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Book Reviews

Physics of Nuclear Reactors. By D. Jakeman. American Elsevier Publishing Co. Inc., Great Britain (1966). 351 pp. $10.00.

This book, as part of the *Applied Physics Guides* edited by Sir Graham Sutton, is, according to the publisher, "... intended for graduate engineers and physicists who wish to become acquainted with the branch of physics dealing with nuclear reactors. No prior knowledge of the subject is assumed, but it is anticipated that the reader will be familiar with calculus and elementary nuclear physics."

The book consists of nine chapters, starting with the usual Introduction, followed by an elementary discussion of The Behavior of Neutrons in Non-multiplying Materials, Slowing Down with Capture, Neutron Thermalization, Behavior of Neutrons in Multiplying Systems, Fast Reactors, Thermal Reactors, Nuclear Fuels, and Reactivity Changes and Control. The material presented has been covered many times in other books and in the readily available literature produced in profusion by various laboratories and journals. A review must then be confined to an assessment of how well the author has met the original intent of offering a guideline to the physics of nuclear reactors.

First, the book cannot be recommended as a textbook for a first course in reactor theory. As admitted by the author himself, the treatment of the subject varies considerably in depth from chapter to chapter. The Introduction is inadequate in three respects, particularly for those not trained in physics. A more complete discussion of neutron-nuclei interactions is needed. Second, a thorough and well-organized discussion of the fundamental problems of reactor physics would be needed if this book were to serve as a "guideline." Finally, too many concepts are presented without adequate discussion. A great deal of supplementary reading would be required by a novice to fully appreciate the material presented in the Introduction. Incidentally, the opening statement in this book referring to the discovery of fission is not correct. Meitner and Frisch were the first to suggest fission as the correct interpretation of the work of Hahn and Strassman (see S. Glasstone, *Sourcebook on Atomic Energy*, 2nd Ed., p. 385-389, D. Van Nostrand Inc., Princeton, N. J. (1958)).

Chapter 2, which concerns the Behavior of Neutrons in Nonmultiplying Materials, is very good. The presentation of a solution for a point source at the center of a finite sphere using eigenfunctions of the Helmholtz equation, and the accompanying illustrations showing the effect of higher harmonics, should prove very helpful in giving the beginner an insight into neutron diffusion.

Chapter 3 on Slowing Down with Capture is not really adequate for an introduction to this material. (The reviewer must admit, however, that he has not yet seen an adequate introductory discussion of resonance capture in any of the literature.) The definition and the discussion of the effective resonance integral is very sketchy. The discussion of the effect of heterogeneities is deferred to Chap. 7 where the presentation is not complete enough to serve as a foundation for understanding resonance absorption in heterogeneous reactors. Although the references provided at the end of these two chapters are reasonably sufficient, the reviewer would like to point out that the method of making heterogeneous systems equivalent to homogeneous systems was first developed by Bakshi rather than Chernick and Vernon, as stated by the author on page 252 (see P. Bakshi, BNL-4381, Brookhaven National Laboratory, Upton, New York (1959).

The chapter on Neutron Thermalization is a very good introduction, although omission of at least references to the work of Nelkin, Honeck, Brown, and St. John on thermalization in H_2O and D_2O should be considered a serious omission at this time in history.

The remaining chapters are reasonably easy to read and should offer the beginner very little difficulty. The book has many tables and illustrations of experimental data and calculations which are useful. On the other hand, many of the definitions and concepts are introduced in a rather loose manner and the organization of some of the material could be improved. The author states in the Preface, "An attempt has been made in the present book to preserve a balance between the older and the current approach to the subject." This reviewer does not believe he has achieved his goal. The omission of a discussion of multigroup theory and the important developments in this field during the last decade upset the balance.

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About the Reviewer: Milton C. Edlund, now Professor of Nuclear Engineering at the University of Michigan, was formerly with The Babcock & Wilcox Company where he served over a period of 11 years successively as Manager of Mathematics and Physics, Manager of Development and, recently, Assistant Manager of the Atomic Energy Division. Prior to this, he was with ORNL, where he initiated the Reactor Physics course at ORSORT and co-authored The Elements of Nuclear Reactor Theory *with Samuel Glasstone in 1951. He received his BS and MS in physics and, recently, a PhD in nuclear science from the University of Michigan. In 1965 he was given the E. O. Lawrence Memorial Award for his contributions to reactor development.*

Proceedings of Physics and Chemistry of Fission Symposium, Vol. I and II. Published by International Atomic Energy Agency. (Symposium held March 1965), Vol I, 635 pages. $13.00; Vol. II, 469 pages. $10.00.

In March 1965, a symposium on the Physics and Chemistry of Fission was held in Salzburg, Austria. Printed proceedings of the nine working sessions, now available in two volumes, present a good summary of our current knowledge and research on the fission process, as did the symposium. The complexity of the process is indicated by its many specific aspects listed among the session titles. The increasing capacity of experimental techniques to record and correlate various specific events associated with fission is strongly evident in the wealth of new data presented, as well as in the variety of new techniques by which they were obtained. The paucity of adequate theory relative to unexplained data, which has characterized fission research almost from its beginning, is also documented in these volumes.

The fact that theory continues to encompass an adequate description of only a small fraction of the observed facts is not, however, an indication that our knowledge of fission is static. It is, rather, associated with the circumstance that large distortions of a finite liquid drop (let alone a many Fermion system) pose a difficult problem and that many aspects of nuclear fission may be essentially dominated by the details of the distortion process. Sufficient progress has been made, however, to lead W. Swiatecki to propose that "we should. . . settle down to working things out from first principles in a thorough and definitive manner."

Another encouraging item for fission theory evident from the Salzburg proceedings is the continuing evolution of our understanding of the transition states through which the nucleus passes en route to scission into fragments. These are a feature of nuclear fission specifically unrelated (so far as is known at present) to the details of the scission itself. Study of them has therefore enabled certain theoretical predictions to be tested, and some implications of data for the transition states to be drawn, even in the absence of a complete theory of fission. The result has been a growth of the effort aimed at illuminating the transition state spectrum, as well as various proposed expansions of the range of fission effects considered relevant to that spectrum. Moreover, modern nuclear structure physics has come, through the study of the transition states, to enjoy a quantitative relevance to some nuclear fission phenomena.

The proceedings document this process in many detailed reports and reconfirm the reviewer's judgment at the time of the Conference that fission barrier transition states may lead fission physics back towards the mainstream of nuclear structure research by providing data on very deformed nuclei which are available for study through nuclear fission alone. The experimental study of fission is, in fact, moving steadily toward the stage when it will provide for the transition-state spectra data of the kind which served as the basis for the unified model of deformed nuclei. In turn, the resulting spectroscopy of transition-state nuclei might allow more rigorous tests of theories of nuclear structure than stable nuclei can provide. Finally, any success in establishing the relevance of other fission phenomena to these transition states simplifies the puzzle of fitting the so many details of fission together into an adequate liquid-drop or many-body theory.

The proceedings also testify to the technological revolution which has been wrought in the scientific laboratory by recent counter and computer advances. The study of x rays from fission fragments, for example, now allows a unique charge to be assigned to a prompt fragment, while modern data processing equipment permits an ever expanding number of nuclear events to be specifically associated with such a label. Here, too, nuclear fission can make a contribution to nuclear structure physics by providing structure studies of nuclei far off the line of beta stability.

The Salzburg conference made it quite clear that such techniques would soon (and had already!) make available data of such quantity and quality as to insure that theory, even armed with computers, would not soon improve its (relative) comprehension of fission phenomena.

In sessions on fission cross sections, on charge, mass and energy distributions in fission, and on beta, gamma, neutron and light particle radiations, these proceedings provide a current source book which is indispensable to researchers and students who must know what is known about nuclear fission. The format is crisp and legible, and the time lag (one year) a credit to the editorial staff.

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April 29, 1966

About the Reviewer: James J. Griffin was graduated from Villanova College in 1952 and received an MS degree at Princeton in 1954 and a PhD in Physics in 1956. He was a Fulbright Fellow at the Institute of Theoretical Physics in Copenhagen, Denmark, during 1955-56, and a National Science Foundation Fellow at the University of Birmingham, England, during 1959-60. He has recently joined the Physics Department of the University of Maryland.

Genie Atomique — Book IV: Les Propriétés des Materiaux des Reâcteurs Nucleâires (Properties of Nuclear Reactor Materials, Vols. I, II), 2nd Edition. Presses Universitaires de France - E. Crémieu - Alcan, Secretary of Editorial Committee (1956). 1400 pp.

At first glance, this two-volume text on *Properties of Nuclear Reactor Materials* seems to represent a major contribution to the literature on nuclear materials technology. Unfortunately, closer examination does not confirm the initial opinion. About 200 pages of the total represent information gained since 1960. The remaining 1200 pages are relatively unchanged from the previous edition.

Volume I is divided into two sections. The first (A) deals with metallic, ceramic, and semimetallic fuels; the second (B) covers metallic and ceramic cladding and structural materials.

Volume II is divided into four sections: 1) Section C is a general discussion of fuel elements for heterogeneous reactors; 2) Section D covers moderators; 3) Section E presents metallic and ceramic control materials; and 4) Section F covers gaseous and liquid coolants.

Returning more specifically to the sections in each book, Part A covers uranium, plutonium, and thorium metal and alloys, as well as their oxides. It also deals with uranium carbide, uranium nitride, plutonium carbide, and thorium carbide. Specific areas of weakness include the limited coverage of swelling in metallic uranium, the absence of newer data on kinetics of transformation in plutonium, and the virtual absence of information of UO_2 and PuO_2, where major contributions have been made in the past five years. Some of the information on carbides of uranium, plutonium, and thorium, and on UN is satisfactory, though limited in scope.

Section B deals with the properties of aluminum, magnesium, beryllium, zirconium and their alloys, plus the steels; it also includes information on ceramic materials and irradiation effects. The work dealing with metals and irradiation damage is out of date, with most of the information of no more recent origin than the second Geneva