bly 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 6*N* 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.

Richard Scalettar
California State University, Long Beach

Acoustics of Fluid-Structure Interactions

Michael S. Howe
Cambridge U. P., New York, 1998.
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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.

David Feit
Naval Surface Warfare Center
West Bethesda, Maryland

New Books

Astronomy and Astrophysics

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