TO WRITE OR NOT TO WRITE MORE CLEARLY THAN ONE THINKS

The Philosophical Writings of Niels Bohr

Niels Bohr
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Reviewed by N. David Mermin

Once I tried to teach some quantum mechanics to a class of law students, philosophers and art historians. As an advertisement for the course I put together the most sensational quotations I could collect. Heisenberg was a goldmine: "The concept of the objective reality of the elementary particles has thus evaporated." "The idea of an objective real world whose smallest parts exist objectively in the same sense as stones or trees exist, independently of whether or not we observe them . . . is impossible." Feynman did his part too: "I think I can safely say that nobody understands quantum mechanics." But I failed to turn up anything comparable in the writings of Bohr. Others attributed spectacular remarks to him, but he seemed to take pains to avoid any hint of the dramatic in his own writings. You don't pack them into your classroom with "The indivisibility of quantum phenomena finds its consequent expression in the circumstance that every definable subdivision would require a change of the experimental arrangement with the appearance of new individual phenomena" or "The wider frame of complementarity directly expresses our position as regards the account of fundamental properties of matter presupposed in classical physical description but outside its scope."

I was therefore on the lookout for nuggets when I sat down to review these three volumes—a reissue of Bohr's collected essays on the revolutionary epistemological character of the quantum theory and on the implications of that revolution for other areas of endeavor, both scientific and nonscientific. (The originals appeared in 1934, 1958 and 1963.) But the most radical statement I could find in all three books was this: "Physics is to be regarded not so much as the study of something *a priori* given, but rather as the development of methods for ordering and surveying human experience." No nuggets for the nonscientist.

Going to the other extreme, what have these volumes to say to today's professional practitioners of quantum mechanics, who grew up in physics several generations after the revolution, drinking the strange elixir like mother's milk? We know what goes through the two slits: The wavefunction goes through, and subsequently an electron condenses out of its nebulosity onto the screen behind. Nothing to it. Is the wavefunction in itself then something real? Of course, because it's sensitive to the presence of both slits. Well then, what about radioactive decay: Does every unstable nucleus have a bit of wavefunction slowly oozing out of it? No, of course not. We're not supposed to take the wavefunction that literally; it just encapsulates what we know about the alpha particle. So then it's what we know about the electron that goes through the two slits? Enough of this idle talk; back to serious things!

These volumes offer little obvious guidance to the modern thinker of such thoughts. Questions like this are not suggested by anything in these pages, whose explicit style and implicit theme is to be extremely circumspect in all utterances, making no commitments and contemplating no puzzles unless they can meaningfully be stated in terms narrow enough to avoid commitment or squeeze out puzzlement. Thinking back to a 1937 conversation with Einstein, Bohr remarks, "I was strongly reminded of the importance of utmost caution in all questions of terminology and dialectics." Indeed, he even goes on to warn "against phrases, often found in the physical literature, such as 'disturbing of phenomena by observation' or 'creating physical attributes to atomic objects by measurements,' " which are "apt to cause confusion since words like 'phenomena' and 'observations' just as 'attributes' and 'measurements' are used in a way hardly compatible with common language and practical definition."

These are extremely cautious essays. After reading into the third volume one wants to shake the author vigorously and demand that he explain himself further or at least try harder to paraphrase some of his earlier formulations. But they come out virtually the same, decade after decade. There are, to be sure, small changes. The earlier writings regularly mention (as late as 1927) "the feature of irrationality characterizing the quantum postulate"; later on, reference to the irrational disappears.

Here is an example of the kind of disappointment I experienced reading these volumes. Typical quantum effects, Bohr notes, resist pictorial representations. Nor should this surprise us, since our ability to construct such representations or explanations in ordinary language was entirely developed in the course of coping with classical phenomena. Bohr repeatedly insists that we must therefore be content with a purely symbolic mathematical algorithm that connects one classically specified set of conditions to another. This formalism offers no explanation in the customary sense, but by embracing all possible experimental arrangements it demonstrates the logical consistency of the

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entire scheme, which is all we can demand of it. But I can't help wondering: Since mathematics was entirely developed in the course of coping with classical phenomena, is it not astonishing that it should contain precisely the conceptual tools to bridge this unpicturable, unspeakable abyss? Apparently not. In any event the question never arises in these pages.

A friend, who has thought more about these things than I have, remarked to me that if anybody other than Bohr had written essays like these nobody would take them seriously. Just what is the man getting at? The major recurrent theme is that complementarity is to be found all about us. Position vs momentum (or the space–time vs the causal description) are joined by justice vs charity, contemplation vs volition, thoughts vs sentiments, and (perhaps) even humor vs seriousness. What is common to all these dichotomies is never made explicit, but I think the lesson Bohr wants us to learn is that we should always be wary of seeking a unified description of phenomena that are manifested only under mutually exclusive conditions (except, perhaps, in the form of a symbolic mathematical algorithm?). The answer to those really hard questions is that they should not be asked—what Einstein called "the Bohr–Heisenberg tranquilizing philosophy."

But against the sometimes maddening frustration brought about by a study of these ponderous essays is the indisputable fact that nobody has succeeded in saying anything manifestly better in the 60 years since Bohr started talking about complementarity. How he could have known that such attempts would fail, right from the start, is yet another puzzle. As a philosopher Bohr was either one of the great visionary figures of all time or merely the only person courageous enough to confront head on, whether or not successfully, the most imponderable mystery we have yet unearthed.

"What Do *You* Care What Other People Think?": Further Adventures of a Curious Character

Richard P. Feynman
(as told to Ralph Leighton)
Norton, New York, 1988.
255 pp. $17.95 hc
ISBN 0-393-02659-0

"What Do You *Care What Other People Think?"* by Richard Feynman (as told to Ralph Leighton) consists of two parts. The first is a set of reminiscences of some of Feynman's interesting adventures not recounted in his earlier book *"Surely You're Joking, Mr. Feynman!" Adventures of a Curious Character* (Norton, New York, 1985; reviewed in PHYSICS TODAY, September 1986, page 61). The second and longer section is his detailed account of his experiences as a member of the Presidential commission investigating the January 1986 explosion of the space shuttle Challenger. [This account is more detailed than Feynman's speech to the Caltech Management Club, an edited version of which appeared as an article in PHYSICS TODAY, February 1988, page 26.]

Following Feynman's death last year, Hans Bethe described him as "the most original physicist" since World War II—and it is sheer pleasure to meet his relentessly probing, sensitive mind in this small volume. Whether Feynman is describing his early introduction to science under his father's tutelage, his close and sensitive relationship with his first wife before and during their tragically brief marriage, or his travels, the reader encounters the same fascinating qualities in these reminiscences that so deeply inspired Feynman's physics colleagues for 40 years and that now have transformed him into an uncommonly worthy cult figure for a larger audience.

The story of how the young Feynman first learned science—and how his father introduced him to its wonders—should be read by everyone who practices, or aspires to, a career in science teaching. The brief ten-page essay, entitled "The Making of a Scientist," is a useful antidote to the "fact stuffing" approach that has contributed to making science teaching such a disaster area in the American school system. (Of course, raising the salaries and improving the status of public school teachers would also help a lot.)

Feynman showed the nation how science is actually done in his famous demonstration, as a member of the shuttle commission, of the loss of resiliency of the solid booster rockets' O-rings when he dipped a ring segment in ice-cold water. Although the commission's work is now well reported, this book gives a more detailed account of Feynman's encounters with bureaucracy in his self-proclaimed role as a "bull in the china shop." It also includes his controversial personal appendix to the report on shuttle reliability, with its important concluding sentence: "For a