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.

Electrical Breakdown and Discharges in Gases—Fundamental Processes and Breakdown

Editors	E. E. Kunhardt and L. H. Luessen
Publisher	Plenum Publishing Corp.
Pages	466
Price	$65.00
Reviewer	J. G. Eden

Although it has been a subject of research for decades, the study of gas discharge phenomena continues to be infused with vitality by the applications of weakly ionized plasmas that arise periodically. The discovery of the laser in the 1960s, for example, prompted an intensive investigation of the collisional and optical properties of low-temperature plasmas that are relevant to laser excitation. In recent years, discharges in attaching gases have attracted attention due to applications of these plasmas in the rapidly growing electronics industry. The progress in the field has created a need for a book that thoroughly reviews the fundamental physics of low-pressure gas discharges, particularly in light of recent experimental results. This book meets such a need.

As noted in the Preface, this volume is a collection of papers presented at a NATO Advanced Study Institute that was held in Les Arcs, France in 1981. The book is divided into five sections: Basic Discharge Processes, Kinetic Theory, Breakdown in Uniform Fields, Breakdown in Nonuniform Fields, and Seminars (special topics). Contributions from well-known workers in the field are included in each section and, with few exceptions, the articles are well organized and clearly written. Particularly noteworthy are the contributions by J. A. Rees (Basic Processes of Electrical Discharges), A. V. Phelps (Transport Data for the Modeling of Electrical Breakdown and Discharges), L. G. Christophorou (Electronegative Gases), and L. C. Pitchford (A Numerical Solution of the Boltzmann Equation).

A significant fraction of the book is devoted to novel methods for solving Boltzmann's equation for the electron energy distribution function. Also, the discussions of breakdown in the third and fourth sections of the book are well done and provide a good deal of useful data for the student or researcher. The book is well illustrated throughout—a generous amount of space has been devoted to individual figures and each one is amply and legibly labeled.

One shortcoming is the lack of attention given to heavy particle collisions in these plasmas. Although electron-heavy particle collisions arguably dominate the behavior of low-pressure plasmas, collisions between two heavy particles, for example, play important roles in laser and lamp plasmas. Finally, the length of time required to publish the volume prevents some of the material from being as timely as one would hope.

Overall, though, the book is excellent, and it is this reviewer's opinion that it should be in the personal library of researchers and graduate students in the field.

J. Gary Eden received his BS in electrical engineering from the University of Maryland in 1972. He later received both the MS and PhD degrees (again, in electrical engineering) from the University of Illinois (UI) in 1973 and 1976, respectively. Dr. Eden was awarded a National Research Council Postdoctoral Research Associateship at the Naval Research Laboratory (NRL) in 1975. In November 1976, Dr. Eden joined the staff of the Laser Physics Branch of NRL. During his tenure there, he made several contributions to the area of visible and ultraviolet lasers and gas phase laser spectroscopy.

Since joining the faculty of the UI in 1979, Dr. Eden has been involved in research involving semiconductor film growth and nonlinear atomic and molecular spectroscopy using excimer lasers. Recent work has included a microwave approach to measuring absolute photoionization cross sections in the rare gases and the first optically pumped rare gas laser. He has directed a research team that demonstrated the growth of semiconductor and metal films by laser photodissociation and photoionization techniques.

Fusion: An Introduction to the Physics and Technology of Magnetic Confinement Fusion

Author	Weston M. Stacey, Jr.
Publisher	John Wiley & Sons, Inc.
Pages	255
Price	$39.95
Reviewer	Robert G. Mills

Weston M. Stacey, Jr., a professor of nuclear engineering at Georgia Institute of Technology, has a fine background in the subject matter of this book (having led the American effort to develop the conceptual design of the

FED-INTOR, a proposed Intermediate Test Reactor) and has written an excellent text. He has made a valiant and largely successful effort to begin with first principles and develop from them the quantitative engineering requirements for successful fusion.

After an introductory chapter dealing with the why and how of fusion and a look toward feasibility (scientific, engineering, and economic), Stacey concisely presents in three subsequent chapters those fundamental aspects of plasma behavior that are essential for understanding why plasma confinement machinery is built the way it is. In Chap. 5, he gives a somewhat brief discussion of plasma heating. Here, as in a few other places, some things are asserted rather than developed, leaving a puzzle. For example, it is stated (correctly) that ohmic heating (OH) saturates at a sufficiently high temperature, but the student may be baffled as to why.

Chapter 6 introduces the potentially serious problem of surface erosion of the "first wall" and related difficulties of augmented radiation due to plasma impurity content, and introduces the concept (again rather briefly) of the divertor as an impurity control device. Neither here, nor in the section of Chap. 11 devoted to vacuum systems, is the divertor's possibly essential role as a pump discussed.

Chapter 7, "Magnetics," is an excellent introduction to real design problems of magnetic confinement machinery. Chapter 8, "Energy Storage and Transfer," is a stimulating introduction to an important aspect of controlled thermonuclear reactor research all too often ignored in texts.

Chapter 9, "Interaction of Radiation with Matter," might well have been titled "Fusion Neutronics," a subject only recently considered relevant to existing machines, but one expected to be vital in the future. The transport of 14-MeV neutrons, their multiplication, the damage that they can do, and the induced radioactivity that will result are all discussed succinctly and well. The book closes with three chapters on tritium breeding and control and future reactors.

This is a fine book for introducing the subject to students, especially if a knowledgeable person is at hand to answer their questions. It is not ideally suited for self-study.

It is all too easy to find bases for criticism of *any* book about fusion. The problems are multidisciplinary, they are rapidly evolving, and the topics are large and diverse. An author is forced to pick and choose from among a panoply of topics; he must oversimplify to stay within reasonable bounds of bulk; he risks early obsolescence; and he must omit a great deal. Therefore, he can always be criticized for his omissions.

For these reasons, I hesitate to complain about omissions, yet I was puzzled that he did not mention the "Lawson criterion," which every student has heard of and would like to understand. The closest approach is on p. 11: "The product of the plasma density, n, and the confinement time, τ, provides a measure of the confinement." Figure 1.3.1 calls it "Quality of confinement."

The threat of obsolescence and the problem of being up to the minute are difficult to deal with. In the case of toroidal confinement, two exciting new developments prior to 1984 were the discovery in Germany of the "*H* mode" (a striking improvement of confinement) and the development in several laboratories of radio-frequency (rf)-driven currents (in contrast to inductively driven currents). The *H* mode appears in the book only as a one-line entry in Table 4.2.1 showing a three-fold improvement of thermal diffusivity with no mention in the text. As far as rf current drive is concerned, there is a parenthetical remark on p. 85: "(However, LH noninductive current drive experiments have been successful.)"; a sentence on p. 124: ". . . , but noninductive methods to supplement or replace the action of the OH coils are being studied"; and a sentence on p. 233: "It is hoped that the noninductive current-drive technique presently being investigated will relax this limit." The "limit" refers to one of the engineering problems associated with the "hole in the doughnut" that must accommodate so many things in a tokamak, in this case, the total flux of the OH transformer.

Having mentioned (and excused) these minor problems, I must raise one major objection. A book on fusion should prepare the student to read much (certainly not all) of the literature and guide him to that information that is particularly valuable. This book apparently contains references to only three or four reports. Most of these reports are not readily available, so the underlying references are hidden, and any student wishing to pursue a topic in detail is stranded.

This book cries out for a second edition that could make it quite valuable indeed. References could be added, and the editors could correct the infrequent but inevitable lapses in spelling, typography, and grammar.

Bill Stacey is a seasoned campaigner and has accumulated years of relevant experience, especially with the U.S. FED and INTOR design efforts. His sophistication is demonstrated in his final chapter on fusion reactors and especially in his treatment of constraints and trade-offs. Numerous authors have played the game of optimizing parameters, but Stacey understands the limitations of these and shows how the constraints are often far more important than the (frequently broad) optima found in parametric variations.

His book is a valuable contribution to the shelf of fusion texts and should be especially valuable for engineering students interested in systems.

Robert G. Mills has worked in fusion research at Princeton University since 1954 and participated in the engineering design of many plasma confinement magnetic devices, having led the engineering department of the Princeton Plasma Physics Laboratory (PPPL) for ~20 years. In the early 1970s, he led an 18-man effort that produced the Princeton Reference Design, the first study of a hypothetical fusion reactor done since Spitzer's original 1954 study of the Model D Stellarator. He now spends half of his time teaching fusion courses in Princeton's School of Engineering and Applied Science (SEAS) and the other half with PPPL's engineering department arranging joint projects between PPPL and SEAS to strengthen ties between these two parts of the university.