Book Reviews

Nuclear Matter and Nuclear Reactions. By Ken Kikuchi and Mitsuji Kawai. North Holland Publishing Co., Amsterdam; John Wiley and Sons, Inc., New York (1968). 314 pp. $16.00.

This well-written monograph on statistical nuclear physics is remarkably easy to read considering the mathematics involved. (The 314 pages of text contain 846 equations that the authors considered important enough to number.) The mathematical sophistication is roughly equivalent to that in Blatt and Weisskopf[1] or Preston.[2] There are five chapters in the book, the first three of which are quite short introductory chapters entitled "Properties of Nuclear Matter," "Two-Body Collisions in Nuclear Matter," and "Aspects of the Actual Nucleus." Chapters 4 and 5, which make up almost three-fourths of the book, are entitled "Nuclear Reactions at Lower Energies" and "Nuclear Reactions at High Energy."

In the first chapter, with the usual assumptions of no surface effects, no coulomb repulsion, and no symmetry or pairing forces, the various properties of nuclear matter are calculated, e.g., nucleon density, average nucleon energy, and various thermodynamic properties. Two-body collisions in nuclear matter are considered in the second chapter. The mean-free-path of a particle in nuclear matter is calculated along with the particle energy and angular distribution after collision. In Chapter 3, the concepts developed in the first two chapters are applied to real nuclei. Corrections necessary because of the initial assumptions are considered and the theory is applied to the analysis of certain experimental data. Form factors from electron scattering data are used to determine nuclear density distributions, and the problem of determining the phenomenological optical potential from such experimental data as total cross section, elastic scattering and absorption cross sections, angular distribution of elastic scattering, and polarization of elastic scattering is considered. The shell and unified models of the nucleus are discussed from the standpoint of nucleon behavior within a nuclear environment.

Chapter 4 constitutes almost half the book and is devoted to low-energy nuclear physics. Several important topics are covered, sometimes in great detail. However, all the substance of this chapter, if not the detail, may be found in one or another of the many books available on quantum mechanical nuclear physics, most of it in either Blatt and Weisskopf[1] or Preston.[2] Utilizing the channel radius concept, a general scattering theory is developed. Compound nucleus theory is presented including such topics as level widths, reduced widths, partial widths, and the Breit-Wigner one-level formula. Also included are discussions of the statistical model, the optical model, strength functions, average cross sections, and the statistical distribution of resonance levels. The chapter is concluded with a detailed and quite good discussion of direct reactions, including the distorted-wave Born Approximation, the adiabatic approximation, and the method of coupled channels.

This reviewer found the last chapter to be by far the most interesting and informative part of the book. It is devoted to nucleon-nucleus reactions at energies of thirty to several hundred MeV, a subject not covered in most of the standard texts on nuclear physics nor encountered by the average low-energy nuclear physicist or nuclear engineer in his work. At these high energies, the nucleon-nucleus reaction is a series of two-particle collisions, the so-called intra-nuclear cascade. Calculations are made of such parameters as the average number of cascade nucleons, the average energy of the nucleons, and the average excitation energy of the residual nucleus. Evaporation parameters calculated include the dependence on A and Z of the initial nucleus, the average de-excitation energy per nucleon, and the energy spectra of emitted particles. The spallation process is considered primarily through the presentation of experimental data.

In general the book is quite well written. However, it is not at all clear for whom it was written, nor for what purpose. Contrary to statements on the dust-cover and in the preface, it is much too limited in scope to be used as a text except in a most severely restricted special topics course. And even there the usefulness of the book is limited by the age of the contents. The authors state in the preface that it evolved from a set of lecture notes used in 1959, and despite the 1968 copyright date, the book appears to be essentially that set of notes. Everything considered, it is doubtful that it is worth the price.

William E. Kiker

North Carolina State University
Raleigh, North Carolina 27607

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About the Reviewer: *William E. Kiker is an Associate Professor of Nuclear Engineering at North Carolina State University at Raleigh. He received a BS degree in Nuclear Engineering from North Carolina State in 1957 and MS and PhD degrees in Physics from the University of Tennessee in 1962 and 1964. After two years with the Lawrence Radiation Laboratory in Livermore, California, Dr. Kiker joined the North Carolina State faculty in 1966. His current research interests include fission fragment kinetics measurements, fission fragment interactions with matter, and the use of fission fragments as a research tool.*

[1] J. M. BLATT and V. F. WEISSKOPF, *Theoretical Nuclear Physics*, John Wiley and Sons, New York (1952).

[2] M. A. PRESTON, *Physics of the Nucleus*, Addison-Wesley Publishing Co., Reading (1962).