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BOOK REVIEWS

Principles of Plasma Spectroscopy, by Hans R. Griem. Cambridge University Press, 1997, 366 pages. ISBN 0 521 45504 9. $100.00.

No scientist is more qualified than Hans R. Griem to write a landmark monograph on plasma spectroscopy. He has done this before with *Plasma Spectroscopy* (1964, McGraw-Hill), and he has done it again with his new book, *Principles of Plasma Spectroscopy*. (Another outstanding accomplishment is his second, more specialized, book, *Spectral Line Broadening by Plasmas* (1974, Academic Press).) Unfortunately, *Plasma Spectroscopy* has been out of print for a very long time, and has become a frequently borrowed, valuable collector's item. This new book is the long-awaited update of its 1964 counterpart. It is a literate, scholarly, authoritative and instructive review of plasma spectroscopy.

Those who already own the original book will value the thoroughly updated and rewritten text and references, and those who have been coveting the original book will find that its overall strengths and spirit have been preserved in the new version. Not surprisingly, much has been added, and much has been taken away. The length, scope and organization of both books are similar, even though the intervening 33 years have seen tremendous progress and revolutionary changes, producing a staggering amount of new information to be included. During this time, computational methods and hardware have dramatically enhanced the quantity, quality and accessibility of theoretical atomic parameters, and have led to dramatic improvements in the accuracy of synthetic spectra and detailed line profiles. Also, lasers have arrived as probes of atomic structure and as drivers of laboratory plasmas with widened regimes of time dependence, temperature and density. The new text is not only up-to-date, but also impressively comprehensive. Much of the updated text is in the form of a critical review of recent plasma spectroscopy research, backed by a 30-page list of roughly 1300 references. This list is particularly valuable as an introduction to the literature. It is well selected, and is certain to remain a valuable resource, even as the literature grows in years to come. Most of the deleted material is no longer as essential as it once was, but owners of the earlier book will want to hold on to it. The new book is noticeably thinner than the old one because more than 200 pages of atomic data have been deleted. As is explained in the text, the updated equivalent of this material is available elsewhere, including data at certain sites on the world-wide web.

The fist three chapters of the book are brief introductions to classical and quantum radiation theory and to the oscillator strengths of radiative transitions. These chapters provide a foundation that supports and unifies subsequent chapters, but they do not substitute for a prior familiarity with standard classical physics and quantum mechanics. Chapter 4, 'Spectral line broadening', begins with a general and rigorous introduction to line broadening. Much of the chapter is a review of important published calculations, approximations and measurements. Here, as in many other places in the book, the reader is sent to the references for many details and derivations. The

material on ion dynamics is one important updated feature of the book. Some useful approximate results, such as asymptotic wing formulae and approximate expressions for various contributions to line widths, have not been retained from the older book. More introductory phenomenology of line broadening would have been useful and instructive, such as an explicit comparison of the orders of magnitude of the relevant competing effects. Also, more on approximate line-profile and line-width models would have been welcome. These are useful in applications where state-of-the-art precision is not always important, such as energy transport and the simulation of complex spectra for diagnostic purposes.

Chapters 5 and 8–11, 'Continuous spectra', 'Radiative energy transfer', 'Radiation losses', 'Spectroscopic density measurements' and 'Spectroscopic temperature measurements' respectively, correspond to similar chapters in the old book. Discussions of dielectronic recombination and the diagnostic importance of dielectronic satellite line ratios are notable additions to Chapters 9 and 10. Chapter 6, 'Cross sections and level kinetics', is a new chapter serving the increased interest in non-equilibrium plasmas, such as in short-pulse laser–plasma experiments, for example. Chapter 7, 'Thermodynamic equilibrium relations', is an updated version of the corresponding chapter in the older book. Notable added topics are high-density effects and equations of state for dense plasmas. The sections in the original book on validity criteria for local thermodynamic equilibrium (LTE) have been consolidated. The chapters from the original book 'Plasma light sources', 'Optical instruments', 'Radiation detectors' and 'Radiation standards' have not been kept. The old final chapter, 'Measurement of atomic parameters', has been removed as a distinct chapter and moved in sections to other parts of the book, where appropriate. A new final Chapter 12, 'Other diagnostic applications of plasma spectroscopy', has been added.

I did not deliberately search for the typographical errors that I found, but they do appear to be scarce and fairly harmless. Mentioning a few will remind the reader to proceed with ordinary caution. In the far right-hand side of equation (2.4) and in the text below on p. 12, indexed components of canonical momentum are represented as lower-case p_j, contrary to the prior introduction of canonical momentum using upper case. This appears to be a vestige of how the components of canonical momentum were represented in the original book. On pp. 234 and 235, the integrals in the numerators of equations (8.34) and (8.35) should be checked. Both are functions of ω, which means that ω cannot also be the integration variable as written in equation (8.34). In equation (8.35), $d\Omega$ cannot be right, because, among other reasons, the units are wrong. Even with these and the very few other errors I found, the overall impression is that the book was created with care. It is a beautiful production with excellent typesetting, clarity and construction that will certainly appeal to book lovers.

The title of *Principles of Plasma Spectroscopy* might suggest to some that it is primarily a pedagogical review of principles. This is only partly true. Those who need something specifically for this purpose will learn a great deal from reading this book. Nevertheless, students looking for a traditional pedestrian approach will be disappointed to find that some sections avoid detailed, step-by-step exposition in favour of a broader review and that they will be dependent on the reference list for filling in some of the details. This is not a bad

thing. In fact, it is probably the preferable learning process for an advanced, evolving subject. The original *Plasma Spectroscopy* was explicitly intended in part as a course textbook, complete with exercises and solutions. These exercises are now gone. Unlike traditional textbooks, very little is presented in the new book as worked-out 'textbook' examples or as instructions for performing calculations. Even though numerical computation has assumed a dominant role as a tool of atomic physics, spectral computation and radiative transport in the years since the original book, computational methods are completely absent. A great deal of experimental work is reviewed and discussed, but there is almost no discussion of instrumentation or other details of experimental methods, and only a small portion of the data is actually presented.

Principles of Plasma Spectroscopy will not satisfy every reader's every need regarding content and appropriate levels of detail, but Professor Griem has defined his boundaries and goals judiciously, and this book cannot be criticized on these grounds. This book is concise in the best of ways. The text is well organized, logical, illuminating, and very readable. As for the book's unique strengths, its emphasis on current problems and areas of potential uncertainty and controversy will certainly be appreciated. Professor Griem is among the most respected authorities on questions of this kind. Throughout the book, he offers valuable insight into the adequacy of various approximations, comparisons of alternative models, and the significance of the agreement of models with the results of selected experiments.

This book is an impressive and satisfying summary of plasma spectroscopy, from its most basic aspects to its most advanced state-of-the-field issues. For a relatively compact book (366 pages, including references and index), the hundred-dollar price is daunting. Even so, I recommend *Principles of Plasma Spectroscopy* strongly to all serious students, teachers and researchers in this field as a promising long-term investment and as an essential reference and research tool.

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Discovery of the Magnetosphere, edited by C. Stewart Gillmor and John R. Spreiter. American Geophysical Union, Washington, DC, 1997. ISBN 0 87590 288X.

The magnetosphere of the Earth was defined by Thomas Gold in 1959 as the region extending from the upper part of the ionosphere out to the limit of the space whose physics is dominated by the Earth's magnetic field. This book is a collection of personal recollections by the scientists whose pioneering work has resulted in our current understanding of this extremely complex part of the Earth's environment. These 23 men and 1 woman were invited to tell their stories in any style that suited them, including personal impressions and anecdotes and controversies, as well as objective scientific outcomes. The result is an eclectic mixture of essays, only loosely related to one another, each a self-

standing story. They range from adventures on the high seas and in the polar wildernesses, to erudite mathematical analysis of magnetohydrodynamics, to a qualitative description of the magnetosphere as presently understood.

The breadth and character of this compendium can be appreciated by scanning the table of contents:

The formation and early evolution of studies of the magnetosphere (C. Stewart Gillmor);

Aurora research during the early space age (S.-I. Akasofu);

The Earth's magnetosphere: glimpses and revelations (Kinsey A. Anderson);

The boundary and other magnetic features of the magnetosphere (Lawrence J. Cahill, Jr);

Lightning whistlers reveal the plasmapause, an unexpected boundary in space (D. L. Carpenter);

Memories, maxims, and motives (J. W. Dungey);

The role of satellite measurements in the development of magnetospheric physics: a personal perspective (D. H. Fairfield);

Early times in the understanding of the Earth's magnetosphere (Thomas Gold);

Whistlers (R. A. Helliwell);

The opportunity years: magnetic and electric field investigations (James P. Heppner);

The magnetosphere is brought to life (Colin O. Hines);

Ray tracing applied to ELF and VLF wave propagation in the magnetosphere (Iwane Kimura);

Music and the magnetosphere (Carl E. McIlwain);

Adventures with the geomagnetic field (E. N. Parker);

The role of the DISCOVERER program in early studies of the magnetosphere (Joseph B. Reagan);

My adventures in the magnetosphere (with addendum: a student's story) (S. Fred Singer and Robert C. Wentworth);

An education in space physics (D. J. Southwood);

Modeling solar wind flow past the magnetosphere (John R. Spreiter and S. S. Stahara);

Early ground based approach to hydrodynamic diagnostics of outer space (Valerie A. Troitskaya);

Energetic particles in the Earth's external magnetic field (James A. Van Allen);

From nuclear physics to space physics by way of high altitude nuclear tests (Martin Walt);

A brief history of research at Minnesota related to the magnetosphere (John R. Winckler);

Present knowledge of the magnetosphere and outstanding remaining problems (D. N. Baker).

Note that the chapters (except the first and last) are included in alphabetical order of the authors, suggesting, as is indeed the case, that no attempt was made to outline a consistent sequential development of the subject. Each contribution stands on its own. The individual discoveries were made, many unexpectedly, as new opportunities presented themselves during post-World War II developments in radio communications and rocketry and satellite technology. Indeed, the advent of artificial Earth satellites enabled most of the progress reported herein. A notable exception is the use of whistling atmospherics (whistlers) for probing the magnetosphere by radio waves by entirely ground-based observations.

This is a very entertaining and stimulating book. This reviewer's impression is undoubtedly influenced by personal friendships and collegial relationships with several of the authors, but other readers will surely enjoy these tales of serendipitous exploitation of technical developments undertaken for military or commercial reasons. This reviewer flew several experiments aboard DISCOVERER satellites, inconvenienced at the time by secrecy and not aware, until reading this volume, of the overall purpose of the programme or how our part related to the whole.

These stories are part of the burgeoning progress in physical science that occurred with the advent of the space age. They should appeal to those who participated in direct or peripheral ways, to students of physics, electrical engineering, geophysics or astronomy, or historians of science. Some technical knowledge is probably required – say the equivalent of an undergraduate degree in physics – to get the most out of them. As an archive of an exciting and extraordinarily important era in the development of geophysics, the book is invaluable.

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