LETTERS TO THE EDITOR

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THE REAL SCANDAL OF QUANTUM MECHANICS

The real scandal of quantum mechanics is that so many physicists still insist on thinking about quantum phenomena with classical ideas. Hobson\(^1\) advised us that the universe “is made of” quantized fields, preferring that to “manifestations of a wave function,” used by Kampen\(^2\) in his letter. The wave function is merely an intellectual tool used by physicists, and the notion that anything is “manifestations of wave functions” is just as incorrect as the notion that electrons are particles. The trouble with the terms “particle” and “wave function” is that each of these has a well-defined meaning, and experiment shows that nothing is made of either of them. In contrast, Hobson’s “quantized field” has no meaning at all and hence is invulnerable to criticism. But, Hobson claimed that he has found what the universe “is made of!”

It seems that almost everyone feels that the universe must be “made of” something and wants to know what. Another outstanding example of this urge of the human mind is the paper\(^3\) by President Bush’s OSTP Director, John H. Marburger III, which I have referenced in my essay, “The mental universe.” It is fine how marvelously Marburger disposes of both “waves” and “particles.”

“...The wave is not in the underlying stuff, it is in the spatial pattern of detector clicks. We do not—cannot—measure waves in the underlying stuff. We can only measure detector clicks. But when we hear the click we say “there’s an electron!” We cannot help but think of the clicks as caused by little localized pieces of stuff that we might as well call particles. This is where the particle language comes from. It does not come from the underlying stuff, but from our psychological predisposition to associate localized phenomena with particles.”

Excellent! However, you will have noticed that, just like Hobson, Marburger demanded that the universe be “made of” something in Marburger’s case, “underlying stuff.” (I was present for Jack’s talk, and he even pronounced it as German “Stoff.”) But, we are also quite aware that Marburger did not advise President Bush to institute a National Science Foundation program to characterize the “underlying stuff” even though this is supposed to be fundamentally what the universe is made of!

Sorry folks—stuff and nonsense! We know for a fact that the universe is not “made of” anything. Get it through your heads, physicists! It is sometimes said that the only thing that is real are the observations, but even that is not true: observations are not real either. They, and everything else, are purely mental.

You are making observations right now. But let us get more sophisticated about it and carefully make some observations of a certain kind. We find in certain selected circumstances that we typically only measure values \(\hbar/2\) and \(\hbar\). We understand these results completely since we have quantum mechanics! It is true that we also have in our minds the notion of a three-dimensional object or “thing,” and that we know from quantum mechanics that any such thing, should it exist, cannot have spin angular momentum less than \(\hbar\), so we know for sure that our observations of half of that value cannot possibly be of things. And, while the observed values that are \(\hbar\) in principle could be of “things” (photons totally flattened in the direction of motion by special relativity), Occam’s razor tells us that, since such a notion adds nothing, and is ruled out for our other observations (the \(\hbar/2\) measurements), we should not even consider the notion, which is valueless or rather worse than valueless.

Now, let us make some more observations, but in a different way. We find now that we often get values \(9.1 \times 10^{-28}\) g. Again, because we have quantum mechanics, we are quite justifiably certain that we are observing one eigenvalue of some operator. In fact, the current central task of physics is to find that operator! It is curious that the job is completely done for angular momentum but is not yet done for mass energy.

Why have we made these two particular sets of observations and not others? It is because Emmy Noether taught us that symmetries lead to conservation laws, and our universe (the set of all of our observations—hey, THAT is all we know about the universe) turns out to have various symmetries (for unknown reasons) that result in conserved quantities.

It is no fun to make measurements of quantities that are not conserved because they are evanescent. But it seems to be very dangerous to make observations of quantities that are conserved...
because they stay the same, and so they start us thinking, again, about "things" (which by definition also stay the same).

Gröblacher et al.\(^5\) put the final end to reality: I quote the first and final sentences of their abstract: "Most working scientists hold fast to the concept of 'realism'—a viewpoint according to which an external reality exists independent of observations." How true! But, then... "Our result suggests that giving up the concept of locality is not sufficient to be consistent with quantum experiments, unless certain intuitive features of realism are abandoned." Aspect\(^7\) captured this as "...it implies renouncing the kind of realism I would have liked."\(\textit{Finis!}\)

Let us review all of our candidates for "what the universe is made of:"

"Particle, wave, and wave function" are wrong by experiment.

"Quantized fields and underlying stuff" are wrong simply because they are meaningless.

"Mental" is correct, which you verify with complete certainty automatically through the very process of thinking about it.


\(^7\)A. Aspect, "To be or not to be local," Nature (London) 446, 866 (2007).

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RESPONSE TO "THE REAL SCANDAL OF QUANTUM MECHANICS," BY RICHARD CONN HENRY [AM. J. PHYS. 77 (10), 869–870 (2009)]

It is remarkable what interpretive extremes physicists will go to in order to make sense of quantum physics. But, as Van Kampen and I argue in our letters, quantum physics needs no interpretation. Once one views electrons, photons, and so forth as fields rather than particles, the pieces fall into place. Those quantum pieces include some surprising and nonintuitive concepts such as uncertainty, nonlocality, and cats that can (in idealized thought experiments) be simultaneously alive and dead, but these are not inconsistencies that need to be rectified by a Copenhagen, many worlds, hidden variables, mental, or mystical interpretation; they are simply phenomena that physicists need to get used to.

If, as Henry asserts, observations and everything else are "purely mental" and "not real," then this desk I am sitting at is not real. Henry apparently takes David Mermin's question "Is the moon there when nobody looks?" very seriously, and answers, "No, and furthermore it is not there even when you do look." Such a view reduces to its ultimate absurdity the notion that quantum physics needs an interpretation.

Eugene Wigner's interpretation of quantum physics invokes mental phenomena in a way that is similar to, but less extreme than, Henry's interpretation. Wigner argued 50 years ago that the consistency of quantum physics requires human consciousness to ultimately "collapse the wave packet," i.e., to select one from the many possible outcomes of an unpredictable microscopic experiment. A recent book by Rosenblum and Kuttner touts this view.\(^2\) But do wave packets then not collapse on planetary systems where there are no humans? Can a low-IQ human collapse a wave packet? Can a monkey, or a cat, do it? decoherence theory explains perfectly well how wave packets are collapsed by the interaction of quantum fields (wave functions) with macroscopic systems.

With great confidence but no stated justification, Henry makes assertions such as "quantized fields have no meaning at all,...the wave function is merely an intellectual tool used by physicists...we know for a fact that the universe is not made of anything," and "observations are not real" but "are purely mental."

As Faraday, Maxwell, Einstein, and most physicists who have thought about it, knew, spatially continuous fields such as the electromagnetic field are physically real. If not, then electromagnetic radiation violates conservation of energy. Furthermore, the quantized electromagnetic field is an elementary variation on the classical field: the energy of the quantized field does not vary over a continuous range but must instead be a whole-number multiple of hf (plus the vacuum energy). Thus a quantized electromagnetic field is continuous in space and time but comes in discrete bundles having energy hf, 2hf, etc. Such a bundle is called a "field quantum." It is not a difficult concept. For an authoritative nontechnical discussion of photons and material particles as field quanta, see Robert Mills' \textit{Space, Time and Quanta}.\(^3\)

Henry asserts that "the wave function is merely an intellectual tool used by physicists." But the wave function for an electron is the nonrelativistic limit of a real physical entity, the quantized electron-positron field. As stated by Weinberg and quoted in my previous letter, such "quantum fields are the basic ingredients of the universe." The views of Weinberg and Mills surely deserve more than Henry's quick brush off.

Henry quotes the paper of Groeblacher et al., and Aspect's response to it, as though this ended all discussion and proved the nonreality of every-
I agree with Henry that the universe is not made of things. But that does not mean it is mental; in fact, it is made of real quantum fields. In an argument similar to Henry's point about spin $\frac{1}{2}$, Redhead used the physical reality of vacuum fields to make precisely this point, namely, that any consistent view of quantum physics must be a field, not a particle, view. Fields are not things and fields are not made of things. It is the other way around: things are made of fields.


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