LETTERS TO THE EDITOR

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ON BOOK REVIEW OF *QUANTUM ENIGMA*

In his recent review[1] of Rosenblum and Kuttner's book *Quantum Enigma: Physics Encounters Consciousness* (QE),[2] David Mermin wrote that the author's "nontechnical description of Bell's theorem is one of the best I've seen, and by far the least mathematical." A nontechnical description of this theorem would certainly be of great pedagogical value, and this endorsement by Mermin, who is one of the leading experts on this subject, carries a great deal of weight. It turns out, however, that his assessment is not correct. Contrary to the claim of the authors of QE, their graphical model used to illustrate a hidden variable theory by a "classical" ensemble of pairs of photons with parallel but randomly oriented polarizations (see Ref. 2, Figs. 13.2–13.5) does not give rise to perfect coincidences when the principal axes of two polarizers, one in front of each of the detectors, are aligned. But such coincidences are essential to establish Bell's original inequality. This problem led the authors of QE to introduce sub-rosa *unphysical* polarizers, which accomplishes this task but violates Malus' law. Hence, their finding "nothing strange in this correlation [perfect coincidences], the twin photons indeed had identical polarization,..." (Ref. 2, p. 145) ignores the fact that in their model, perfect coincidences for aligned polarizers do not occur when polarizers obey the laws of physics. This contradicts their claim that "the only actual assumptions in our derivation of Bell's inequality were the physical reality of each's photon's polarization and the separability of the two photon twin states" (Ref. 2, p. 147). Mermin also seemed unaware that the proof of Bell's inequality presented in QE is an original proof due to Nick Herbert who, at the outset, *assumed* the quantum prediction of perfect coincidences for aligned polarizers.[3]

Moreover, Mermin ranks the QE treatment of two-slit interference "right up there with Feynman's" approach. But this comparison is far fetched, because the QE treatment gives an essential role to *consciousness* in quantum mechanics. For example, on pp. 182–183 of their book, in a section entitled "Do we need a Conscious Observer," the authors conclude "that by your conscious free choice of experiment you can prove either that the objects [in a two-slit experiment] were concentrated or that they are distributed…you are faced with the quantum enigma and consciousness is involved." Replacing in this sentence the words "by your conscious free choice of experiment" with "by your choice of experiment" leads to the conventional resolution of wave-particle duality first advocated by Bohr. But to show that "consciousness" and "free will" are *necessary* elements to resolve this duality, the authors discuss the option that the choice of alternative experiments is decided by the toss of a coin. Their conclusion is startling: "you find something puzzling: The coin's landing seems inexplicably connected with what was presumably in a particular box-pair set [pair of slits]. Unless ours is a strangely deterministic world, one that conspired to correlate the coin landing with what was in the box pairs, there is no physical mechanism for that correlation."

Mermin's "major reservation" is that the role of consciousness has been exaggerated in QE, but he regards it as a "debatable issue." Feynman, on the contrary, concludes that "Nature does not know what you are looking at, and she behaves the way she is going to behave whether you bother to take down the data or not."[4] This is a sharp rejection of the central thesis of QE that "physics encounters consciousness," which the author's of QE claim "cannot be denied." For further criticism, see Ref. 5.

[1] David Mermin, "Quantum Enigma: Physics Encounters Consciousness," Am. J. Phys. **75**, 287 (2007).

[2] Bruce Rosenblum and Fred Kuttner, *Quantum Enigma Physics Encounters Consciousness* (Oxford U.P., New York, 2006).

[3] Nick Herbert, *Quantum Reality* (Anchor Books, New York, 1985).

[4] R. P. Feynman, R. B. Leighton, and M. Sands, Feynman Lectures (Addison-Wesley, Menlo Park, California, 1977), Vol. 3, pp. 3–7.

[5] Michael Nauenberg, Critique of "Quantum Enigma: Physics Encounters Consciousness," Foundations of Physics, DOI 10.1007/s10701-007-9179-8.

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REPLY TO NAUENBERG

The hidden variable Rosenblum and Kuttner (hereafter RK) use in their discussion of Bell's theorem is an angle which determines by some rule the behavior of the photon at a polarizer. That angle is not (as Michael Nauenberg assumes) the direction of a classical linear polarization and that rule cannot (as Nauenberg correctly notes) be Malus' law. Rereading RK, I see why Nauenberg misconstrued their argument. RK represent that abstract angle by the orientation of a "polarization stick" in the plane perpendicular to the direction of propagation, and they say that they are testing the assumption that each photon "has a real polarization." This strongly suggests Nauenberg's misreading, despite RK's statement that "the sticks are merely stand-ins for *any* hidden variable" (their italics). As a "leading expert on the subject," I understood what RK had in mind, and failed to realize that many (if not most) readers—particularly those well acquainted with the concept of polarization—would be misled by RK into identifying stick angle with polarization direction, thereby making nonsense of their argument.

This pedagogical lapse diminishes my enthusiasm for Rosenblum and Kuttner's treatment of Bell's theorem. What had actually inspired my half-sentence of praise was their basing their argument on the polarization correlations for only slightly misaligned detectors, leading to a particularly simple argument. But as Nauenberg points out, this approach is due to Nick Herbert.[1] I don't recall having seen Herbert's version before coming across it in RK's book. So much for my expertise! Since RK acknowledge Herbert, I should have checked this out, before waxing enthusiastic. My only excuse is that I acted on the implicit maxim that while criticism has to be well supported, nobody complains about ill-founded praise. Wrong again!

Finally, I stand corrected by Nauenberg on my praise of RK's description of two-slit interference (the other half of that sentence). Rereading their discussion, I find at its center a disappointing reference to the same unphysical parable (qualified, to be sure, by the phrase "something like this") that I spent four full paragraphs of my review criticizing.

[1] Nick Herbert, "Crytographic approach to hidden variables," Am. J. Phys. **43**, 315–316 (1975).

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REPLY TO NAUENBERG AND MERMIN

The reactions of Nauenberg and Mermin to *Quantum Enigma*[1] bear out the book's first sentence: "This is a controversial book." The book continues with: "The experimental results we report and our explanation of them with quantum theory are completely undisputed." Of course, what we say can be *incorrectly* disputed, and Nauenberg's criticism of our Bell's theorem proof is an example. Since Mermin's letter addresses Nauenberg's error, we won't comment on it.

Nauenberg also notes that "…the proof of Bell's inequality presented in QE is an original proof due to Nick Herbert…." Does he imply we claim credit for someone else's idea? Our proof is indeed a modification of Herbert's, and at the start of our proof we say, "Nick Herbert invented the general idea we use." In fact, Herbert read *Quantum Enigma*[1] in galley proof and gave us the comment used on the back cover of the Oxford University Press edition: "Employing the simplest correct demonstration of the Great Quantum Dilemma that I have ever seen, Rosenblum and Kuttner starkly expose the hidden skeleton in the physicist's closet."

Nauenberg's claim that "…the QE treatment [of two-slit interference] gives an essential role to consciousness in quantum mechanics…" is incorrect. Our demonstration is *quantum-theory-neutral*. The encounter with consciousness comes about *only* through the observer's having been able to choose a different experiment, of having free will. By conscious choice, he or she could have established a different prior reality. We will soon briefly respond to Nauenberg's referenced post.

In his first paragraph, pointing out Nauenberg's "misreading," Mermin notes, "As a 'leading expert on the subject,' I understand what RK had in mind." But he believes that readers well acquainted with the concept of polarization would be misled by our use of the words "polarization direction" instead of "stick angle." In a class for non-science students, with *no* previous acquaintance with polarization, we find students are *not* misled. It seems a little knowledge is a dangerous thing. In the next printing of *Quantum Enigma*[1] we will change the wording to "stick angle."

In fact, in our derivation *no* property of the sticks—other than reality and separability—was actually used. We emphasize this by rephrasing the model in terms of an intentionally ridiculous "photon pilot" whose paper travel documents tell him whether or not to pass through a particular polarizer. We do not understand why Mermin's realization that our derivation was a modification of Herbert's should change his expressed opinion that our "…nontechnical description of Bell's theorem is one of the best I've seen, and by far the least mathematical."

Mermin fears some readers will accept our parable as a physically possible situation. In fact, we are explicit that the point of the parable is only to display the *bafflement* one experiences with the enigma of wave-particle duality. At the parable's start, we refer to the story as "magical." At its conclusion, we say, "…it can't be demonstrated in the real world." Later, in discussing the bafflement (Ref. 1, p. 88), we reemphasize that what was displayed in our parable "…is *not* actually possible." We have presented this parable in a popular course for non-science students over many years. Students invariably take it as an illustrative, impossible story in the spirit of George Gamow's *Mr. Tompkins in Wonderland*.

Nauenberg's claim that Bohr resolved the wave-particle duality is belied by the many currently contending interpretations of quantum mechanics. In our book we quote the leading exponents of various interpretations needing to refer to consciousness—even if only to show why the physics discipline need not deal with it (something we explicitly agree with).

Nauenberg's reference to "coin landing" is a misreading of our refutation of the common misperception that a not-conscious robot can eliminate the encounter with consciousness. Introducing the robot merely moves the encounter down the "von Neumann chain." Nauenberg's reference to Feynman seems irrelevant. Feynman also said: "[N]obody understands quantum mechanics."

[1] Bruce Rosenblum and Fred Kuttner, *Quantum Enigma: Physics Encounter Consciousness* (Oxford University Press, New York, 2006).

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DECOHERENCE AND THE QUANTUM MEASUREMENT PROBLEM

In his letter "Comment on Mermin's Review of *Quantum Enigma* by Bruce Rosenblum and Fred Kuttner" [Am. J. Phys. **75**(10), 869 (2007)] Art Hobson argues that "Starting from this notion, the decoherence theory of Wojciech Zurek and others solves the von Neumann chain (or Schrödinger's cat, or classical quantum boundary) problem." To my mind, such an argument is misleading as, for example, Stephen L. Adler[1] or Maximilian Schlosshauer[2] have shown that, within the standard interpretation of quantum mechanics, decoherence cannot solve the problem of definite outcomes in quantum measurement. It would be of interest to come to know how—in view of the arguments given by Adler and Schlosshauer—Hobson can maintain his statement that "the measurement problem has been resolved within the realm of normal, realistic physics."

[1] S. L. Adler, "Why decoherence has not solved the measurement problem: a response to P. W. Anderson," Stud. Hist. Philos. Mod. Phys. **34**, 135–142 (2003).
[2] M. Schlosshauer, "Decoherence, the measurement problem, and interpretations of quantum mechanics," Rev. Mod. Phys. **76**(4), 1267–1305 (2004).

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