times when the mathematicians had no clear idea of the actual meaning of real numbers. My first paper appeared on the subject already 6 years ago, and nobody has made any objection. Thus I can assume that it is generally accepted.

Perhaps he was right. Perhaps his attempted refutation of determinism is still accepted. But in that case, the philosophical ineptitude of the reasoning therein displayed should prompt physicists to at least revisit the issue to see whether the issue of determinism versus indeterminism really is as passŽ as so many think it is.

Argument 2: Determinism asserts the existence of causal relations between independently existing determinate states of physical systems, including microphysical ones. But for the case of microphysical systems, such determinate states do not exist autonomously, or do not exist at all. Hence determinism is false.

This, I take it, is the argument Niels Bohr is advancing when he writes:

> The renunciation of the ideal of casualty in atomic physics which has been forced upon us is founded logically only on our not being any longer in a position to speak of the autonomous behavior of a physical object.[10]

I think the first premise in my schematized version of Bohr's argument is true. Einstein, for instance, made much of the claim that microphysical states in themselves are absolutely determinate in the sense that events such as the firing of a Geiger counter occur at precise times and attributed the failure of quantum probabilities to predict such a determinate outcome to the incompleteness of that theory. And Schrodinger, as I understand him, was making much the same point with the help of his Cat Paradox. If the definite, fully determinate, outcome of the cat's fate can't be predicted by quantum probabilities, then so much the worse for the theory. Indeterminateness, he would say, is a feature of the theory, not of the microphysical states it purports to be about. I am sure that determinists such as Einstein and Schrodinger would agree that the determinism they are defending presupposes that microphysical states do exist determinately, and that they so exist whether or not they are being observed or measured.

The only way, therefore, to evade the indeterministic conclusion of Bohr's argument is to take issue with its second premise. And that means taking issue with the claim that for the case of microphysical systems, determinate states either do not exist at all or do not exist "autonomously" (as Bohr put it), i.e., independently of the whole experimental apparatus we use in measuring or observing them. In defence of the second premise, Bohr sometimes contented himself with claiming merely that quantum objects exist only in conjunction with measuring set-ups. Sometimes he claimed more strongly that quantum states don't really exist at all – as when he said, in the already quoted passages, "There is no deep reality" and "There is no quantum world". But whichever version of the second premise he and other quantum indeterminists advance, it is clear that the argument as a whole won't succeed unless the arguments for antirealism also succeed.

And since the arguments for antirealism are the province of Part II of my paper, I proceed without further ado to examine them.

PART II: ARGUMENTS FOR THE DEMISE OF REALISM IN QUANTUM THEORY.

In 1962 I published a paper, in the *British Journal for the Philosophy of Science*, entitled "Determinism of Indeterminism in Microphysics"[11]. There I maintained that the orthodox arguments from experimental evidence to indeterminism were all enthymatic: they rely on

additional, but unstated, premises. What – I wanted to know – are these premises? And is there any good reason for supposing these missing premises to be true?

The missing premises – I argued – are not themselves to be found in any empirical science. Rather they are highly contentious, and dubious, philosophical ones to do with a commitment to instrumentalism as a methodology, combined with one or both of verifiability as a theory of meaning, and phenomenalism as an epistemology-cum-metaphysics.

Now, in Part II of the present paper, I will take issue with orthodox arguments for antirealism, and will contend that most of these arguments derive their plausibility from appeals – sometimes implicit, but often quite explicit – to one or more of these very same philosophical positions.

These sorts of appeal are particularly evident in the reasoning of the Copenhagen School founders. So I'll treat them first. Then I'll make a few brief comments on the reasoning of those latter-day theorists who, like d'Espagnat, invoke experimental confirmation of John Bell's inequality theorem in order to try to bridge the gap between what he describes as "facts established by experience" and the conclusion he advances, viz., the falsity of the realist claim that "the world is made up of objects whose existence is independent of human consciousness."

Instrumentalism.

By an instrumentalist account of scientific theories I mean that which holds that a scientific theory is nothing but an instrument for obtaining the right predictions about the phenomena of the scientific domain concerned. The excellence of a theory is to be judged only by whether it works, not by whether it provides a true account of reality.

From the earliest times, when the Babylonians developed their tables of ephemerides – roughly, astronomical almanacs – astronomers and cosmologists often rested content with producing abstract calculating devices for making predictions about the observed behavior of the objects they were investigating. Instrumentalism was archetypally propounded in the Preface to Nicholai Copernicus's *De Revolutionibus* written by a clergyman named Osiander. In his unsolicited preface, Osiander tried to defuse the charges of heresy that he feared would be leveled against Copernicus by claiming that the heliocentric theory should be viewed, not as making any claims about reality (about which the Church claimed omniscient authority), but only as a mathematical instrument or device for yielding the right predictions about the motions of planetary bodies. Copernicus himself was a realist; his clerical defender an instrumentalist.

Instrumentalists, when they are careful, are agnostic about the nature of reality itself. That is to say, instrumentalism doesn't imply anti-realism. But the history of science shows that

instrumentalists frequently slide from prudent agnosticism into imprudent metaphysical dogma by claiming either that reality is exhausted by their mathematicized phenomenalistic models or, more radically, that the very notion of a theory-independent reality is meaningless.

Arguably, most serious scientists – from Babylonian days through the Greeks, Romans, and Islamists, until about three centuries ago – have had realist aspirations for their theories.[12] Only since religious apologists such as Osiander and Bishop George Berkeley have many scientists come to think of their theories as nothing more than successful recipes for prediction. Since then, however, a strong form of instrumentalism which renounces all talk of reality seems to have had a strong grip on the thinking of many – especially those working in the fields of physics and astronomy. In astronomy, many would embrace Sir James Jeans's view:

> The final truth about a phenomenon resides in the mathematical description of it; so long as there is no imperfection in this, our knowledge of the phenomenon is complete.[13]

Or Stephen Hawking's view:

> . . . a scientific theory is just a mathematical model we make to describe our observations: it exists only in our minds. So it is meaningless to ask: Which is real, "real" or "imaginary" time? It is simply a matter of which is the more useful description.[14]

And in quantum physics, many would embrace Bohr's claims:

> *There is no quantum world*. There is only an abstract description.

Fom a scientific realist's perspective, what is wrong with strong instrumentalism is its total neglect of the concept of truth – or rather, its reliance on a pragmatist account of truth rather than a realist one. A "good" theory, these physicists are saying, is simply one that works by "saving the appearances", not one that says how things really are.

One of the philosophical moves that takes thinkers from weak instrumentalism into strong metaphysical antirealism is the adoption of a verificationist theory of meaning.

Verificationism.

The early quantum theorists found themselves in a quandary over how to interpret quantum experiments. Conceptual, and logical, difficulties over such issues as wave-particle duality, how the real world could have a dual nature, and whether there really are such things as electrons, loomed large in their thinking. How to solve these problems? According to Max

Born, Heisenberg, who was Born's assistant at the time, came up with a simple solution. Heisenberg, as Born put it, simply:

> cut the Gordian knot by a philosophic principle [which] asserts that concepts and pictures that do not correspond to physically observable facts should not be used in theoretical description.[15]

Born himself echoed this philosophic principle when he wrote:

> Modern physics has achieved its greatest successes by applying the methodological principle that concepts which refer to distinctions beyond possible experience have no physical meaning and ought to be eliminated.[16]

Heisenberg's and Bohr's refusal even to countenance the conceptual possibility that an electron, say, should in fact have a determinate path between two successive measurements, swiftly followed. Like the positivistically inclined Bishop George Berkeley and Ernst Mach before them, they would say that the very concept of an object whose existence can not be empirically verified "has no meaning."

Theories of meaning, however, are notoriously tricky to handle. And Verificationism is no exception. Even the sharpest minds among the positivists of the Vienna Circle found it difficult to formulate in a way that could evade the problem of self-indictment: the problem that, if it were true, then since it itself cannot be empirically verified it would be meaningless and hence not true after all.

Quite apart from that, there are other problems. If, for instance, one claims that a certain sentence "Electrons follow determinate paths in between measurements" is meaningless because empirically unverifiable, then not only can that sentence not be meaningfully asserted; it can't meaningfully be denied either. That is to say, it will also be meaningless to say "Electrons do not follow determinate paths in between measurements." The notion of meaningfulness is logically prior to the notions of truth and falsity. A fortiori, meaningfulness is logically prior to those of verification (observation-reliant knowledge of truth) and of falsification (observation-reliant knowledge of falsity). Little wonder that verificationist accounts of meaning, on which the orthodox theorists rely, is now regarded not just as outmoded but as seriously confused.

A better account, I submit, is to be found in some sort of truth-conditional analysis of the conditions under which a [nonanalytic] sentence is meaningful: roughly, that a sentence says something meaningful if we can imagine, think of, or conceive of possible situations in which it would be true and possible situations in which it would be false. Interestingly, this – or something like it – seems to be how Einstein thought of it. He insisted that it is

meaningful to talk about the "real external world" in the absence of any observation-dependent knowledge of it; and further that a description of the real external world had no place for such epistemic notions as these. Everything, he said,

> . . . is to be reduced to conceptual objects situated in space-time and to strict relations which hold for these objects. In this description, nothing appears which refers to empirical knowledge about these objects. A spatial position (relative to the co-ordinate system used) is attributed to, say, the moon at any definite time, quite independently of the question whether observations of this position are made or not. This kind of description is meant if one speaks of the physical description of a 'real external world'.[17]

Born, however, would have none of this. As a verificationist, he insisted, to the contrary, that:

> The main point is that the physicist has not to do with what can be thought of (or imagined), but what can be observed. From this standpoint a state of a system at time t, when no observation is made, is not an object of consideration.[18]

Strong instrumentalism and verificationism, especially when taken together, lead to antirealism. Instrumentalists want to "save the appearances". Verificationists want to deal only with "experience" and "observation".

But what do we mean by "appearances", "experience", and "observation"?

Phenomenalism.

By "phenomenalism" I mean the belief that the domain of epistemology is exhausted by experience, i.e., by our observations, or the way things appear to us, where these notions are analysed in terms of something like raw sense-data or, perhaps, sensations shaped (in Kantian fashion) by concepts.

Now it is well-known, to philosophers, that phenomenalism provides a quick road to idealism – to the metaphysical position, epitomized by the Eighteenth Century philosopher, Bishop George Berkeley who proclaimed:

> All those bodies which compose the mighty frame of the world have no subsistence without a mind.

One starts with something like John Locke's so-called representational – or causal – theory of perception, according to which our knowledge of objects external to our own minds is via their representations, i.e., ideas, which occur only in our minds. One then points out, as did Berkeley, that since we have no "immediate" knowledge of anything except these ideas in our minds, all talk of material substances occurring outside our minds must be based on illegitimate inference and be strictly meaningless. Berkeley would say, contrary to Einstein, that the moon doesn't have a spatial position outside our minds. A fortiori, it doesn't exist at all except in so far as it is being perceived. And then it exists only in our minds.

It is Berkeleian idealism, of course, that is being endorsed by the likes of Wheeler, Wigner, Mermin, and d'Espagnat. And for the same, or similar, reasons. Wigner, for example, makes it quite explicit when he writes:

> . . . there are two kinds of reality or existence: the existence of my consciousness and the reality or existence of everything else. . . . excepting immediate sensations and more generally, the content of my consciousness, everything is a construct . . . [19]

The move from something like Locke's causal theory of perception to Berkeleian idealism involves an intellectual con job by linguistic subterfuge. One starts off by inquiring how I, for instance, standing in your presence can see you and hear what you are saying. One then gives a causal explanation of the processes involved: starting with my optic nerve being sensitive to light rays and my eardrums to sound-waves; continuing with a story about nerve impulses traveling along the sensory pathways to the brain; and finishing up with some sort of story – at the end of the chain – about my awareness of so-called "ideas" or "sense-data". These, and these alone, it is then insisted, are the things of which I am *immediately* aware; these are the things that present themselves to my consciousness.

But note the violation of commonsense and semantic meaning that results once the weasel-word "immediately" is introduced into the explanation. We started off with various truths of experience as the data to be explained, viz., my awareness of you by virtue of the fact that I see and hear you. We finish up with the conclusion that I don't "really" see or hear you at all; all I am aware of is my "immediate" sensations – the kind of thing that Berkeley and Wigner, et al, call "the content of my consciousness". On this account, the truths of experience with which we began turn out not to be truths at all, but falsehoods. Not only that: on this account, the words "see", "hear", "smell", "touch", and the like, are deprived of any meaningful role in language. One can't "really" see, hear, smell, or touch anything describable as outside the content of one's consciousness. But then by the same token, one can't see, hear, smell, or touch anything inside the content of one's consciousness either. Certainly no-one has ever seen, heard, smelled, or

touched the epistemologist's postulated entities, sense-data, let alone the postulated states of consciousness.

Physicists, I submit, have no need of these linguistic, psychological, and metaphysical absurdities.

The violation of Bell's inequality.

I turn now, albeit briefly, to another argument which purports to derive antirealist conclusions from quantum mechanical premises. In his *Scientific American* article "The Quantum Theory and Reality", Bernard d'Espagnat tries to show that the doctrine that the world is made up of objects whose existence is independent of human consciousness must be false since, he claims, it turns out to be in conflict with quantum mechanics and with facts established by experience. The facts he has in mind have to do with the violation of Bell's inequality – a violation which has now been confirmed experimentally by Alain Aspect and others.

The argument is ingenious. But, for two main reasons, it falls far short of establishing its conclusion. First, although the failure of Bell's inequality in quantum theories raises problems for what he calls Einsteinian separability or locality – the view that no influence of any kind can propagate faster than the speed of light – all this does is to call into question the viability of the kind of scientific realism that wants to incorporate Einsteinian separability into its account of how the real world in fact behaves. It does nothing whatever to demonstrate that metaphysical realism without Einsteinian separability must be abandoned. D'Espagnat wants us to conclude, with him, that the world wouldn't exist apart from human consciousness. But none of the premises he adduces in favour of this conclusion even refer to consciousness. And – as any logician knows – the conclusion of a valid argument can't contain concepts that don't feature in its premises.

A second objection to his argument is that advanced by Rachel Wallace Garden, to the effect that the failure of Bell's inequality is a consequence, not of any breakdown of the laws of logic, of set theory, or of metaphysical realism, but only of the fact that – as she puts it – "the magnitudes used in quantum theories to describe reality are not always compatible, or equivalently, that these theories do not have bivalent states."[20] It is to be expected of any theory that operates with what Roger Penrose describes as the current concepts of "observables, measurements, state preparations, and so on."[21]

So far I've contented myself with demonstrating that the arguments for antirealism are bad. Now, in Part III, I provide a frontal attack on antirealism itself.

PART III: THE ABSURDITY OF ANTI-REALISM IN QUANTUM THEORY

Let's return to what I described as "paradigmatic expressions of metaphysical antirealism" – those quoted near the beginning of this paper.

The claims of these believers in orthodoxy fall into three broad classes: (i) those which assert that microphysical objects exist only in so far as they are measured [I'll call this Measurement-created reality]; (ii) those which assert that microphysical objects exist only in so far as they are observed [I'll call this Observer-created reality]; and (iii) those which assert that microphysical objects exist only in so far as we are conscious of them [I'll call this Consciousness-created reality]. I allow that some anti-realists have at times blurred the distinctions between these three types of assertion. But that will in no way detract from the force of my objections to all three.

Any frontal attack needs to be short, swift, and decisive. That's what I will make mine.

Definition of "complex object".

First, a definition. By "a complex object" I shall mean an object composed of simpler constituents.

Some basic scientific truths.

Given this definition, each of the following statements is true:

(1) Atoms are complex objects with subatomic particles or wave-packets as their simpler constituents.

Statement (1) is a truth of atomic physics. It is, of course, an open question – to be decided empirically, if at all – whether any given subatomic particle or wave-packet will turn out to be a complex object; and an open question whether there are any ultimate simples from which all the complex objects making up the furniture of the universe are constituted.

(2) Molecules are complex objects with atoms as their simpler constituents.

Statement (2) is a truth of physical chemistry.

(3) All macrophysical objects, from things like calcite crystals, to genes, to human beings, to planets, stars, galaxies, galaxy clusters, and the universe at large, are complex objects with atoms and molecules among their simpler constituents.[22]

Statement (3) is a more general truth sanctioned by various sciences such as chemistry, molecular biology, animal biology, astronomy, and cosmology.

Two logico-semantic truths.

Next, I wish to advance two claims each of which, I submit, has the status of a necessary truth, or – if you prefer – a logico-semantic truth, viz.,

(4) If a complex object exists, then all (and a fortiori, some) of its constituents exist.

On my account, (4) has the same sort of status as the statement that whatever is necessarily true is possibly true. It is not itself a truth of first-order logic any more than is the statement that necessity implies possibility, but – like the latter – it is a theorem of a richer logic, viz., in the present case, of the mereological extension of predicate logic. I also claim the same sort of status, as a necessary truth, of

(5) If, at a given time t, none of the constituents of a complex object exist, then that object itself does not exist at t.

Statement (5) follows logically from statement (4) and is so obviously true that it is almost embarrassing to have to state it.

Yet, as I shall now argue, the truth of (5) seems to have been overlooked, ignored, or forgotten by the proponents of quantum mechanical orthodoxy. For (5), when conjoined with (1), (2), and (3), and with our prototypical pronouncements, leads to conclusions which no scientist or otherwise sane person could rationally accept.

Measurement-created reality.

Consider, first, the claims of those who say that microphysical reality is measurement-created. Anti-realists who adopt this view are committed to

(6) Microphysical objects such as electrons, protons, etc., exist only when they are being measured, i.e., exist when they are being measured and do not exist when they are not being measured.

As most quantum theorists recognize, there is a major problem here.

The quantum measurement problem.

If we take a concrete case of a quantum measuring device – say a calcite crystal being used to measure the polarization of a beam of light – it seems wholly arbitrary as to when we should say that the act of measurement "collapses" the wave-function into a polarized photon. Does the collapse occur at the time when the wave-form passes through the calcite crystal? Or when it reaches the phosphor screen? Or when it passes through the lens that focuses the light? Or when it reaches the sensitive plate that records the result? In short, at what time does the act

of measurement "create" the photon? And what is the duration of the photon? According to the measurement-creation view, the photon exists only at the time – whatever that may be – when it is "in conjunction with an instrument of measurement". As Heisenberg claimed, the concept of the path of an electron or photon "between" successive measurements is absolutely meaningless. But when, in a given measurement process does the electron or photon come into existence? And when does it pass away?

The physical status of measuring instruments.

The so-called quantum-measurement problem is the least of the difficulties faced by the measurement-creation theorist. Much more problematic is the physical status of the various parts of the measuring device. Heisenberg, Bohr, and the rest, regard each of the constituents of the measuring set-up as macrophysical objects belonging to the world of classical physics. Yet, according to (3), (2), and (1), all parts of the macrophysical set-up are constituted from microphysical objects such as subatomic particles or wave-packets. And according to (5) none of these microphysical objects will exist except at those times when they in turn are being measured. Hence we can conclude

(7) Macrophysical measuring instruments exist only when their microphysical constituents are being measured and do not exist when they are not being measured.

An infinite regress.

Here we have the seeds of an infinite regress. In order for any first-order macrophysical measuring instrument to exist, its simpler microphysical constituents would have to be measured by second-order macrophysical measuring instrument; and the simple microphysical constituents of this second-order instrument would have to be measured by a third-order macrophysical measuring instrument; and so on ad infinitum. Hence the act of measuring microphysical objects in order to bring them into existence could, in principle, never get started.

Is there any way of escaping from this absurdity?

One suggestion that has been made is that the act of measuring that is required, in order to bring into existence the microphysical constituents of macrophysical measuring instruments, is in fact being performed all the time by other microphysical objects with which they are in close proximity.

But this trivializes the notion of measurement. It certainly is not what the likes of Heisenberg, Bohr, and Bridgman meant by "measurement". And it would have the consequence, contrary to what the antirealists maintain, that the subatomic world is objectively real after all in the sense of existing independently of whether *we* are measuring or observing it.

Observer-created reality.

Another escape route might seem to be available, viz., that of making the existence of a microphysical world dependent, not on the existence of macrophysical measuring instruments, but only on the existence of our acts of observation. Hence the second class of prototypical pronouncements mentioned above: reality is observer-created.

But this will not do. For the notion of an observer-created microphysical reality is ambiguous between two construals:

(a) that according to which we, as observers, are to be regarded as nothing more than macrophysical biological objects with sensory organs capable of observing the readings on measuring instruments; and

(b) that according to which we, as observers, are to be thought of not as physical objects at all, but solely as pure consciousnesses.

The construal (a) will not help. For according to it the following will be true, viz.,

(8) Human observers are macrophysical objects.

But from (8) and (5) we infer

(9) Human observers exist only when their microphysical constituents are being observed and do not exist when they are not being observed.

And (9) sows the seeds of an infinite regress once more.

Consciousness-created reality.

The second construal – (b) above – brings us to the third class of pronouncement, that typified by Wheeler's and Wigner's claims that microphysical reality is consciousness-created. On this view, the collapse of the wave-function occurs at the point when a physical signal in the brain of an observer becomes an experience of the human mind or consciousness.

Now the interesting thing about the consciousness-creation view is that it does evade the absurdity of an infinite regress. It does so by virtue of the assumed truth of

(10) Consciousness is not neither a macrophysical nor a microphysical object; since it is not a physical object of any sort.

In effect, (10) offers a way out of the regress by postulating a different kind of entity and according it privileged status in much the same way as a great Uncaused Cause or God is accorded privileged status – by proponents of the First Cause argument – in order to evade an infinite regress of causes.

But (10) poses its own problems.

First, it presupposes a rather naive sort of Cartesian dualism in which consciousness is viewed as either identical to, or a function of, mind or mental substance. And not only is that view subject to grave philosophical objections. It also runs counter to the philosophically and scientifically more plausible view that consciousness is not a thing of any kind, but an emergent property of certain sorts of things, viz., biological organisms such as ourselves and, perhaps, other higher mammals.

Second, on the consciousness-created account, the creative act of consciousness comes in only at the end of a chain of purely physical events, starting with some sort of macrophysical measuring instrument, continuing with nerve impulses in a human body, and ending – on the physical side of the ledger – with the brain state that somehow "becomes" a state of consciousness. But the difficulty with this is posed by another statement to which the consciousness-created advocates are committed, i.e., by the correlate of (9), viz.,

(11) Human beings exist only when their subatomic constituents are objects of consciousness and do not exist when they are not objects of consciousness.

It scarcely needs to be pointed out that – as a simple matter of fact – the following statement is true, viz.,

(12) Human beings are never conscious of their own subatomic constituents.

But from (11) and (12) it follows that

(13) Human beings do not exist.

In short, if the consciousness-created account were true, there would never have been anyone to propound it. A fortiori, none of us here present would be here to even discuss it.

The scientific absurdity of all three anti-realist views.

The same absurd consequences can easily be deduced – mutatis mutandis – from both the other kinds of account as well: the measurement-created and the observer-created.

Now perhaps there are some brave souls who are prepared to bite the bullet and accept these absurdities. Such views are not unheard of among other-worldly philosophers. Hence Bishop Berkeley's claim: "All those bodies which compose the mighty frame of the world have no subsistence without a mind".

But it is scientists, not philosophers, who are here propounding these factually absurd and philosophically extreme doctrines. And they must surely pause when they are brought face to face with the scientifically unacceptable nature of their views. It is easy to see that each of the following scientifically repugnant statements – and countless others too numerous to enunciate – are consequences of this sort of anti-realism:

(14) Since human beings – equipped with measuring instruments, powers of observation, or consciousness – did not exist until relatively late in evolutionary history, we could not have had evolutionary ancestors.

This will give comfort to so-called Scientific Creationists, no doubt, but not to evolutionary theorists or to the proponents of any of the other sciences whose consilience (to use Edmund Wilson's wonderful word) sets evolutionary theory on as firm a foundation as Gravitational Theory.

(15) Since, at this very moment, we are not measuring, observing, or conscious of the subatomic constituents of more than, say, a few million or billion atoms, the whole of the universe at the moment has no greater mass than a sugar cube or maybe a soccer ball.

So what is the Hubble telescope peering at? And what is the mode of existence of the telescope itself?

I could go on. But my point is made.

Outdoing Bishop Berkeley.

It comes almost as an anti-climax, therefore, to say that the quantum anti-realists are fundamentally confused. When Niels Bohr, for instance, says there is no "deep reality" or "quantum world" he intends us to understand that at least there is a non-deep, non-quantum, classical reality. But he can't consistently say even that. For according to (5), if there is no microphysical reality then there is no macrophysical one either. Likewise, when David Mermin says that the moon is "not there when nobody looks", he intends us to understand that at least it is

there when we do look. But he can't consistently say even that. For on his anti-realist view, if we aren't measuring, looking at, or conscious of the moon's microphysical parts, it isn't there even when we *are* looking. Even Bishop Berkeley wouldn't want to go that far.

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[1] S. Hook, "Necessity, Indeterminism and Sentimentalism", *Determinism and Freedom in the Age of Modern Science: A Philosophical Symposium* (ed. S. Hook), New York 1957, p.170.

[2] The first five are quoted, without references, in Nick Herbert's *Quantum Reality*. The passage by d'Espagnat is from his *Scientific American* article,

[3] Karl Popper was one.

[4] De Broglie defected to orthodoxy for some 20 or so years before once more resuming his realist/determinist stance.

[5] Bohm abandoned orthodoxy after he had developed, at Einstein's suggestion, de Broglie's long-abandoned realistic, and deterministic, model of quantum-mechanical phenomena – the "pilot-wave" model.

[6] Albert Einstein, "A Reply to Criticisms", *Albert Einstein: Philosopher-Scientist*, (ed. P. A. Schillp), New York 1951, p. 666.

[7] Louis de Broglie, Foreword to David Bohm's *Causality and Chance in Modern Physics*, London, 1957, pp. x, xi. De Broglie was making a philosophical point, grounded in his understanding of the history of science. He was arguing that our concept of chance is an epistemic one, not an ontological one, that it has to do with our ignorance of how things really are rather than a failure of causality in the world itself.

[8] *Universitas*, p. 361.

[9] Max Born, "Continuity, Determinism, and Reality", (Danish Academy of Science, Mthematics, and Physics. Section 30, No. 2, 1955). The kind of sentence that does have physical meaning, he goes on, must be of the form:

> The probability for the value of a physical quantity to be in a given interval (represented by two real nmbers) has a certain value (again a real number). Or, in other words, for any quantity x there exists a probability density P(x).

[10] Neils Bohr, "Causality and Complementarity", *Philosophy of Science*, 1937, 4, p. 290.

[11] *BJPS*, Vol. XIII, No. 51, pp. 193-215.

[12] See Alan Musgrave,

[13] Quoted by Nick Herbert, p.4. Jeans goes on to say:

> We go beyond the mathematical formula at our risk; we may find a model or picture which helps us understand it, but we have no right to expect this, and our failure to find such a model or picture need not indicate that either our reasoning or our knowledge is at fault.

[14] Stephen Hawking, *A Brief History of Time*, p. 139.

[15] Max Born, "Statistical Interpretation of Quantum Mechanics", *Science*, Oct., 1955.

[16] Max Born, "Continuity, Determinism, and Reality", (*Danish Academy of Science, Mathematics and Physics*, Section 30, No. 2, 1955), p. 4 .

[17] [Einstein, *Scientific papers presented to Max Born*: Oliver and Boyd, 1953, p.33; quoted by Max Born in "Continuity, Determinism and Reality, p.8]

[18] Born, "Continuity, Determinism, and Reality,", p.11.

[19] (*Symmetries and Reflections: Scientific Essays*, Bloomington Indiana: Indiana University Press, 1967). [Quoted by Alan Musgrave, *Commonsense, Science, and Skepticism*, 98.] Wigner here is following in the footsteps of Eddington: "The only subject presented to me for study is the content of my consciousness. According to the usual description, this is a hererogeneous collection of sensations, emotions, memories, etc." (*The Philosophy of Physical Science*, Cambridge University Press, 1939.) [Quoted by Alan Musgrave, *Commonsense, Science, and Skepticism*, 9

[20] Rachel Wallace Garden, "Logic, States, and Quantum Probabilities", *International Journal of Theoretical Physics*, Vol. 35, No. 5, 1996, p. 897.

[21] Roger Penrose, "Quantum Physics and Conscious Thought".

[22] Atoms and molecules need not exhaust their simpler constituents. Statement (3) is formulated so as to allow for cases where the simpler constituents include such things as radiation.