BOOK REVIEWS

Selection of books for review is based on the editor's opinions regarding possible reader interest and on the availability of the book to the editor. Occasional selections may include books on topics somewhat peripheral to the subject matter ordinarily considered acceptable.

Controlled Nuclear Fusion—Fundamentals of Its Utilization for Energy Supply

Authors	J. Raeder, K. Borass, R. Bünde, W. Dänner, R. Klingelhofer, L. Lengyel, F. Leuterer, M. Söll
Publisher	John Wiley & Sons, Inc., Somerset, New Jersey (1986)
Pages	316 (illustrated)
Price	$100.00
Reviewer	Clifford E. Singer

This book is a translation of *Kontrollierte Kernfusion*, written in 1980. Despite the delay in translation, the book remains a timely summary of many aspects of tokamak physics and engineering. Some of the articles may also be of interest to those working on reactor concepts other than tokamaks. These include articles on pellet injection (by L. Lengyel), safety (W. Dänner), and fuel reserves (R. Bünde).

Most of the book is devoted to a survey of the main components of a tokamak reactor. These include articles on plasma physics (K. Borass), plasma heating (R. Klingelhofer and F. Leuterer), first walls and blankets (W. Dänner), magnet systems (M. Söll), and reactor design and balance of plant (R. Bünde et al.). For a collection of articles by different authors, the material is remarkably well integrated and proceeds without abrupt changes in style, emphasis, or notation. It is also tolerably well translated and adequately and attractively illustrated. It, therefore, has advantages over a similar compendium edited by Dolan, and over other less well-integrated collections of articles on tokamak physics and engineering.

Despite these advantages, *Controlled Nuclear Fusion* has a major drawback in common with many other surveys and texts on practical aspects of fusion energy. It fails to ground the core material on tokamak physics and engineering either on first principles or references easily understandable by newcomers to the field. The reader, therefore, needs to know the field already to really understand the material. But if the reader already knows the field, why is he reading this book? This is not a reflection on the seriousness of the authors' efforts but rather on the state of tokamak research. Major experiments and design studies have evidently so consumed the time of experienced workers that there is a great shortage of rigorous but comprehensible review articles that should serve as the basis for such a text.

In summary, the book by Raeder et al. should serve as a useful supplementary text for courses on controlled fusion and a useful enough reference to justify its purchase by researchers and instructors active in the various fields of tokamak research that it covers. Despite the recent publication of a number of very good efforts, the definitive, self-contained, introductory text on fusion reactor design and a more widely useful reference work for tokamak researchers remain to be written.

Clifford E. Singer received his PhD at the University of California, Berkeley. He has worked on the theory and applied physics of plasma transport in tokamak experiments and reactors at Princeton Plasma Physics Laboratory (and the University of Illinois) since 1977. He has published studies of space and planetary physics, interstellar propulsion and communication, and molecular biology and evolution. He is a fellow of the British Interplanetary Society.

Introduction to Fusion Energy

Author	J. Reece Roth
Publisher	Ibis Inc., Charlottesville, Virginia (1986)
Pages	650 + xii
Price	$35.00
Reviewer	Chan K. Choi

This book is an introductory level textbook on fusion for college juniors and seniors with emphasis on magnetically confined plasmas. This is a welcome addition to existing fusion textbooks at this level. It covers quite effectively not only the basic physical processes on fusion-related plasmas and the major fusion reactor concepts, but also describes quite well the alternate confinement approaches including many useful applications.

The first four chapters introduce the basic plasma physics, including single-particle confinement, plasma transport, equilibrium, and instability. Plasma heating and refueling, fusion reactions, and the plasma particle and energy balance are treated in Chaps. 5, 6, and 7, followed by the physics and engineering constraints on fusion reactors in Chaps. 8 and 9, respectively.

Chapter 1 displays interesting statistics on U.S. energy sources and world energy consumption rates, including the devastating atmospheric effects of CO_2 on the world climate. The historical development of magnetic confinement up to 1972 is also illustrated. Comparisons of similar energy pictures with the existing fission reactors also might have been very informative to the readers. Chapter 2 describes the basic kinetic theory and the concepts of plasma physics through which a particle distribution function is introduced. Note that the distribution function is to be defined in terms of the phase space, not just in a velocity space, as was done in Eq. (2-27). It also would be desirable to elaborate on the physical implications of the coulomb logarithm, which was really an arbitrary cutoff parameter, to make a converging plasma relaxation process.

Plasma confinement and transport are discussed in Chap. 3. Magnetic drift surfaces, various particle drifts including the radial drift, neoclassical diffusion, and the scaling laws are well presented in this chapter. A specific example with an $l = 2$ stellarator geometry is quite illustrative. This chapter is organized and explained very well. Perhaps more homework problems at the end of this chapter could have enhanced the material appreciation by the students. Chapter 4 analyzes the plasma equilibrium and instabilities, both on magnetohydrodynamics and microinstability. Discussion of the Bohr-Van Leeuwan theorem is an interesting addition to the subject of plasma equilibrium, which typical textbooks of this level often fail to mention. Description of the force-free plasma, however, needs more physical explanations rather than just the definition $\boldsymbol{F} = \boldsymbol{J} \times \boldsymbol{B} = 0$. On the treatment of microinstability, the two-beam plasma instability could have been expanded.

Plasma heating and refueling are discussed in Chap. 5. Plasma heating methods by ohmic, neutral beam (including fusion products), and radio-frequency heating are presented. In dealing with ohmic heating, it would be desirable to include discussions or a simple derivation on the plasma current limit (via the Kruskal-Shafranov limit). Also, the energy relaxation processes, when discussing neutral beam heating, should perhaps contain the energy loss mechanism, including the Rutherford differential cross section. Topics on compressional heating (e.g., the concept of the adiabatic toroidal compressor tokamak) are not discussed in this chapter, and the treatment of plasma refueling is rather limited. In Chap. 6, which relates to fusion reactions, note that the side reaction of deuterium-tritium (D-T) fuel yielding a $^5He + \gamma$ reaction would be only one part in 10^3 compared to an $n + {}^4He$ reaction; hence, the gamma energy would be very significant, posing some concern about the conventional shielding and diagnostic arrangements.

Chapter 7 describes the plasma particle and energy balance. When discussing Fick's law, it would be natural to add the physics of ambipolar diffusion. Note a word of caution about the terminology; "cyclotron" radiation is not the same physical phenomenon as "synchrotron" radiation, which is often confused to have the identical meaning. Incidentally, this chapter could use some homework problems. Chapters 8 and 9 lay out some physical and engineering constraints on fusion reactors. The Lawson criterion, with some examples for D-T and D-^{3}He plasmas, and illustrations of some operating regimes for wall loading, etc., for D-T and advanced fuel reactors are quite useful additions to these chapters.

Chapters 10 through 16, covering the last half (about 300 pages) of the book, discuss the various confinement concepts for toroidal and nontoroidal devices and topics on plasma engineering, including fusion power plant design studies. The history, characteristics, and physics of the tokamak are very well summarized in Chap. 10. This book is one of only a few textbooks that have good descriptions (in Chaps. 11 and 12) of alternate confinement concepts, including the reversed-field pinch, ohmically heated toroidal experiment (OHTE), toroidal magnetic cusps, topolotron, stellarators, torsatron, bumpi tori, heliac, tandem and multiple mirrors, cusp, surmac, theta and z pinches, imploding liner, Linus, astron, field-reversed mirror, spheromak, rotamak, plasma focus, and even Migma. Comparisons of various confinement concepts are summarized on Tables 11-5 and 12-1, which are quite informative. This represents the author's long research activities in the area of alternate confinement approaches.

Plasma engineering, reactor technology, and fusion reactor applications are covered in Chaps. 13, 14, and 15. Discussions of topics like direct energy conversion (in Chap. 13), neutronics, activation analysis, and displacements per atom analysis (in Chap. 14) might have been more in-depth. Chapter 16 completes the book by presenting fusion power plant design studies based on both the mainline D-T reactors (the MATT 1050 tokamak, the STARFIRE tokamak, and the Mirror Advanced Reactor Study) and the alternate concept reactors (the compact reversed-field pinch reactor, the OHTE, the Elmo Bumpy Torus reactor, etc.). However, only descriptive comparisons with tables and diagrams are presented. Nevertheless, these materials provide a good insight into the advantages and disadvantages of all concepts that are introduced.

Overall, this book is self-contained and provides a good basis and overview on various topics of fusion energy that are quite suitable for undergraduate students. The annotated bibliography at the end of the book is quite useful to students. As for revision, this current edition needs quite a bit of editorial touch, ranging from the index (e.g., "diamagnetism" is not even indexed) and a more unified set of homework problems to the quality of reproduced figures and diagrams. Often it is difficult to distinguish "8" from "B" in some of the figures. Also, the page numbers (e.g., pp. 102, 292, 328, etc.) are out of place. According to the *Chicago Manual of Style*, odd-numbered pages should begin on the right. Obvious typographical errors should be corrected in the next edition. My students mentioned to me jokingly that this book has a not-so-attractive appearance but that it is the best introductory fusion textbook they have come across so far. I would agree! For instructors, I would just like to add that the instructor's kit is available for this textbook.

Chan K. Choi is an associate professor of nuclear engineering at Purdue University. Previously, he served as the assistant director of the Fusion Studies Laboratory at the University of Illinois, Urbana-Champaign. He devotes much of his research efforts to theoretical and computational fusion plasma engineering, including studies of the charged-particle slowdown in fusion plasmas and advanced fuel inertial confinement fusion. He has edited two important conference proceedings, one on advanced fuel fusion (1977) and the other on fusion engineering (1981). He has also published more than 100 articles and technical reports.