Neutrons, Nuclei and Matter: An Exploration of the Physics of Slow Neutrons

Jim Byrne
IOP, Philadelphia, 1994.
760 pp. $400.00 hc
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Very soon after its discovery in 1932, the neutron was recognized as a powerful probe for the study of the microscopic structure of matter. The first applications concerned the study of the atomic nucleus and were of critical importance in the early development of nuclear physics. Since then neutron physics, using low-energy neutrons, has come to include an astonishing variety of scientific investigations based on the utility of the neutron as a probe. This currently includes research in areas as widely diverse as crystallography, molecular dynamics, lattice dynamics, magnetic structures, polymer physics and surface physics, as well as nuclear and particle physics. Modern neutron sources reflect this diversity and serve as multidisciplinary facilities for physicists, chemists, biologists and engineers. Most of these investigations employ neutrons, particularly neutron scattering, as a tool for the study of condensed matter. Such research, recognized by the 1994 Nobel prize, has experienced extensive growth and continues to motivate the design and construction of high flux neutron sources (see PHYSICS TODAY, November, page 17).

While most neutron research has been based on the neutron as a probe, the availability of high fluxes of low-energy neutrons has led to a vigorous, parallel research program in which the neutron itself is the object of study. This work has provided novel and important results for the determination of fundamental constants, for the study of physics beyond the standard model, for astrophysics and for fundamental tests of quantum mechanics.

Neutrons, Nuclei and Matter is the first one-volume review of the broad field of low-energy neutron physics to appear in more than two decades. In it Byrne has wisely focused his attention on topics that are not readily available in the more specialized literature concerned with neutron scattering. Thus, the most useful portions of the book deal with theoretical and experimental studies of the properties of the neutron and its basic interactions. In this regard, *Neutrons, Nuclei and Matter* reflects the research interests of the author, who has extensive experience in nuclear and particle physics with low-energy neutrons. Most recently, he has been involved in several elegant experiments at the High Flux Reactor of the Institut Laue–Langevin in Grenoble, France.

The book is directed towards experimenters interested in neutron properties and interactions, and there is no doubt that for them it will be an invaluable resource. It will also be of value for those engaged in any facet of neutron physics research, for *Neutrons, Nuclei and Matter* provides a first-principles discussion of the fundamental neutron interactions and most of the experimental techniques exploited by those who use the neutron as a probe. The writing is clear, and the explanations stress essential physical principles. The introductory material, which has a strong historical emphasis, is quite interesting in its own right.

A review text, however thorough, cannot cover all topics. While the choice of material in *Neutrons, Nuclei and Matter* provides an excellent survey, many readers would have benefitted from a discussion of the very beautiful experiment of W. Weirauch and coworkers to measure the ratio of Planck's constant to the neutron mass, h/m_n (E. Krüger, W. Nistler and Weirauch in *Nuclear Instrumentation Methods A* **284**, 143 (1989)). This experiment, with its surprising implications for the field of fundamental constants and tests of quantum electrodynamics exemplifies a theme eloquently presented in *Neutrons, Nuclei and Matter*: the breadth, importance and elegance of low-energy neutron physics.

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Quantum Theory: Concepts and Methods

Asher Peres
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446 pp. $129.00 hc
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I will start with a gripe, not about the content of this book but about its price. The publishers do a disservice to themselves, the authors and, particularly, the potential readers by putting an interesting book like *Quantum Theory: Concepts and Methods* out of the reach of graduate students, postdocs and assistant professors—exactly the intended audience. (I raised this issue with David Larner, the publisher, and was informed that the price can be reduced to $59.00 if the book is adopted for a course and more than six copies are ordered.) Such pricing practices are not justified when one considers that many publishers provide very little copyediting or typesetting any more, as is obvious from the "TeX"-ish look of most books published recently, this one included.

Having gotten this off my chest, let me hasten to say that I like Asher Peres's book and would recommend it to anyone teaching or studying quantum mechanics. It is not really a textbook that teaches you how to solve problems. Rather, to quote the preface, its purpose is "to clarify the conceptual meaning of quantum theory and to explain some of the mathematical methods which it utilizes."

The book explains the foundations without going into the "philosophy" of quantum mechanics. Although the mathematical background expected of the reader varies, Peres does an excellent job of reviewing or explaining the necessary techniques. Sometimes he works out the more elementary derivations in detail and leaves more complicated ones as exercises (some of which I would consider hard for an average graduate student; some more detailed hints, or solutions would be welcome, particularly for the armchair reader who is not inclined to get out a pencil and paper).

The book is divided into three parts: gathering the tools, cryptodeterminism and quantum separability, and quantum dynamics and information.

The first part develops the usual tools, starting from the primitive notions of "preparations and tests" and building up mathematical formalisms involving not only pure states, as most textbooks do, but also mixtures, described by density matrices. The treatment of continuous spectra is brief.

Part II is, in my opinion, the most interesting; it deals with the material clearly and with a lot of common sense. Here are a few quotes: "Unperformed experiments can have no results" and "While quantum theory can in principle describe anything, a quantum description cannot include everything." The author deals here with such difficult and often misinterpreted topics as the Einstein–Podolsky–Rosen "paradoxes" and Bell's inequalities, occasionally making use of Galileo-inspired dialogs. Various famous theorems are discussed in a