ONTOLOGICAL PROBLEM OF QUANTUM MECHANICS

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Abstract: The article provides analysis of the main features of “Copenhagen interpretation” of quantum mechanics and illustration of paradoxes in terms of ontological theory.

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Quantum mechanics, to put it gently, is not the most philosophically lucid theory in physics. Its conventional interpretations include fantastic claims that strike at the realist and empiricist underpinnings of modern science. Among these claims are the principle of “superposition,” where an object can be in an existentially indeterminate physical state, or simultaneously in contrary physical states; “wave-particle duality,” where fundamental particles are thought to become wave-like in between observations; and a more general “observation problem,” where the mere act of observing a quantum system necessarily alters it. These are just a few of the bizarre paradoxes of quantum mechanics. More troubling than their presence, perhaps, is the fact that most physicists do not perceive these paradoxes as problematic. If quantum mechanics contradicts Aristotelian logic and philosophical realism, so much the worse for logic and philosophy. Quantum mechanics has been empirically verified, we are told, so we must boldly embrace what is counterintuitive.

What is really going on in nature when we are not looking? To suppose that such a question has a definite answer entails a belief in objective reality, that is, a reality outside of the thinking, perceiving subject. If we ask in what sense anything may exist or be when we are not looking, we are making an ontological inquiry, for we are not considering the attributes of this or that entity, but of the act or reality of being as such. When we ask broad questions about the reality of wavefunctions, which characterize every type of physical entity, we are really asking questions of ontology (Herbert, 1985).

The most widely taught approach to interpreting quantum mechanics is the so-called “Copenhagen interpretation,” which is actually a collection of varying, even contradictory, opinions proffered by Niels Bohr and Werner Heisenberg, among others. Common features of this interpretive approach include: (1) the wavefunction as a probabilistic description of phenomena; (2) Bohr’s “complementarity principle,” where matter exists simultaneously and contradictorily as a wave and a particle; (3) the impossibility of knowing non-commuting properties at the same time, per the Heisenberg uncertainty principle; (4) the principle of superposition, where matter may exist simultaneously in two contrary well-defined states; (5) the “collapse of the wavefunction” and various paradoxes where reality is altered by the act of observation.

Note that there is a great amount of tension among these principles. First and foremost, there is inconsistency about the reality of the wavefunction. If it is a measure of purely subjective probability, it makes no sense to appeal to it as physically real, as principles 2, 4, and 5 seem to do. If it measures an “objective” probability (assuming such a concept can be made cogent), then it makes little sense to invoke the role of the subjective observer as altering reality, since we are not dealing with subjective probabilities. Second, if “superposition” states are treated as objective realities per principle 4, then there is no reason to insist that matter is always particle-like, as the complementarity principle seems to imply. If the wavefunction is not a physical object, there is little reason to insist per the complementarity principle that matter is always wave-like. There are additional internal tensions beneath the surface, which can be seen only be examining the physico-mathematical theory in some detail, as we shall do later.

The Copenhagen interpretation is a muddled, barely coherent, quasi-subjectivist morass of metaphysical propositions. It simultaneously pretends to have nothing to do with philosophy and posits an ontological theory, a poor one at that. We can hardly expect better when an ad hoc philosophy is constructed by physicists without reference to any technically rigorous metaphysics. Bohr sought to preserve the theoretical independence of physics from philosophy by denying that we can know anything beyond experimental results, but this came at the expense of reducing physical theories and concepts to useful fictions for describing the behavior of real entities. Ultimately, all we definitely know from quantum mechanics is that its mathematics predicts the statistical outcomes of experiments. It teaches us nothing certain about what is really happening at the subatomic level in between measurements, or even if such a question has a definite answer (Антипенко, 1973).

Many physicists, in their disdain for philosophical constraints, try to have things both ways. Pointed philosophical questions about wave-particle duality or the objective reality of unobserved events are routinely dismissed as meaningless, unverifiable speculation. Yet in the next breath, a physicist may interpret the mathematical formalism of quantum mechanics to provide dubious answers to these supposedly meaningless questions. Emancipation from metaphysics has allowed physicists to assert logically incoherent theories as though they were profound, oscillating inconsistently between subjectivist and realist interpretations. Some have even claimed that quantum mechanics disproves the principle of non-contradiction! If abstract philosophical logic contradicts quantum mechanics, this only proves the limitations of standard logic, in the eyes of those convinced of the explanatory completeness of this physico-mathematical theory (Эйнштейн, 1966).

The inability or unwillingness of many physicists to see a viable alternative to the Copenhagen style of interpretation results from lack of exposure to any technically sophisticated metaphysics of being. Most scientists, like people in general, hold a commonsensical binary notion of existence and a mechanistic notion of causality, both of which break down under quantum mechanics. A technically sound philosopher, however, is aware of multiple modes of being (e.g., potency and act, possibility and necessity, esse and essentia), which may resolve quantum paradoxes without logical absurdity. Heisenberg, to his credit, attempted to explain quantum mechanical states as neo-Aristotelian potentia, but this aspect of his opinions never became part of the accepted consensus. The philosopher Karl Popper adopted a vaguely similar theory of “propensity,” based on his discussions with Einstein, but the cultural disconnect between philosophy and physics prevented his work from having much impact on the latter.

As a rule, physicists will listen only to other physicists about physics, so the only alternative ontological interpretations that have enjoyed some limited success in recent years have come from physicists. A notably distinct interpretation was that of David Bohm (1917-92), who argued that the wavefunction is physically real. A more recent fashionable theory considers the time-reversed “advanced wavefunction” as ontologically co-equal with the standard “retarded wavefunction.” These alternative explanations have many merits, yet their vision is limited by the philosophical insularity of the physicists who formulated them. To reopen the dialogue between philosophy and physics, we must lay bare the underlying absurdities and misconceptions of Copenhagen-style theorizing, and then show how philosophically cogent thinking may provide a remedy.

References:

1. Herbert N. Quantum Reality (Beyond the New Physics). London et al., 1985. – 113 с.
2. Антипенко Л.Г. Проблема физической реальности. М. Наука. 1973. – 167 с.
3. Эйнштейн А., Подольский Б., Розен Н. Можно ли считать квантовомеханическое описание физической реальности полным? // Альберт Эйнштейн. Собр. науч. трудов, т. III, М.: Наука, 1966. – 4 с.

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