Book Reviews

Experimental Reactor Physics. By A. Edward Profio. John Wiley & Sons, Inc., New York (1975). 805+ pp. $30.00.

This book is an extremely useful review of a wide variety of topics in experimental neutron physics and radiation measurements. In its 811 pages, the author covers an impressive amount of material that would otherwise be found only in a diverse assortment of references. In his Preface, Professor Profio indicates that the book is intended both as a text for a senior-graduate-level course in nuclear radiation measurements and reactor physics, as well as a reference for those engaged in experimental research in these fields. It better fits the latter purpose, since the author more often chooses to present a broad review of a given topic rather than to develop it in a pedagogical sense. For example, there are no problems at the end of chapters, nor are there many examples of numerical calculations within the text itself. As a reference text, the book fills an important need since there is no comparable single volume in which its wealth of contents can be found.

The first chapter, while not an essential part of the subject matter, is an excellent historical coverage of the discovery of fission and the early development of nuclear reactors. The second chapter includes a fairly extensive review of radiation interactions, cross sections, and reaction energetics. Chapter 3 is also an introductory review covering radioactive decay, activation, and some counting statistics. Chapter 4 discusses neutron sources and is somewhat unusual in its thorough coverage of accelerators and different types of research reactors.

The next four chapters are a surprisingly complete review of radiation detectors, nuclear electronics, and applications in various basic measurements. As a unit, these chapters present a very useful review of this material and include a reasonable sampling of recent developments. However, references to literature are somewhat limited and those included are often older than necessary. For example, Chap. 5 has no references later than 1968, and Chap. 6 has none after 1970. The coverage of detectors and instrumentation is of considerable value but easily overlooked by those who will gauge the book's contents only by the title.

The remaining four chapters provide a very thorough coverage of experiments in moderators, subcritical assemblies, critical facilities, and research reactors. Moderator measurements involving age, diffusion length, and albedo are first discussed with detailed explanation of error sources and measurement interpretation. Next is an extensive description of modulated source methods for the measurement of moderator properties and thermalization time. Multiplication in subcritical assemblies is the next topic and includes analysis and discussion of experiments in approach-to-critical, exponential experiments, and alpha dieaway measurements. The chapter on critical facilities not only discusses traditional measurements made with specialized facilities such as ZPR-3, but also experiments that are appropriate for low-power research reactors involving reactor kinetics, rod calibrations, temperature coefficient, and xenon poisoning. The final chapter concerns measurement of various lattice parameters and neutron spectra determination in thermal and fast reactors. In these last four chapters, the author draws on much of his own experience and considerable contributions he has made to many of the topics. The subject matter is very clearly presented and somewhat more thoroughly referenced than some of the initial chapters.

The book is not a laboratory manual, but all the topics are presented from an experimentalist's point of view and stress the performance and interpretation of measurements. Particularly laudable are the attention paid to error analysis and the inclusion of results of similar experiments reported in the literature.

While seldom derived from first principles, sufficient theoretical development is normally given so that the measurements can be put into proper context. Some of the topics are rather specialized (for example, extensive coverage of accelerator-related measurements), but most of the topics will be of interest to those working with research reactors or pulsed neutron sources.

The text is reproduced by photo offset from typewritten pages and seems to be remarkably free of typographical or other errors. It represents an impressive contribution by a single author and will surely be widely read and used by experimentalists in many areas of neutron physics.

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About the Reviewer: Glenn F. Knoll is professor of nuclear engineering at the University of Michigan where he completed his graduate studies in 1963. Professor Knoll has diverse interests in the measurement of nuclear properties, in the development of instrumentation and methodology applicable to nuclear medicine, and has contributed to the exploration for life in the current Viking endeavor. He has been the recipient of U.S. Atomic Energy Commission, National Science Foundation, National Aeronautics and Space Administration, Fulbright, and Science Research Council (London) fellowships or awards.

Editor's Note: The author of *Experimental Reactor Physics* has requested this notice of several errors in the book. *DC*

1. The detectors in Fig. 8.5, p. 482, should be identified

as 12 cm^3 (coaxial) and 1.0 cm^3 (planar) detectors with the point source 3 cm from the front surface.

2. The diffusion coefficients for water listed in Table 9.3 on p. 556 are too high by a factor of 10. They should read:

$$\overline{D}_0 = (3.585 \pm 0.01)\ 10^4\ \mathrm{cm^2/sec}\ \text{(Ref. a)}$$

$$\overline{D} = 0.130\ \mathrm{cm}\ \text{(Ref. a)}$$

$$= 0.144\ \mathrm{cm}\ \text{(Ref. b)}.$$

3. On p. 693, Eq. 5, the second term in the square bracket should be $\phi_i\phi_i^\dagger \cdot \delta(\Sigma_{ai}V_i)$.

Fusion Energy Conversion. By George H. Miley. American Nuclear Society (1976). 454 pp. $39.80.

This book is intended to provide a framework and essential background for future research, development, and engineering programs for achieving improved energy conversion techniques for nuclear fusion reactors. The first 76 pages are devoted to introduction, fuel cycles, and energy balances (93 references), followed by 76 pages on direct conversion of charged-particle energies to electricity (82 references), 80 pages on electromagnetic coupling (100 references), 72 pages on thermal conversion (123 references), 54 pages on nonelectrical conversion (127 references), and appendices covering ten miscellaneous topics (96 references), plus an update of recent references (21, of which 7 are dated 1976).

Chapter 1, "Introduction," discusses scientific engineering, economic, and environmental considerations of potential fusion reactors. Also included is an overview of the contents of the book. The deuterium-tritium (DT) reactor will have an ~90% energy release via neutrons and radiation, thus necessitating a thermal conversion cycle. Later generation fusion power plants may involve the ecologically more satisfying DD- or D^3He-fueled systems.

Chapter 2, "Fuel Cycles and Energy Balances," treats cross sections and reactions over the range 1 to 1000 keV. The primary D-T-Li cycle is treated, and a useful comparison is given of several possible DD cycles and the D^3He cycle as regards total energy release and the fraction of power in charged particles. More recent studies suggest that D^3He may be another order of magnitude freer of neutrons than Miley indicates. "Exotic" fuel cycles are treated, but no clear-cut answers are presented on their feasibility. Detailed treatments of various system efficiencies and of energy multiplication in blankets are given. Projections are presented on potential fusion reactor plant performance.

Chapter 3, "Direct Collection," discusses the direct conversion of charged-particle energies to electrical energy, emphasizing the Lawrence Livermore Laboratory approaches. Toroidal divertors for direct conversion are also treated. These approaches seem rather torturous to the reviewer, and it may be that a new invention is needed to obtain simple, efficient direct collection at high-dc voltages.

Chapter 4, "Electromagnetic Coupling," treats methods of expanding the plasma against the magnetic field, the use of internal currents (e.g., the bootstrap current in tokamaks) to do work via inductive coupling, and plasma exhaust expansion in an inductive magnetohydrodynamic channel. As with direct collection, all these concepts involve the use of only the charged particles, but convert their energies via an intermediate, inductive method to electrical energy.

The complexity of both direct and indirect coupling technologies does not bode well for the case of the pure DT reactor, since only ~10% (reviewer's estimate) of the net energy flow from the plasma is in charged particles. The advanced fuels DD and D^3He appear to be ideal candidates for direct and electromagnetic coupling, though roughly half the charged-particle energy release shows up as radiation losses which will necessitate a thermal cycle.

Chapter 5, "Thermal Conversion," is applicable to *all* fusion-reactor-fueled systems (DT, DD, D^3He, D^6Li, $p^{11}B$), since about half or more of the energy release from the plasma is in neutrons and/or radiation which demand a thermal cycle for energy conversion. Tritium-handling systems (important even in the "clean" D^3He cycle), heat pipes, magnetofluid pumping, and power conversion cycles are covered in this chapter.

Chapter 6, "Nonelectrical Conversion," discusses several applications of the intense sources of neutrons, radiation, and high-temperature plasma. This includes fissile breeding, the fusion-fission hybrid reactor, fission product and actinide burning, materials and chemical processing, and synthesis of portable fuels. The prospects of using waste heat from fusion reactors for agricultural and for industrial processes are treated. Fusion propulsion prospects are also presented.

The Appendices cover numerous topics, with a very extensive discussion in Appendix A, "Evaluation of $n\tau$ for Various Reactors," of the Lawson parameter $n\tau$, or ρR in the case of pellet fusion, for various situations. Other appendices are: B, "Fusion Fuel Reserves"; C, "Evaluation of Radiation and Fusion Powers"; D, "Requirements for $n\tau$"; E, "Auxiliary Losses, Surface Effects, and Voltage Holding in Direct Collectors"; F, "Energy Recovery in Neutral-Beam Systems"; G, "Compression-Expansion Relations"; H, "Efficiencies for Type-S and Type-P Cycles"; I, "ATC Scaling and Clamped-Burn Efficiency"; J, "Idealized Analysis of Bootstrap Coupling"; and K, "Comments on Recent Studies."

This is the first comprehensive text on the subject of advanced energy conversion specifically related to potential nuclear fusion reactors. The author is to be commended for his attention to detail and well-paced coverage of a difficult subject matter. The book uses figures extensively. References are adequate for those wishing to pursue the subject further. The text is highly recommended for both plasma researchers and fusion engineers.

It should be emphasized that at the present stage of fusion research, many of the subjects treated in this book are very speculative and highly imaginative, but this is how inventions are generated. Edward Teller once said a new invention consists of six crazy ideas, but until the sixth crazy idea is weaved into the mix, there is no invention and the first five crazy ideas make no sense at all.

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About the Reviewer: J. Rand McNally, Jr. has extensive experience and accomplishments in the areas of atomic and plasma physics, having published over 100 papers in these areas. He is an authority on advanced fusion fuel cycles