



## What's Wrong With This Quantum World?

N. David Mermin

If you ask Google to search for “no quantum world,” you will get nearly 300 hits. They all give the following quotation (or recognizable corruptions of it):

There is no quantum world. There is only an abstract quantum physical description. It is wrong to think that the task of physics is to find out how nature is. Physics concerns what we can say about nature.

Over 90% of them attribute the statement to Niels Bohr, with phrases like “Bohr’s dictum . . . ,” “Bohr insisted that . . . ,” “Bohr proclaimed . . . ,” “Niels Bohr said, in a frequently quoted passage . . . ,” “Niels Bohr wrote [my emphasis] . . . ,” and even “Explain and evaluate Bohr’s philosophy of quantum theory with reference to his assertion . . . .”

Here is yet another example of the power of the internet to enrich our knowledge. There is only one problem. Bohr, who took writing very seriously indeed, never published such an assertion in any of his writings, although he repeatedly refined, reformulated, and often simply repeated his position on the philosophical foundations of the quantum theory.

The statement actually comes from an essay by Aage Petersen, “The Philosophy of Niels Bohr,”<sup>1</sup> which he published in the *Bulletin of the Atomic Scientists* shortly after Bohr’s death. Petersen introduced the words with

When asked whether the algorithm of quantum mechanics could be considered as somehow mirroring an underlying quantum world, Bohr would answer . . .

So what may now be the most celebrated of all Bohr quotations on the nature of the quantum theory is at best an attempt by a close associate to

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characterize Bohr’s general response to the highly problematic notion of a “quantum world,” written too late for Bohr to respond.

When you ask Google to list only those pages that also mention the actual author of the words, Petersen, the number of hits drops from 286 to 18. The status of this “quotation” as hearsay is in danger of being lost.

I’m particularly sensitive to this risk because in the 1980s I used to enjoy giving physics colloquia on Bell’s theorem and its implications for our understanding of quantum mechanics. I was always fond of Petersen’s recollection of what Bohr used to say, and I felt that his formulation captured something important about the situation revealed by Bell’s theorem. So I would read it aloud in those talks, always emphasizing that it was Petersen reminiscing, and not from anything Bohr himself had actually written.

That worked quite well until the day in 1982 when I gave the physics colloquium at MIT. To my great pleasure, Victor Weisskopf was sitting in his usual place in the front row, smiling approvingly up at me. (It’s surprising how much such encouragement from such a source can improve the quality of a talk.) His smiles continued right up to the moment when I read the Petersen quotation. No sooner had I finished reading it than Viki was on his feet. The smile was now a frown. “That’s outrageous,” he proclaimed, “Bohr couldn’t possibly have said anything like that!” Somewhat taken aback by this sudden flip from approbation to condemnation, I feebly protested that I wasn’t attributing it to Bohr, merely to Aage Petersen’s memory of Bohr. That did not extinguish the flames. “Shame on Aage Petersen,” declared Viki, “for putting those ridiculous words in Bohr’s mouth!”

(I must emphasize that although I have used quotation marks, as the rules of punctuation require, my Weisskopf “quotations” are based only on my unreliable memory of what Viki actually said 20 years ago. They are crude reconstructions that I hope capture the spirit of his remarks. If you

like to collect Weisskopf quotations, please do not add these to your list.)

I have been a big fan of Weisskopf ever since, as a graduate student at Harvard in the late 1950s, I would watch him arrive at Harvard physics colloquia with the MIT contingent; he always made a point during the lecture of asking “dumb” questions. The purpose of the questions, as far as I could tell, was to help the students in the audience understand what was going on. His junior colleagues at MIT would invariably rush to provide patronizing answers, but that never bothered him or deterred him from the practice.

Since Weisskopf had spent considerable time with Bohr in the early days of quantum mechanics, I took his strong reaction quite seriously and dropped the Petersen quote from subsequent versions of my lecture. I did, however, comb the writings of Bohr to see if I could find anything that seemed to express a similar sentiment.

Was Bohr ever willing to publish anything like what Petersen said he used to say? The closest I can find to the Petersen pseudo-quotation is this:

Indeed from our present standpoint, physics is to be regarded not so much as the study of something a priori given, but as the development of methods for ordering and surveying human experience.<sup>2</sup>

If you take “something a priori given” to be a quantum world, and you take “methods for ordering and surveying human experience” to be what we can say about nature, then there it is!

Is this correspondence far-fetched? I don’t think so. Something a priori given that might have been regarded as the object of study of physics before we arrived at quantum mechanics (“our present standpoint”) sounds to me like the external world. And is not the “ordering and surveying [of] human experience” just an elaboration of “what we can say about nature”? After all, nature only impinges on us through our experience. And to speak about something, we must order and survey what we know about it.

If that doesn't persuade you, try this:

In our description of nature the purpose is not to disclose the real essence of the phenomena but only to track down, so far as it is possible, relations between the manifold aspects of our experience.<sup>3</sup>

If you read this as suggesting that there is a "real essence of the phenomena" that it is not our purpose to describe, then Bohr is saying something quite different from "there is no quantum world." But I would be surprised if he believed in real essences while acknowledging that our description of nature could not disclose them. When he says that physics ("our description of nature") is not about real essences of phenomena, he is saying that quantum mechanics does not mirror an underlying quantum world. And since we have no access to nature except through our experience, what we can say about nature can only consist of an enumeration of the relations between the manifold aspects of that experience.

I doubt that this reading of Bohr will elicit unanimous agreement. But consider this: Half a dozen years after the MIT colloquium, during which I had learned to live with such pale reflections of "there is no quantum world," I was visiting my former postdoctoral adviser, Rudolph Peierls, in Oxford. (I was at his wonderful department in Birmingham for two years in the early 1960s.) Like Weisskopf, Rudi Peierls had also spent time on Blegdamsvej in Copenhagen during the early days of quantum mechanics, and I was curious to get his take on Viki's outburst. So I started telling Peierls the story of my MIT colloquium. I began by reminding him that shortly after Bohr died Aage Petersen had written about his philosophical views in the *Bulletin of the Atomic Scientists* and had attributed to Bohr a certain point of view. More precisely, Petersen had said that Bohr liked to say, "There is no quantum world . . . ."

When I got to the end of the Petersen quotation, before I could begin to say anything about Viki's reaction at MIT, Rudi beamed at me. "Yes," he said happily, "that's exactly the kind of thing Bohr loved to say!" He did not back down one inch when I reported how Viki had reacted to the same words. He just raised his eyebrows and shrugged his shoulders.

(Once again quotation marks are dictated by the rules of grammar, and their contents are to be viewed in full awareness of the frailty of memory.

But I will vouch for the sign of Peierls' response to Petersen's pseudo-quotation: it was distinctly positive.)

So I started using the Petersen pseudo-quote in talks again, always attributing it to the correct source. And I mused on how two of the physicists I admired the most, both well acquainted with Bohr, could have had such diametrically opposite impressions of what Bohr did or did not like to say.

Unfortunately I was never able to get back to Weisskopf with Peierls' reaction to "there is no quantum world. There is only an abstract quantum physical description." But I did conclude that there is no Copenhagen interpretation of quantum mechanics. There is only a range of quantum physical positions. Some are held by Weisskopf's Bohr and some by Peierls' Bohr. There are even positions held by my own Bohr, who, unlike the other two Bohrs, is not constrained by my ever having actually met the man, except for a remote sighting in 1957 from the back row of an enormous auditorium where he spoke for an hour, inaudibly. My Bohr is rather similar to, but considerably more cautious than, Petersen's Bohr. My Bohr would also attach more weight to the word *relations* in reference 3 than I suspect the Bohrs of Petersen, Weisskopf, or Peierls would do.

Setting aside such subtleties, I hope that this column will serve to restore the unfortunately vanishing distinction between Petersen's Bohr and what we might, for clarity, be better off calling Bohr's Bohr.

## References

1. A. Petersen, *Bull. At. Sci.* **19**, 8 (1963).
2. N. Bohr, *Essays 1958-1962 on Atomic Physics and Human Knowledge*, Ox Bow Press, Woodbridge, CT (1987), p. 10.
3. N. Bohr, *Atomic Theory and the Description of Nature: Four Essays With an Introductory Survey*, Macmillan, New York and Cambridge U. Press, London (1934), p. 18. Reprinted in *Niels Bohr, Collected Works*, vol. 6, J. Kalckar (ed.), North Holland, Amsterdam (1985), p. 296. ■

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