tics, nuclear interactions, and nuclear forces, respectively. The fairly high level of these problems, however, may prove difficult for the average undergraduate. Krane's textbook, for example, contains problems of more varied levels of difficulty.

One of my favorite features in both Heyde editions is what the author calls "boxes," short sidebars that expand upon particular subjects in the text or connect the material in a given chapter with recent related advances. The lively and timely information highlighted in the boxes conveys to the reader excitement at what is currently happening in nuclear physics.

Heyde, a highly respected nuclear structure theorist with a worldwide reputation, has written several textbooks, all of which present the relevant course material in a straightforward style. The present book is no exception and will make a suitable text for a one-semester nuclear physics course at the advanced undergraduate or graduate level. It will need to be supplemented, however, with another textbook or additional material to cover nuclear reactions—both theory and experiment—in more detail. I liked the first edition and used it as a supplemental textbook in my graduate course on nuclear physics. I am currently utilizing the second edition in a similar manner.

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Understanding Quantum Mechanics

Roland Omnès
Princeton U. P., Princeton, N.J., 1999. 307 pp. $35.00 hc ISBN 0-691-00435-8

Quantum Philosophy: Understanding and Interpreting Contemporary Science

Roland Omnès
Translated by Arturo Sangalli
Princeton U. P., Princeton, N.J., 1999. 296 pp. $29.95 hc
ISBN 0-691-02787-0

Roland Omnès, professor of physics at the University of Paris, is the author of *The Interpretation of Quantum Mechanics* (Princeton U. P., 1994), which is the basic treatise on decoherence and the consistent histories formulation of quantum theory. His new books, *Quantum Philosophy* and *Understanding Quantum Mechanics*, provide substantial modernization and simplification of this earlier work. I believe they will prove to be indispensable adjuncts to standard quantum mechanics and philosophy of science courses. This review focuses on the physical interpretation of quantum theory, which is the common thread underlying both works; it deals with Omnes's exhaustive analysis of related philosophical questions only by implication.

The nature of the problems addressed by Omnès is embodied in the following three questions:

(1) Is there a universal logical language that permits a description of "all" physics?

(2) Are the laws of classical physics a consequence of fundamental quantum theory?

(3) Is the linearity of quantum amplitude superposition compatible with the noninterference and probabilistic uniqueness of macroscopic phenomena?

The consistent histories picture, invented by Robert Griffiths and further developed by James Hartle and Murray Gell-Mann, goes a long way toward providing a satisfactory resolution of the problems implicit in the above questions.

Before indicating how this comes about, let me first comment on Omnès's intent in writing these books. He states that they are "addressed to beginners with some elementary knowledge of quantum mechanics." While such readers will undoubtedly find helpful the first two parts of *Understanding Quantum Mechanics*, difficulties may well be encountered in part III, where proofs of important results are sketchy and sometimes omitted completely. (Note that the discussion of physical problems in *Quantum Philosophy* relies heavily on the fuller mathematical treatment in *Understanding Quantum Mechanics*.)

Let me now try to convey the essence of the new messages in Omnès's works. A history is a temporal sequence of propositions and associated projection operators in the Hilbert space of the closed system under consideration. Histories are to be regarded as elements of a sample space to which probabilities are assigned according to a well-defined rule. Not all families of histories are admissible if the Kolmogorov probability axioms are to be satisfied. Complete families that satisfy these axioms are referred to as consistent. The basic reason for inconsistency is the incompatibility of linear superposition of amplitudes with the required additivity of probabilities for mutually exclusive events.

Griffiths and Omnès obtained necessary and sufficient conditions for consistency, which are algebraically quite complicated. An important advance made by Omnès is his recognition that these algebraic considerations may frequently be replaced by much quicker arguments stemming from decoherence and the demonstrable classical behavior of macroscopic devices.

Omnès makes the further notable observation that, with appropriate definitions of the logical connectives and inference, reasoning may be carried out within a unique consistent family according to the familiar rules of Boolean logic. But it must be emphasized that there exist many families of histories that are internally consistent but that cannot be combined into larger consistent families. This is the formal manifestation of complementarity in the present picture, and several physically interesting examples are analyzed by Omnès. The existence of complementary families of histories motivates the adoption of Omnès's universal rule of interpretation: Valid reasoning may only be carried out within a unique consistent family. The choice of such a universe of discourse depends on the experiment one wishes to analyze or, indeed, on whatever one may wish to discuss, real or fanciful—after all, we are constructing a language. Failure to observe this rule lies at the heart of most misunderstandings of the consistent histories picture.

The universality of the language is still in question: I have been speaking entirely in quantum mechanical terms and have not yet considered how classical physics gets into the act. Omnès demonstrates that we can assign quantum projectors to sufficiently large and regular cells in phase space, thus enabling an up and back translation of classical and quantum propositions for macroscopic systems. More spectacular still is his proof of the equivalence of classical dynamics for closed macroscopic systems with the quantum dynamics generated by the time evolution operator. This proof is based on the replacement of the quantum Hamiltonian by its Weyl symbol and the powerful Egorov theorem of microlocal analysis. Thus, Bohr's correspondence principle, relating classical and quantum physics, becomes a theorem, and it is not necessary to live simultaneously in two worlds with no clear line of demarcation and logical connection between them. We are well on the road to the creation of a universal logical language.

But we have not yet attained our goal, since macroscopic systems are rarely isolated from their environment, with which they are inextricably intertwined. We separate out the relevant collective coordinates from the very numerous environmental degrees of freedom, whose temporal development is impossible to follow in detail. An effective state operator is defined by tracing out the environment, and a master equation for its temporal development can be (approximately) derived. Omnès shows that, for certain privileged bases in Hilbert space—so-called pointer bases—the effective state operator exhibits a remarkably rapid approach to diagonality. This is the decoherence effect previously alluded to and is responsible for the disappearance, for all practical purposes, of interference among pointer basis states.

Omnès notes that the pointer basis permits the return from $6N$ dimensional phase space to the familiar three-dimensional space of Newtonian mechanics. Moreover, he demonstrates that decoherence implies the consistency of classical determinism with quantum probabilistic rules, if the histories language and logic are adopted. Thus a long-standing conceptual problem is laid to rest.

We are essentially at the end of the road—all three questions, previously posed, have been more or less satisfactorily answered. The usual postulates of measurement theory become so many demonstrable theorems, since measuring devices are macroscopic. There is no physical reduction effect—it is the decoherent interaction of the environment with the macroscopic measuring device (not the quantum system under study) that allows for the possibility of unique, albeit probabilistic, predictions of experimental results.

A particularly beautiful illustration of the utility and power of the combination of logical consistency and decoherence is given by Omnès's comparison of ideal (von Neumann) measurements and real (decoherent) measurements. Ideal measurements yield results that are not unique (that darned cat) and logically inconsistent. Real measurements give probabilistically unique results (the cat is either alive or dead), and the histories description is logically consistent, hence admissible.

For the more practical-minded, the consistent histories picture has proven to be useful in clarifying some recent experiments on decoherence in the Brune experiment, on quantum jumps in the Dehmelt experiment and many others, as well as in the field of quantum computation.

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Acoustics of Fluid–Structure Interactions

Michael S. Howe
Cambridge U. P., New York, 1998.
560 pp. $85.00 hc
ISBN 0-521-63320-6

The last few decades have seen the public become increasingly concerned with the environmental impact of noise and vibrations emanating from modern transportation systems such as jet aircraft and high-speed trains. Michael S. Howe's *Acoustics of Fluid–Structure Interactions* is devoted to the theoretical analysis of the principal mechanisms by which these systems generate noise. When the operational fluid medium is air, the subject is referred to as "aeroacoustics;" in the case of water flow, it is called "hydroacoustics." The same mechanisms are responsible for the sounds emanating from heating or ventilation systems and certain musical instruments.

Howe has been a prolific contributor to acoustics and fluid mechanics journals for more than 25 years. In large part this book collects and presents much of his own work, and that of others, thus providing the reader with an excellent overview of the subject in one volume. Another book that covers much of the same material but is now out of print is the more comprehensive, two-volume *Mechanics of Flow-Induced Sound and Vibration* by William K. Blake (Academic, 1986).

Howe's introductory chapter, at exactly 100 pages, the longest in this six-chapter book, includes the governing equations for fluids, structures, and acoustics. It introduces the various mathematical principles used throughout the book, including Fourier transforms, stationary phase integration, Green's functions, and reciprocity. Vorticity, considered by the author to be the ultimate source of acoustic energy in aero- and hydroacoustics, is discussed extensively at the end of this chapter.

Chapter 2 treats the production of sound from unbounded flows and begins with a discussion of Lighthill's acoustic analogy. This has proved to be one of the more enlightening ways to describe the origins of aerodynamic noise. It is used to predict the scaling laws for sound generation in technologically important flows such as jet engine exhaust noise. Howe then discusses the effects of two-phase flow and the large increase in water-turbulence noise caused by the presence of bubbles produced by gaseous entrainment or cavitation. The chapter ends with a fairly practical discussion of jet noise, including empirical formulas relating noise levels in flight to static measurements.

Sound generated by unsteady flow in the presence of rigid bodies is treated in chapter 3. To provide a useful and intuitive way of estimating the sound generated by sources near vibrating solids, Howe uses the notion of a compact Green's function, an approach that I haven't seen elsewhere in precisely this form. Also discussed is the problem of vortex–airfoil interaction noise and trailing edge noise, both of which have great practical interest. The following chapter extends the analysis to include the interaction of sound with elastic, as opposed to rigid, bodies. Here, I found it quite surprising that he makes no reference to two other books devoted to such problems: *Sound, Structures and their Interaction* by Miguel C. Junger and me (MIT, 1972) and *Sound and Structural Vibration* by Frank Fahy, (Academic, 1985).

Chapter 5 deals with the general problem of vorticity-generated noise resulting from sound disturbances interacting both with smooth surfaces and those with sharp edges. This vorticity derives its kinetic energy from the incident field, thereby resulting in a decrease of the acoustic energy.

The final chapter is devoted to sounds generated by resonant and unstable systems. These are the mechanisms responsible for the musical sounds emanating from flutes and organ pipes, and the deleterious effects—sometimes resulting in serious structural damage—arising from the exposed openings on aircraft and ships. Howe does an excellent job of presenting rigorous solutions to linearized models and approximate solutions to nonlinear models and provides valuable insight into these extremely complicated phenomena.

The book will be accessible to those who are fairly well versed in applied mathematics, and the effort required even of them will be very worthwhile. Howe has provided us with a valuable compendium of analyses devoted to the mathematical modeling of the exceedingly complex mechanisms by which unsteady fluid flows interact with solid bodies to produce the sounds around us.

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NEW BOOKS

Astronomy and Astrophysics

Adaptive Optics in Astronomy. F. Roddier, ed. Cambridge U. P., New York, 1999.