LETTERS

Postmodernism, Copenhagen and the Sokaled Science Wars, by Jove

Mara Beller's fine article, "The Sokal Hoax: At Whom Are We Laughing?" (PHYSICS TODAY, September 1998, page 29), reminds us that no matter how far we progress in our understanding of the universe, we—even the most brilliant among us—remain susceptible to the foibles of the human mind. On reading of the philosophical and other extrascientific speculations of Niels Bohr, Werner Heisenberg, Max Born and other giants, I was reminded of that earlier giant William Gilbert. Having shed brilliant light on the nature of electricity and magnetism and laid the foundation for the study of geomagnetism in his *De Magnete* (1600), he ventured beyond his newly discovered continent of solid science and followed his magnetic compass far out to sea. Only two decades later, Francis Bacon quite rightly criticized him:

"Men become attached to certain particular sciences and speculations, either because they fancy themselves the authors and inventors thereof, or because they have bestowed the greatest pains upon them and become most habituated to them. But men of this kind, if they betake themselves to philosophy and contemplations of a general character, distort and color them in obedience to their former fancies; a thing especially to be noticed in Aristotle, who made his natural philosophy a mere bondservant to his logic, thereby rendering it contentious and well nigh useless. . . . [A]nd Gilbert also, after he had employed himself most laboriously in the study and observation of the lodestone, proceeded at once to construct an entire system in accordance with his favorite subject."[1]

We must not place too much blame on the founders of quantum mechanics for falling prey to the same temptation. But though their aspirations as political scientists or philosophers may have overreached their capabilities, there can be no question of their mastery of physics, and it is for this reason that we receive their speculations with respect if not with adherence. The same respect cannot be claimed for the likes of Stanley Aronowitz, Jacques Lacan and Donna Wilshire, who try to base a credo close to their hearts or (heaven help us!) found a philosophy on gross ignorance.

I think it only fair to make a distinction between the great innovator, such as Gilbert or Bohr, who, pushing his brilliant new concepts as far as they will go, strays too far, and the true believer, such as Aronowitz or Wilshire, who tries to mold what he or she does not understand to his or her predetermined ends.

Reference

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PHYSICS TODAY seems determined to defuse or derail criticism by scientists of the claims made by writers of the postmodernist or social constructionist persuasion. The latest evidence is the article by Mara Beller, who claims that the philosophical speculations of Niels Bohr and Wolfgang Pauli are as obscure and naive as those of any postmodernist.

Let us grant that this is so, and then note that those speculations have been rightly relegated to utter obscurity (I doubt that one physicist in a hundred has heard of them). If postmodernist writings are equally lacking in content, then they should share the same fate, and the sooner the better. The lack of content is really the crucial point, and here Beller makes no defense.

Returning to PHYSICS TODAY and its attitudes, I propose an experiment. Let's see if the magazine will print a particular sentence (a whole sentence!) from the work of a leading postmodernist, Sandra Harding. I claim it gives a much fairer picture of the postmodernist attitude toward,

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and understanding of, science than anything PHYSICS TODAY has yet been willing to discuss. Here's the sentence: "Is it not as illuminating and honest to refer to Newton's Laws as 'Newton's Rape Manual' as it is to call them 'Newton's Mechanics'?"[1]

If any readers think I'm being unfair to Harding, I invite them to read her book, which is readily available in college libraries, if nowhere else. If any readers think Harding is an isolated extremist, I encourage them to consult reference 2.

Of course, if PHYSICS TODAY doesn't print the sentence, only I will know the outcome of the experiment. Talk about your observer effects. . . .

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In quoting the founders of quantum theory, Mara Beller has torn their words out of context and thrown them at the reader, who is invited to laugh at these authors rather than at—or at least as much as at—the postmodernist sociologues. For my part, I feel rather ashamed for the quotees because of the nakedness of some of the quotations and of some of Beller's assertions.

Commenting on Niels Bohr's well-known heavy and often obscure style, Beller notes that "When physicists failed to find meaning in Bohr's writings, no matter how hard they tried, they blamed themselves, not Bohr." This is true of many physicists (myself included), but it simply reflects one's willingness to accord an author credit for achievements beyond one's own capacity of understanding. Another case in point is the use Beller makes of John Wheeler's imaginary dialogue with the universe, in which she leaves unexplained the Bohrian meaning of the term "phenomenon," thereby rendering the whole quotation, well, laughable. She even invites us to laugh at David Mermin, who, in his in-depth analysis of some specific aspect of the quantum world's paradoxical nature, cannot find a better comparison than to say, in playing off a famous line of Albert Einstein's, that the Moon is not there when one isn't looking.

As for Beller's statement that "nonlocality, is, in fact, naturally contained in David Bohm's causal, observer-independent alternative to the standard quantum theory," I invite all Bohmian faithfuls to try translating, say, Robert Laughlin's wavefunction describing the fractional quantum Hall effect[1] into Bohmian formalism (I haven't tried). Indeed, in strongly correlated quantum systems like this one or high-temperature superconductors, particle–wave duality ceases to be meaningful, and only the wavefunction of the complete system, as the one given by Laughlin (apart from fancy models such as the "composite fermions"[2]) may do justice to such complex situations. Unfortunately, neither philosophers nor historians of science seem yet to have taken notice of this aspect of modern physics.

Probably one must understand the present-day calling into question of quantum theory as a reaction to our extremely rational scientific epoch, as was the "flower power" of the hippies in the late 1960s. On this point, I offer the following mediating quotation from Wolfgang Pauli in hopes that it will somewhat cover the nakedness of Beller's Pauli quotation: "I believe that it is the destiny of the occident continually to keep bringing into connection with each other these two fundamental attitudes, on the one hand the rational–critical, which seeks to understand, and on the other the mystic–irrational, which looks for the redeeming experience of oneness. *Both* attitudes will always reside in the human soul, and each will always carry the other already within itself as the germ of its contrary" (emphasis in original).[3]

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Mara Beller has written a provocative article calling attention to some occasional philosophical pronouncements made by Niels Bohr, Max Born, Werner Heisenberg and Wolfgang Pauli. From a contemporary viewpoint, these utterances may sound overblown. However, it is a stretch beyond credibility to say, as Beller does, that in them "we find the roots of the postmodernist excesses of today."

Rather than providing a basis for deconstructionist and postmodernist critiques of science, several quotations from Bohr and Born may be seen as part of the two physicists' effort to make the new concepts of quantum mechanics seem less difficult to nonphysicists. Some of Beller's other examples are private expressions—quotations from letters from Pauli to Markus Fierz, Born to Bohr and Albert Einstein to Eduard Study. From a contemporary physicist's point of view, it would seem poor judgment on the part of historians, sociologists, feminist scholars and other nonscientists to use these ruminations and recollections to guide their cultural studies of science.

Beller takes to task physicists who are critical of obscurities in the writings of Jacques Derrida and other deconstructionist and postmodernist scholars but who accept in awe the words of Bohr. She neglects the fact that it was not Bohr's words but rather the precise, quantitative relations he was responsible for introducing that held people in awe, since these explained the mysteries of observed atomic spectra and much else that had baffled physicists for many years.

Finally, Beller scores physicists for having, in effect, "created and sustained the illusion that one needed no technical knowledge of quantum mechanics to fully comprehend its revolutionary epistemological lessons." Creating and sustaining such an illusion is opposite to what physicists do.

It is an amusing but unrealistic suggestion of Beller's that Bohr and other physicists are somehow responsible for much that has gone wrong in contemporary science studies.

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The waves stirred up by Alan Sokal's hoax just won't subside. Now we must contend with Mara Beller, a historian and philosopher of science, who tries to shift the blame for the hogwash enunciated by so-called postmodernist social scientists to physicists themselves. In attempting to make her case, she has assembled an impressive selection of idiosyncratic and overblown statements from the writings of our greatest teachers. Now, it may be permissible to poke fun at the giants of physics—after all, they were also fallible humans. But it is ridiculous to equate their lapses with the sensationalized, generally unspecific pronouncements made by mass-produced social scientists.

It may be appropriate to point, as Beller does, to the overwhelming respect with which most physicists

have pondered the sometimes obscure statements made by their great leaders. As one example, Beller brings up Carl von Weizsäcker's self-tortured puzzling over something Niels Bohr had said to him. But Beller is wrong in implying that von Weizsäcker was engaging in some form of hero worship. Rather, having worked with Bohr for many years and recognizing him, rightly, as one of the greatest, most versatile minds of this century, von Weizsäcker was simply intent on figuring out what Bohr had meant by his last cryptic statement. But let me ask: What greatness has been exhibited or world-shaking discoveries achieved by those postmodernist social scientists who criticize not one or another facet of physics, but its entire structure and the sciences' role in, and relation to, society? *Quod licet Jovi, non licet bovi.*

Beller says that it just may be possible that, under certain circumstances, "we must judge the undertaking of the postmodernist cultural analysts to be respectable, commendable and important, even though we may regret, and perhaps even condemn, the scientific illiteracy of some of them." I ask: If they are scientific illiterates, how can one take their work about science to be "commendable and important"?

Beller errs when she says that "it is not possible to combine the partial pictures [of the particle–wave dualism] into a unified picture." That was successfully achieved some 60 years ago by quantum field theory. And it is also untrue to say that "the 'orthodox' interpretation of quantum physics . . . confidently announced the final overthrow of causality." Similarly, whatever Stanley Aronowitz may have said or thought, Beller is not correct in declaring that "the most honored heroes of 20th-century physics" have "endlessly repeated" assertions about the "final overthrow of determinism."

Finally, I ask: If Beller is permitted to ridicule Bohr and company, why does she condemn those giants of the Copenhagen school who dared to criticize (not "ridicule" as she says) Albert Einstein's conceptualization of classical reality? And why, in quoting at length John Wheeler's struggle for understanding, does Beller settle for ridiculing him rather than trying to disprove his views—if she could?

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Perhaps Mara Beller hasn't fully considered the various aspects of the remarkable individuals who created modern physics. Take Niels Bohr, for example. There's Bohr finding the first solution of the fundamental problems in atomic physics, Bohr inspiring and challenging a whole generation of younger physicists, Bohr the subtle bully who spared no effort to impose his own views and Bohr the legendary hero, now better known from anecdotes than from his works and printed words.

And what about Wolfgang Pauli, reputed to have the sharpest mind, if not always the best judgment, in this century for questions of theoretical physics? Are we not puzzled (or should we laugh?) when he applies Carl Jung's psychology and mysticism to problems in physics?

Unfortunately, some philosophers and historians of science try to understand all the different aspects of certain individuals in terms of some preconceived framework, or they try to see the many contributions of different people working on the same problem as fitting into some consistent structure. Such efforts, though, hardly present a true picture of scientists at work, simply because every scientist is a separate and distinct individual.

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Much hot air has been expended over the Sokal hoax. It is refreshing to see that PHYSICS TODAY has chosen to publish Mara Beller's article. As she so ably points out, a valid case can be made for physics providing the basis for the postmodern world that physicists find so offensive.

In fact, though, physics entered the postmodern world voluntarily, even before it was known as the postmodern world. Beller points out that the roots of postmodernism lie as much with Max Born, Wolfgang Pauli and Niels Bohr as with Jacques Derrida and Michel Foucault. Perhaps we should have paid more attention to Søren Kierkegaard's influence—through his student Harald Høffding—on Bohr. This philosophical relationship gives new meaning to the Copenhagen interpretation of quantum mechanics. Richard Rhodes suggests that Bohr's use of the phrase "point of view" rather than the word "principle" is rooted in "language, that slippery medium in which Bohr saw us inextricably suspended."[1] That makes Bohr sound a little like Derrida, doesn't it? Physicists were postmodern before postmodern was cool.

In the postmodern world of physics, where there is only relative knowledge, we can never understand what anyone else really means. Even Born, Pauli and Bohr apparently understood that. For a long time, we were so busy with their equations that we never bothered to see what the writers meant.

All of our training in modern physics provides each of us only with our own unique understanding of physics, since there is never time for the question, "But what does it mean?" We can write down the equations, but what does the Heisenberg uncertainty principle mean? Just because we choose not to think about it doesn't mean that the philosophers won't. Believe me, they do. I feel certain that more students learn about the Heisenberg uncertainty principle from philosophers than from physicists. And you would be absolutely amazed at what some people think quantum mechanics and relativity are. That's our fault as physicists, though; we have chosen not to teach the theories.

Poking fun at postmodernism, however, will accomplish little other than reinforce the difference between the scientific and nonscientific cultures. After all, the hallmark of postmodernism is relativism.

I feel sure that any hope of reconciliation between the postmodernists and those of us who think that the Enlightenment was a pretty good idea lies in the sense of community. For most of my career, I have associated only with technically minded people. At the campus where I presently teach, the administration has gone out of its way to mix the science faculty and the arts faculty. I now teach the science component of a team-taught History of Thought seminar in our philosophy program. The team includes a philosopher, a mathematician and myself. We are all in the classroom, involved in teaching the course all the time. We find no difficulty in getting students to understand the conceptual foundations of either quantum mechanics or relativity. But then, we work hard at doing so. And I have found that I have more in common with the guy who teaches philosophy than I ever would have suspected. We complement rather than contradict each other. Both the faculty and the administration are committed to this joint science/arts approach, so it works.

What's more, I occasionally actually have to speak to my friendly neighborhood English professor. Interestingly enough, she knows why airplanes fly. I, on the other hand, cannot tell a gerund from a sibilant. Dare I suggest it is we scientists who have become myopic?

Meanwhile, it's worth remembering that our present worldview will be postmodern only until "whatever-comes-next" finally gets here. If his-

tory is any guide, physics and the other sciences will help point the way. Postmodern physics will only be with us until the new physics arrives.

In the interim, I encourage us to think about the unthinkable—and then to teach more than equations. Granted, it takes a lot of work. It's easy to say, "They wouldn't understand," and then blow it off. But, isn't that at least part of how we got into this mess? Presumably, when whatever-comes-next finally gets here, it will give both physics and our society as a whole the answers to our determinism/indeterminism dilemma, as well as give us the understanding to deal with our newfound power over nature and ourselves.

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Mara Beller concludes her article with the suggestion that a public declaration by physicists rejecting the philosophical pronouncements of the Copenhagen orthodoxy "could have diminished greatly the explosive proliferation of the postmodernist academic nonsense. . . ."

Maybe so. But in the US, such a public declaration probably has never been possible. The training of US physicists does not include any serious education in philosophy, with the result that they have effectively abdicated (and continue to abdicate) the philosophical implications of their work to philosophers who are amateurs in physics and to physicists who are amateurs in philosophy. The attitude of most US physicists is quite simply, "The hell with that, I'm going to the laboratory." Maybe they are right. And the attitude of most philosophers is, "The hell with you, I'm going to the library." And maybe they are right too.

This suggests that the solution to the problem of the nonsense of "postmodernist" science is to not leave the domain of the philosophical aspects of physics in the hands of amateurs, but to bring the experts together in a climate of mutual respect in an attempt to forge a consensus. It has been done before, and it should be done again—and as often as possible.

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BELLER REPLIES: Only those who remain silent never utter nonsense: It is this tolerant attitude toward the pronouncements of great physicists outside of their fields of expertise that characterizes Lawrence Lerner's letter, as well as others. Such a charitable approach is asymmetrical, though, for it holds that physicists' speculations should be treated, as Lerner says, "with respect if not with adherence" even when "their aspirations . . . may have overreached their capabilities," while such respect should be withheld from "the likes of Stanley Aronowitz" when their statements exceed their expertise. Such selective charity implies that the value of a statement should be judged not by its content and objective standards of reasoning, but by the reputation of its author—an extremely relativistic stand that not many physicists would accept.

I am not suggesting, as Ted Lawry does, that the opaque speculations of physicists, together with those of postmodernists, should be "relegated to utter obscurity." The existential appeal of complementarity—allowing contradictions to be sustained rather than resolved—has enchanted many physicists, Charles Enz included. Yet complementarity between what Wolfgang Pauli termed the "rational–critical" and the "mystic–irrational" (as cited by Enz), no matter how spiritually inspiring, is a poor guide for dealing with the foundational problems of quantum physics. Pauli's idea that a rational approach must be supplemented by the mystic–irrational supports the antirationalistic tendencies in some postmodernist writings on science.

Nina Byers is mistaken in claiming that what "awed" physicists were not Niels Bohr's words, but the "precise, quantitative relations that he was responsible for introducing." As is clear from Enz's letter, physicists accepted with awe those words of Bohr's that were "beyond one's own capacity of understanding." Precisely such words cannot be formalized; in contrast, mathematical statements are comprehensible to every physicist.

Although there is no disagreement among physicists about the immense solving power of quantum theory, the problem of its interpretation remains controversial. Many physicists approve of Richard Feynman's opinion that "nobody understands" quantum mechanics. David Mermin's recent words echo Feynman's: In quantum physics "the practice is strikingly coherent and unambiguous" but "nobody understands what they are talking about."[1] In such "an exquisite conceptual muddle" (Mermin's phrase), it is tempting to accept Bohr's positivistic dictum that quantum theory is merely a predictive and descriptive calculational tool. Yet many physicists have found such positivistic strictures too confining. Bohr's definition of a physical phenomenon—"No elementary phenomenon is a phenomenon until it is a registered (observed) phenomenon"—is problematic for application to, for example, quantum gravity. It was in this context of the realism/instrumentalism issue applied to cosmology (not out of context, as Enz charges) that I quoted John Wheeler's struggling with Bohr's positivistic guidelines. Wheeler's evident unease is amplified in his conclusion: The fact that one can ask such strange questions demonstrates "how uncertain we are about the deeper foundations of the quantum and its ultimate implications."[2]

In such a situation of interpretive uncertainty, dismissal of other than orthodox options, such as Enz's rejection of the Bohmian alternative, is puzzling. As a historian of science, I have learned how crucial it is to explore competing theoretical options for the advance of knowledge. John Bell, for example, deduced his seminal results by open-mindedly exploring David Bohm's hidden-variables theory.

Bell was bewildered that "people go on producing 'impossibility proofs' " of deterministic quantum description even after the appearance of Bohm's deterministic version.[3] Paul Roman errs in claiming that such is not the case. Statements of the "final" overthrow of determinism are common in the philosophical writings of Bohr, Pauli, Max Born and Werner Heisenberg. What is more, the writers ridiculed those physicists who suggested otherwise. Heisenberg, for example, identified Bohm's arguments for deterministic description with the hope that "$2 \times 2 = 5$, for this would be of great advantage for our finances."[4]

Another "impossibility" claim is that of unifying the wave and particle descriptions (that claim, by the way, is not mine as Roman alleges, but an orthodox one). Roman is right that such unification was achieved by quantum field theory. For that reason, Heisenberg never accepted Bohr's complementarity, his public endorsement of Bohr notwithstanding. Pascual Jordan's three papers on field quantization in 1927–28 (one cowritten with Oskar Klein, one with Pauli, one with Eugene Wigner) demonstrated to Heisenberg that one does not need "both waves and particles," but that one can do it "either way."[5] Yet "impossibility" claims of unified physical description persist, inspiring some postmodernist appraisals of science.

I am not claiming that the philosophical writings of quantum physicists are the only source for postmodernist criticism of science. But they are a source, and a most authoritative one. The impact of the Copenhagen writings on the postmodernist predicament is more profound than was apparent from my PHYSICS TODAY article. The Copenhagen claim of the impossibility of gradual modification of the quantum paradigm inspired the Kuhnian notions of irrational jumps from one paradigm to another, of the impossibility of communication between different conceptual frameworks, of the absence of rational standards for comparison between alternatives and consequently of excessive relativistic claims about science.[6] These notions had a far-reaching impact on the general academic discourse.

The reasons for the emergence and the diffusion of the Copenhagen interpretation are diverse.[7] Bohr's philosophical background is one of them. Through his teacher Harald Høffding, Bohr inherited from Immanuel Kant the idea of deducing "irrefutable" knowledge by philosophical analysis of "conditions of experience." This approach underlies Bohr's simple thought experiments, which, avoiding mathematics, supposedly necessitate quantum uncertainty and complementarity. Byers is right that physicists are unlikely candidates to spread the illusion of the dispensability of mathematics, yet by endorsing such misleading explanations (that are, in Byers's words, "less difficult to nonphysicists"), they unintentionally do so. Rather, the patient teaching of the theories themselves, as done by Scott Keyes and his colleagues, can diminish scientific illiteracy and prevent gross misunderstandings of science.

It should be clear by now that in my article I did not intend to ridicule anyone. My point was rather that unleashing arrows of satire is an uncontrollable experiment, in which one cannot ensure where such arrows may ultimately land. Ironically, Alan Sokal chose to make his plea for a return to reason not by using rational argument, but by other means.

A return to the Enlightenment idea of rationality is as desirable as a return to classical physics. The notion of binding universal reason is too impoverished to take into account the sociohistorical context of science and individual scientific creativity. As Martin Gutzwiller writes, every scientist at work is a "distinct individual." How can we explain that many scientific results can be both strikingly imaginative and amazingly well-grounded? Such an explanation cannot be obtained by using empty slogans and hostile accusations.

Perhaps we should follow Dan Agin's advice "to bring the experts together in a climate of mutual respect."

Perhaps we also should invite each other to dinner, as was suggested by Robert Oppenheimer when he similarly faced excesses of antirationalism and a gap between two cultures: "We can have each other to dinner. We ourselves, and with each other by our converse, can create . . . [an] intricate network of intimacy, illumination and understanding."[8]

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Hooray for 1998 Nobel in Physics, but What about Fowler *et al.*?

I was pleased to see that in 1998 a second Nobel Prize was awarded for work on the quantum Hall effect. This one, for work on the fractional quantum Hall effect, may be of more fundamental interest than the one awarded to Klaus von Klitzing in 1985.

Nevertheless, I feel that the Nobel committee is perpetuating an oversight by continuing to neglect the most fundamental and far-reaching work in the field—namely, the experimental demonstration of the existence of the two-dimensional electron gas by Alan Fowler, Frank Fang, Webster Howard and Phil Stiles in 1966.[1] Their work, which had a profound effect on the direction of semiconductor research, is the basis for both the 1985 and 1998 awards. The Nobel committee acknowledged that in 1985, but did not even bother to do so in 1998. In addition, the pioneering work done by Fowler and colleagues has also been the basis for several successful semiconductor devices. Just how long must they wait for the recognition they deserve?

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Abbot, with Physics Career of 8 Decades, Passes Bethe Test

In his letter to the editor (PHYSICS TODAY, September 1998, page 15), Reuben Rudman essentially proposes an honor roll of professional longevity, noting that Paul P. Ewald's 70-plus years of activity were a match for those of his son-in-law Hans Bethe. However, surely their place on the roll is below that of Charles Greeley Abbot, who studied solar radiation from the time he reached the Smithsonian Institution in 1895 until shortly before his death in December 1973 at the age of 101, and who—according to his PHYSICS TODAY obituary (May 1974, page 65)—spoke at the opening of a symposium the month before he died.

Abbot was scientifically active through seven sunspot cycles, and I remember hearing that a Fourier transform of the number of his papers showed a peak with that 11-year period. His long-term scientific results about solar variations were controversial, though, and have since been reevaluated in the context of modern results by Peter V. Foukal, David H. DeVorkin and others.[1] And the link between solar radiation and terrestrial weather that Abbot reported is not currently believed.

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Correction

August 1998, page 49—In the pie chart on the cumulative costs of the US nuclear arsenal, the slice labeled "other outlays" should have been 0.11%, not 1.1%. ■