

Why were two theories (Matrix Mechanics and Wave Mechanics) deemed logically distinct, and yet equivalent, in Quantum Mechanics?

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Abstract

A recent rethinking of the early history of Quantum Mechanics deemed the late 1920s agreement on the equivalence of Matrix Mechanics and Wave Mechanics, prompted by Schrödinger's 1926 proof, a myth. Schrödinger supposedly failed to achieve the goal of proving isomorphism of the mathematical structures of the two theories, while only later developments in the early 1930s, especially the work of mathematician John von Neumann (1932) provided sound proof of equivalence. The alleged agreement about the Copenhagen Interpretation, predicated to a large extent on this equivalence, was deemed a myth as well. If such analysis is correct, it provides considerable evidence that, in its critical moments, the foundations of scientific practice might not live up to the minimal standards of rigor, as such standards are established in the practice of logic, mathematics, and mathematical physics, thereby prompting one to question the rationality of the practice of physics.

In response, I argue that Schrödinger's proof concerned primarily a domain-specific ontological equivalence, rather than the isomorphism. It stemmed initially from the agreement of the eigenvalues of Wave Mechanics and energy-states of Bohr's Model that was discovered and published by Schrödinger in his First and Second Communications of 1926. Schrödinger demonstrated in this proof that the laws of motion arrived at by the method of Matrix Mechanics could be derived successfully from eigenfunctions as well (while he only outlined the reversed derivation of eigenfunctions from Matrix Mechanics, which was necessary for the proof of isomorphism of the two theories). This result was intended to demonstrate the domain-specific ontological equivalence of Matrix Mechanics and Wave Mechanics, with respect to the domain of Bohr's atom. And although the full-fledged mathematico-logical equivalence of the theories did not seem out of the reach of existing theories and methods, Schrödinger never intended to fully explore such a possibility in his proof paper. In a further development of Quantum Mechanics, Bohr's complementarity and Copenhagen Interpretation captured a more substantial convergence of the subsequently revised (in light of the experimental results) Wave and Matrix Mechanics.

I argue that both the equivalence and Copenhagen Interpretation can be deemed myths if one predicates the philosophical and historical analysis on a narrow model of physical theory which disregards its historical context, and focuses exclusively on its formal aspects and the exploration of the logical models supposedly implicit in it.

Keywords: Quantum Mechanics; Matrix Mechanics; Wave Mechanics; Equivalence; isomorphism; Bohr's atom;

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