THE EVERETT INTERPRETATION OF QUANTUM MECHANICS

by

Neill Graham

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Approved by:

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Adviser

1. THE BORN INTERPRETATION

The Born interpretation -- the postulate that the absolute square of the wave function should be interpreted as a probability density -- was developed by Born in (1.1), (1.2), and (1.3). These papers are included in (1.5), a volume of reprints of Born's papers on the probability interpretation. Additional discussion by Born of his interpretation of the wave function can be found in (1.4) and (1.6).

The probability interpretation seems to have been accepted as an independent postulate of quantum mechanics from the start, and for many years no attempts were made to derive it from the other assumptions of an unmodified quantum theory. (Some attempts to explain the probability interpretation were made by the hidden variable advocates, but only in the context of some modified form of quantum mechanics). The first step toward a derivation was taken by Everett (1.7) in 1957. Although Everett's derivation is not entirely satisfying -- it involves a measure whose physical significance is obscure -- the mathematical approach suggested by Everett is the basis for later work on the subject.

The first completely satisfactory derivation of the Born interpretation was given by Hartle in (1.9). A quite similar derivation was arrived at independently by the present author; its first publication is in this thesis. Both of these treat probability, or relative frequency, as an observable and define a corresponding Hermitean operator, whose properties are then investigated.

2. THE COPENHAGEN INTERPRETATION

The fundamental works on the Copenhagen interpretation are clearly those of Bohr, (2.1) - (2.7), and of Heisenberg, (2.12) - (2.16). Bohr himself felt that his clearest discussion of the principles of quantum mechanics is the first paper of (2.7). We agree.

Of the many critics of the Copenhagen interpretation, three of these were themselves founders of the quantum theory: de Broglie, Einstein and Schrödinger. De Broglie's efforts have largely been directed to finding alternatives to the orthodox theory; his works, (5-20) - (5.36), are listed under hidden variables. Einstein and Schrödinger both criticized the Copenhagen interpretation extensively; their criticisms were often in the form of ingenious paradoxes. See (2.6), (2.33), (11.5), and (11.6) for Einstein and (2.30 - (2.33; (2.33) and (11.16) - (11.18) for Schrödinger.

In recent years Rosenfeld has acted as the defender of the faith; his spirited attacks on the heretics can be found in (2.25 - (2.29).

Two of the clearest and most reasonable defenses of the Copenhagen interpretation have been given by Hanson in (2.10) and (2.11).

Some philosophical aspects of the Copenhagen interpretation are discussed by Hall (2.9) and Aage Peterson (2.25). An excellent historical discussion of the early days of the quantum theory has been given by Jammer in (2.19).

10. VON NEUMANN THEORY OF MEASUREMENT

In his famous book (10.8) on the foundations of quantum mechanics, von Neumann presented a theory of measurement in which the change state of a system during the measurement process is described by a projection operator, while its change in state when undisturbed is described by a unitary transformation. Von Neumann also introduced the density matrix, which allows quantum probabilities and ordinary statistical probabilities to be treated on the same footing. The book also contains von Neumann's well known anti-hidden-variable proof.

Several papers have been published explaining the von Neumann theory of measurement that are easier reading than (10.8). A rather complete discussion of the entire theory is given by Band, (10.1) and (10.2), and a simplified presentation of the hidden variable proof is given by Albertson (9.6).

Komar (10.5) shows that a measurement process that changes every state into an eigenstate of the observable being measured is not possible if both system and apparatus are described by the Schrödinger equation. A similar result has been given by Wigner (9.53). These results constitute the principle objection to the von Neumann theory of measurement.

12. PHILOSOPHY

This section includes papers concerned with the philosophy of quantum mechanics as well as some giving a general treatment of interpretations of quantum mechanics.

Bunge (12.7) has given an excellent survey of the various interpretations quantum theory. In (12.9), he gives the best discussion of physical axiomatics that we have seen. His attacks on formalism and operationalism are of particular interest. An axiomatization of quantum mechanics consistent with the principles advocated in (12.9) is given in (12.8).

An interesting discussion of the philosophy of the Copenhagen interpretation is given by Hall (2.9). In this connection, see also Peterson (2.25).

Margenau has given careful discussions of various aspects of quantum mechanics in a number of places. See (12.21) - (12.25).

For a critique of a number of interpretations of quantum mechanics, including the Everett interpretation, see Shimony (12.30).

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