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effect of our experimental interventions. But, if one tries to push this special circumstance further and identify an overarching "reality" completely independent of our interventions, then this is where the trouble begins and one finds the raison d'être of the various "interpretations."

Todd Brun and Robert Griffiths point out that "physical theories have always had as much to do with providing a coherent picture of reality as they have with predicting the results of experiment." Indeed, have always had. This statement was true in the past, but it is untenable in the present (and likely to be untenable in the future). Some people may deplore this situation, but we were not led to reject a freestanding reality in the quantum world out of a predilection for positivism. We were led there because this is the overwhelming message quantum theory is trying to tell us.

The main point of disagreement we have with Brun and Griffiths is about the existence of a wavefunction of the universe that would include all its degrees of freedom, even those in our brains. We assert that this would lead to absurd self-referential paradoxes. Therefore, it is necessary to restrict the discussion to a (reasonably small) subset of the dynamical variables. Brun and Griffiths ask, "Can we only describe the Big Bang, or an exploding supernova, in terms of the light that reaches our telescopes?" We never demanded such a restriction. We did not claim that only what is directly observed exists. There is much more to say about astrophysical phenomena than just describing the light that originates from them. Yet, their description cannot be so detailed as to include every particle involved in their observation, such as those in the retina of the observer, in the optic nerves, in the brain cells, and so forth. A limit must be put somewhere between the object of our description and the agent that performs that description. Quantum theory can describe anything, but a quantum description cannot include everything.[2]

We agree with Brun and Griffiths that the violation of Bell's inequality by quantum theory is not a proof of its nonlocality. Quantum theory is essentially local. Bell's discovery was that any realistic theory that could mimic quantum mechanics would necessarily be nonlocal. Near the end of his life, Bell was indeed inclined to seek such a theory, bearing traces of realism and nonlocality. We do not rule out that such an extension of quantum theory may some day be produced, but no one so far has achieved this goal in a useful fashion, nor is an extension required for a clear understanding of the quantum phenomena about us.

We surely agree with Brun and Griffiths that "in science, one cannot rule out alternatives by fiat; one must evaluate them on their merits." We do not find any merit in the various alternatives that were proposed to the straightforward interpretation of quantum theory: It is a set of rules for calculating probabilities for macroscopic detection events, upon taking into account any previous experimental information. Brun and Griffiths may think this a "straitjacket," but it prevents the endless conundrums that arise solely from shunning quantum theory's greatest lesson—that the notion of experiment plays an irreducible role in the world we are trying to describe.

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Physics, Engineering Are Intimately Interdependent

I was mightily disappointed to read the defensive exposition regarding the lack of attribution given to the physics roots of engineering achievements in the 20th century (PHYSICS TODAY, May, page 48). Of course engineering achievements are built upon fundamental physics. What useful construction can anyone make that is without reliance on electromagnetics, dynamics, materials, or any other flavor of physical science? Some would even say that the raison d'être of engineering is to turn fundamental ideas into workable, practical systems that are sufficiently cost-effective to allow them to become part of the fabric of our society. However, if we were to turn the question of proper attribution around, one might possibly wonder how often the grand discoveries in physics have relied on a well-

engineered piece of equipment. It is not without some irony, for example, that I note how many of the pages of PHYSICS TODAY are graced with engineering devices that are presumably of some use to its readership.

Never mind that the distinction between physicist and engineer has historically been a blurry one; no good purpose can be achieved by drawing attention to intellectual snobbery. Perhaps in a perfect world we would hear constantly about those upon whose shoulders we stand. As it is, physics and engineering depend on each other in such an intimate way that we should be secure enough to allow each to congratulate itself without demanding an academy award acceptance speech that must each time thank the $2\frac{1}{2}$ pages of people that made it all possible.

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Single Photon's Nondestruction Clarified

I enjoyed Richard Fitzgerald's article "Single Microwave Photons Can Be Measured Nondestructively" (PHYSICS TODAY, October 1999, page 22) and learned a great deal about recent advances in an exciting field outside of my own; something for which I have come to rely on PHYSICS TODAY. I was disturbed, however, by the repeated use of phrases such as "detecting the presence of a single photon in a nondestructive way," and "a single photon in the cavity field produces a phase shift. . . ." Such language implies that a photon is never destroyed upon interaction with the rubidium atom in the cavity. I would contend that one is: The absorbed photon is destroyed. Under the careful and clever experimental design of the Haroche group at Ecole Normale Supérieure, the Rb atom then emits a different photon. The fact that this second photon is identical to the original photon does not diminish its status as an entirely new photon.

Throughout the remainder of the article, the author is careful to point out that it is the photon number that remains unchanged, or "trapped." This is technically correct and uncontroversial, and should be the type of language used throughout the whole article. I fully understand that the author's intent was not to mislead but to use journalistic license for the purpose of grabbing and holding a physicist's attention. Particularly effective was the hinting about challenges to the very tenets of quantum mechanics. But such journalistic license comes attendant with possible hazards of misinterpretation.

As an educator who often deals with the layperson, I am distressed to have any additional mystery added to quantum mechanics. I am frequently called upon by my colleagues from other academic disciplines to clarify misinterpretations of physics, particularly quantum mechanics. As physicists we must be very careful in our communications to the layperson. I consider PHYSICS TODAY to be within the reach of some mainstream readers, and certainly within the purview of journalists in the popular scientific press. Therefore, I ask that the editors keep these lay readers in mind so that the magazine can continue to serve both them and the physics community.

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FITZGERALD REPLIES: Because the terminology I used in this story is the language used in the field, I contacted Serge Haroche and Jean-Michel Raimond who headed up the research. Their response follows.

HAROCHE AND RAIMOND COMMENT: Derrick Boucher's concern about the fate of the photon in our experiment is sometimes raised when we present our results; we are glad to be given the opportunity to clarify this point. The problem often arises because the classical vocabulary is inadequate to describe quantum concepts. If the photon were a classical particle, absorbed and re-emitted by a classical atom, one could wonder whether the final particle is the same or an "entirely new" one. However, photons in the same field mode are fundamentally indistinguishable quantum entities. In this respect, the question raised by Boucher, although obeying classical logic, has no quantum meaning.

The only relevant concept here is the information contained in the field state. This information is completely preserved in the experiment, as shown in more recent publications by our group.[1] Any superposition of 0- and 1-photon states survives the full absorption–emission atomic cycle, provided one does not attempt to find out what happens to the system during this cycle. Throughout the atom–field interaction (except the very moment when the atom is midway through the cavity and the