

Progress," begins with Theodore Maiman's construction of the first laser (ruby) in July of 1960; his paper, rejected by *Physical Review Letters*, was published in the 6 August issue of *Nature*. Most of the remainder of this chapter concerns the development of other lasers, particularly gas and semiconductor lasers.

The final chapter, on "The statistical properties of light," makes up about a fourth of the book. This is quite appropriate, for the statistical and coherence properties of laser light are what distinguish it from thermal radiation. There is a clear and concise summary of the work of Albert Einstein and Satyendra Nath Bose on the wave-particle duality and photon statistics of thermal radiation. Bertolotti considers the Hanbury Brown-Twiss (or "photon bunching") effect in some detail, and quotes R. Hanbury Brown at length about the difficulty many physicists had in accepting the effect. ("These difficulties about photons troubled physicists who had been brought up on particles and had not fully appreciated that the concept of a photon is not a complete picture of light.") He also discusses the quantum theory of optical coherence, including the Glauber-Sudarshan P -representation, and experiments on the photon statistics of laser radiation.

This attractively slim and highly readable book, written by a leading contributor, should appeal to researchers and students of laser physics and quantum optics, especially those interested in the evolution of ideas in these broad subjects.

Probabilistic and Statistical Aspects of Quantum Theory

A. S. Holevo

312 pp. North-Holland, New York, 1982.
\$85.00

This book, which constitutes Volume 1 of the North-Holland Series in Statistics and Probability, was originally published in Moscow in 1980. It has been translated by the author, Aleksandr Semenovitch Holevo, who is a member of the Steklov Institute of Mathematics in Moscow. (Curiously the author's name is spelled "Kholevo" in the Library of Congress catalog.)

Most approaches to quantum mechanics from the side of mathematics emphasize either the arcane properties of unbounded operators or the "quantum logics," neither of which seems to reveal the physical essence of the subject. While unbounded operators and their domains are very much in evidence here as calculational tools, the emphasis in this book is on the statistical description of measure-

ments. This keeps the subject matter fairly close to observations and makes this book more useful to physicists than are most mathematical approaches to quantum mechanics.

The author begins by defining "statistical model" so as to be able to treat classical and quantum models uniformly within one formalism. A model consists of two sets of elements, "states" and "measurements." A state is naturally associated with a preparation procedure, and thus with the potential ensemble of systems that may be subjected to the preparation. Thus Holevo effortlessly avoids the conceptual pitfalls that characterize the approaches that deal with a quantum state as a property of an individual system. A state is associated with a statistical operator S ; a measurement with a family of projection operators $\{M_u\}$, where u is one of (or a subset of) the possible outcomes. The probability μ_u of the outcome u is given by $\text{Tr}(SM_u)$. In a classical model, all of these operators are simultaneously diagonal; in a quantum model, S and M_u need not be.

Holevo expresses the results of this analysis in the language of mathematical statistics, and it is his objective to generalize many theorems of classical statistics to quantum statistics. From the physicist's point of view, the results provide sometimes a different view of familiar territory and sometimes one entirely novel.

Holevo shows how any statistical model is equivalent to a "hidden-variable" model. He points out that his assertion does not contradict the "no-go" theorems of Simon Kochen and E. P. Specker and of John S. Bell because those require more of such models than he does. No doubt he is correct, but an illustration of those differences by a simple example would have been welcome.

An essential property of the projection operators associated with a measurement is that they form a "resolution of the identity," $\sum_u M_u = I$. By allowing not only the familiar orthogonal resolutions of identity, but also nonorthogonal resolutions (provided by overcomplete sets such as the coherent states of the harmonic oscillator), Holevo is able to generalize the theory to treat several cases that do not fit into standard quantum measurement theory. These include joint measurements of coordinates and velocity (not violating the uncertainty principle), measurement of a time observable (for which no canonical operator exists), and measurement of rotation angle variables.

The book has a bibliography of 147 items, in addition to a brief subject index. The quality of the translation and of the printing are excellent, and the price is correspondingly high. Both

mathematicians and physicists should find something of interest in this book.

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Direct Nuclear Reactions

G. R. Satchler

833 pp. Oxford U.P., New York, 1983.
\$110.00

Our present comprehensive knowledge of nuclear structure largely comes from studies of direct reactions. Direct reactions in nuclear physics are scattering reactions with a peaked angular distribution for the scattered particle and a small energy transfer to the target nucleus. There are many useful kinds of direct reactions: Elastic scattering, inelastic scattering and particle-transfer reactions all provide different kinds of information about nuclear structure.

G. Raymond Satchler, a theorist who pioneered in the application of direct reactions to nuclear studies, has written a treatise on direct reactions covering practically all aspects of the subject.

Although Satchler is concerned with details of theory and the great variety of experimental phenomena, he has taken pains to provide a broad perspective of the subject. The introductory chapters are very readable, presuming only a knowledge of elementary quantum mechanics. Satchler explains in physical terms how direct reactions occur, as projectiles interact with the surface region of the nucleus. Illustrating his discussion with some well-chosen cross-section data, Satchler shows the evidence for the classification of varieties of direct reactions and the geometric origin of the peaked oscillatory angular distributions.

At a more technical level, his book invites comparison with the monograph written by Norman Austern in 1970, *Direct Nuclear Reaction Theories*. The theoretical framework was in place in Austern's earlier work, which used the distorted-wave Born approximation and its generalization into the coupled-channel method. At that time, however, the scope of the theory was unclear, and the experimental picture was much sketchier. Satchler brings the subject up to date with recent data that illustrate new successes of the theory as well as limitations. The inelastic scattering reactions have revealed the existence of new giant vibrations: Reaction theory enables their intrinsic properties to be measured. On the subject of particle-transfer reactions, new experimental tools have allowed the study of the reaction under a greater variety of conditions. With spin-polarized projectiles and heavy-ion projectiles one can measure the

spin as well as the orbital angular momentum of the transferred nucleon, to obtain more detailed spectroscopic information than previously available.

One of the major directions of nuclear physics in the last decade, made possible by the new heavy-ion accelerators, has been the study of interactions between large nuclei. Satchler devotes much attention to the direct reactions induced by heavy-ion beams, an unexplored subject at the time of Austern's book. The calculation of heavy-ion cross sections, computationally difficult because of the short wavelengths of the heavy-ion projectiles, requires hundreds of partial waves in the angular momentum expansion of the scattering amplitude. Satchler's theoretical discussion ranges from the numerical tricks used to speed up the computation to semiclassical diffraction theory: Diffractive scattering effects (analogous to the classical Fraunhofer and Fresnel diffraction) can be seen in heavy-ion reactions and can be used to interpret the data.

Another recent advance, brought about partly by the obvious need in heavy-ion physics, is fast computer codes for calculating cross sections that include many reaction channels simultaneously. Satchler goes beyond the formalism to discuss the actual computational techniques. In one section, for example, he discusses a method by which a computationally time-consuming multipole expansion of the interaction is avoided. While Austern had only the formalism of the coupled-channel theory, Satchler has many examples of how it works and what it does for different kinds of reactions.

Satchler's book is well written and may well serve as the definitive work on direct reactions in nuclear physics. It describes the detailed status of direct reaction theory and experiment; it also provides information for users of the distorted wave theory who need a reference on such matters as the sign convention for polarization measurements or specific potential interactions for inelastic scattering calculations.

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Newtonian Mechanics

R. Baierlein

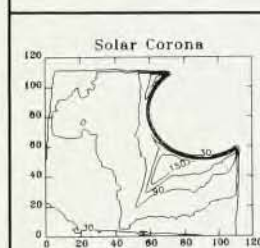
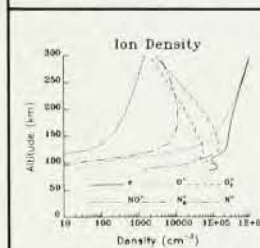
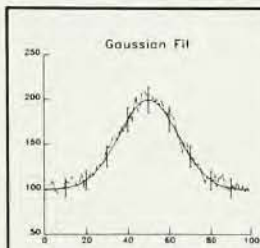
326 pp. McGraw-Hill, New York, 1983.
\$31.50

While many authors of elementary texts attempt to give the reader an intuitive feeling for physical phenomena, authors of classical mechanics texts for juniors and seniors are less likely to make such an attempt. I believe the greatest success of Ralph Baierlein's book is his ability to make the reader reach out and understand

what is happening qualitatively in a particular physical situation. The coherence of the book also makes it successful. In "A note to the problem solver," he quotes a colleague who, teaching from a preliminary edition, advised students to read each chapter in its entirety before trying the problems. I second the colleague's advice.

Baierlein has a lively and informal style that will engage and encourage readers. He motivates readers to continue the study of classical mechanics

by mentioning numerous applications of the mathematical expressions to modern-day problems in physics: For example, the structure of the equation for the damped harmonic motion resembles, for some purposes, a bound oscillating electron. In the chapter on nonlinear oscillators he cites van der Pol's equation, which first appeared around 1920 and reappeared in the 1960s in a theory of lasers; theories of turbulence and of biochemical self-organization also build on properties of



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