The Physics and the Philosophy of the Foundations of Quantum Theory

The Interpretation of Quantum Mechanics

Roland Omnès
Princeton U. P., Princeton, N. J., 1994. 550 pp. $39.50 pb ISBN 0-691-03669-1

Reviewed by Richard Scalettar

Roland Omnès, of the University of Paris, has devoted the last seven years to a formulation of the consistent histories picture of quantum theory, culminating in the present important 550-page monograph. *The Interpretation of Quantum Mechanics* is the first quasi-pedagogical presentation of this subject. It is well written and may usefully serve as a supplement to a standard quantum mechanics text or as the basis for an independent course on the foundations of quantum theory. In the words of Christopher Isham: "Most workers in the field agree that, at the very least, the idea of consistent histories provides valuable insight into the relation between classical and quantum physics."

The starting point for consistent histories methodology is the assignment of a probability to a history (a temporal sequence) of events, specified by von Neumann propositions and their associated projectors. The mathematical form for this probability is exactly that of the Wigner formula. There is, however, an important mathematical and physical distinction: The formula presented by Robert Griffiths in his seminal 1984 paper in the Journal of Statistical Physics, **36**, 219 (1984) applies to closed physical systems (the entire universe!), not to the observed system as in the case of the Wigner formula. Correspondingly, the Hamiltonian, which governs the time evolution of the projectors, is that of the closed system, and no reference is initially made to measurement *per se*.

Now consider a family of histories for the closed system under study. The probability assignment for each history, itself considered an event in the sample space, is required to satisfy the conventional Kolmogorov axioms of probability theory; this leads to a set of consistency conditions, first discovered by Griffiths. Meaningful probabilistic assertions are then restricted, by fiat, to a consistent family of histories. For a given closed system, there are many such consistent families, some of which are, however, incompatible with one another. In this way, Bohrian complementarity is manifested in the consistent histories picture.

A beautiful formal accomplishment of the Omnès treatment is the proof that the satisfaction of the probability consistency conditions entails the applicability of the rules of conventional Boolean logic. A family of consistent histories may thus be thought of as a quantum logic with a universe of discourse whose events are the

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Veiled Reality: An Analysis of Present-Day Quantum Mechanical Concepts

Bernard d'Espagnat
Addison-Wesley, Reading, Mass. 1995. 474 pp. $65.75 hc ISBN 0-201-56988-4

Reviewed by Richard Scalettar

Bernard d'Espagnat has had a long and distinguished career in physics. He has served as director of the Laboratoire de Physique Théorique et Particules Elémentaires in Orsay, France, and is presently an emeritus professor of physics at the University of Paris.

The primary stated purpose of *Veiled Reality* is to make accessible to students of philosophy a precise mathematical formulation of fundamental interpretative problems of quantum theory. However, this work will prove to be very useful to students of physics as well; its central portion is a clear and unique analysis of the standard formulation of quantum mechanics, its interpretational difficulties and the many reformulations that have been proposed for resolving these problems.

It is, perhaps, appropriate to remark, for those who may be put off by philosophical considerations, that many distinguished physicists, past and present, have devoted much effort to obtaining an understanding of the relation between physics and reality. Moreover, as d'Espagnat makes abundantly clear, philosophical assumptions implicitly underlie many of our basic considerations and influence our conclusions, as is illustrated, for example, by his discussion of ontological approaches to quantum theory.

On purely philosophical grounds, d'Espagnat argues that independent reality—that is, reality independent of human observers—does indeed exist. However, in deference to the work-a-day world of the ordinary physicist, he places primary emphasis on empirical reality, the domain of observable phenomena, which are the building blocks of all scientific investigations. Finally, he argues that, while empirical reality provides some indirect insight into the nature of independent reality, a complete picture of the latter is "veiled" from our view and probably always will remain so.

This review will focus on the concept of empirical reality, which is of primary importance for the operationally minded physicist. The analysis presented by d'Espagnat in the final chapters of his work owes a considerable debt to the interpretation of Roland Omnès (see the accompanying review of Omnès's *The Interpretation of Quantum Mechanics*). Omnès argues that in most circumstances, decoherence causes the collective properties of macroscopic objects to obey the laws of classical mechanics. These properties are designated as "facts" by Omnès and are by definition regarded as true. They are, in excellent approximation, compatible with one another and hence may be included in consistent logics, which are designated as "sensible logics." Other properties (in particular those of microscopic systems) that