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BOOK REVIEWS

Theory of Mode Conversion and Tunneling in Inhomogeneous Plasmas, by D. G. Swanson. Wiley, New York, 1998. ISBN 0 471 24776 6. £48.50.

The treatment of mode conversion in plasma–wave interactions is a fascinating and much-studied area of plasma physics. In this book, Swanson draws together twenty years of research, by himself and co-workers, into a sophisticated 'how-to' manual for calculating the scattering and absorption parameters for waves propagating through resonance regions.

The central thesis of the book is that, to describe the exact propagation of a wave through a resonance region, we must treat the problem as one of mode conversion between the propagating wave and a slower local mode, such as the Bernstein mode. This can be treated theoretically by reducing the system to a fourth-order ordinary differential equation. The solution of this equation, to produce scattering parameters between the two modes, is far from trivial, and Swanson provides us with two methods, a Green-function method and exact order reduction.

Chapter 1 defines the problem and gives us a very welcome review of the many different theoretical methods used for treating mode-conversion problems. Over the years, a multitude of such techniques – analytical and numerical – have been developed, and this is undoubtedly the most complete review of them.

Chapter 2 describes the reduction of a mode-conversion problem to a fourth-order ordinary differential equation. This is done for a variety of ion and electron cyclotron wave resonances. The algebra here is familiar, but its inclusion is vital for the following chapters.

Chapters 3 and 4 then go on to develop the Green-function method for solving the wave equation. The analysis involves a testing mathematical journey along the contours of the complex plane, but a reader with a fair understanding of complex analysis should make it safely over the saddles and back down along the valleys again. The inclusion of diagrams here is a great aid to the reader, as are the summary tables.

Chapter 5 gives a full account of how to solve the equations developed in Chapters 3 and 4 numerically. This, again is detailed, and should enable any code writer to reproduce the method. (Swanson has also made his own codes available by e-mail request.) The rather limited discussion of comparisons with other numerical methods, at the end of this chapter, however, contrasts strongly with the very good review of theoretical techniques in Chapter 1. This, perhaps, reflects a lack of research on direct comparisons between the various methods currently in use.

Chapter 6 presents the elegant method of exact order reduction, as an alternative method of numerical solution.

Chapter 7 provides a fascinating extension of mode conversion theory to resonant emission. This has a wide relevance to the interpretation of data from plasma diagnostics as well as from astrophysical plasmas. The theory is nicely

developed, and two good examples – electron and ion cyclotron emission from a thermal plasma – are provided.

Finally, Chapter 8 derives some asymptotic limits and proves a few other identities for theoretical completeness. The chapter goes some way to providing useful limiting cases, but could go further. It is well known that in certain limits, mode conversion can be small, but this is not discussed fully here.

Undoubtedly, the most attractive feature of this book is its completeness in describing Swanson's method. All the steps in the calculation are developed patiently and clearly, with the relevant functions defined in the appendices. The nature of the calculations mean that a considerable number of variables must be defined and abbreviations used for several equations, but these are all well documented and used consistently throughout. Summary tables bring together the key results of each chapter, but the involved nature of the problem, and the detailed notation, mean that it would not be easy for a casual reader to bring out results quickly.

The book would have benefited, however, from a little more discussion. Many assumptions are made in reducing the real physical problems to linear fourth-order ordinary differential equations, but these are never really dealt with. Swanson's views on how the method sits in a wider context, or at least some more references to such material, would have been of great benefit to the reader. (The parameter ranges necessary for ignoring toroidal geometry, the impact of non-Maxwellian distributions, and the consequences of nonlinear behaviour are three obvious examples.)

In conclusion, this book provides a unique account of the description of mode conversion in plasma waves. I would recommend this book to anyone working with the theoretical description or modelling of plasma–wave absorption or emission.

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Physics of Highly Excited Atoms and Ions, by Vladimir S. Lebedev and Israel L. Beigman. Springer-Verlag, Berlin, 1998, 298 pages. ISBN 3 540 64234 X. £65.00, $99.00.

Highly excited (Rydberg) states of atoms have historically been used in the initial unravelling of atomic spectroscopy through analysis of Rydberg series. Nowadays, the growth of interest in these states has been stimulated by extremely rapid developments in high-resolution laser spectroscopy and powerful modern techniques of excitation and detection, as well as radio astronomy. This book presents the most important physical approaches and theoretical techniques in the underlying physics of highly excited atoms and ions. Efficient methods for calculations in the theory of collisions involving highly excited atoms and electrons, ions, atoms and molecules are presented.

The book starts with a review of widely used methods for describing isolated highly excited atoms and ions. Basic parameters, and hydrogen-like wave functions in the coordinate and momentum representation, as well as an

account of semiclassical methods are given. Derivations of explicit expressions for Coulomb Green functions, the density matrix, and classical and quantum distribution functions of the Rydberg electron momentum and coordinates are also presented.

Chapter 3 presents theoretical techniques for calculating the dipole matrix element and form factors for transitions involving highly excited states of atoms and ions. In Chapter 4, the basic theoretical approaches to collisions involving Rydberg atoms and ions are described. Various versions of perturbation theory, classical and semiclassical methods, the close-coupling method, binary-encounter theory and impulse approximation are given in a form independent of the specific kind of projectile or type of transition. The theories described in this chapter are then applied to particular cases in the following four chapters.

Collisions involving Rydberg atoms and neutral particles are dealt with in Chapters 5–7. General techniques for calculation of transition probabilities and cross-sections between highly excited states and ionization induced by the scattering of the quasifree Rydberg electron by a neutral target are reviewed. Different elementary processes of excitation, de-excitation and ionization are considered. Theoretical results are also compared with available experimental data on quenching (depopulation) and ionization of Rydberg atomic states. The effect of the ion core on excitation, quenching and ionization following collisions with neutral particles is also studied.

In Chapter 8, a review of the extensive collision theory of Rydberg atoms with charged particles is presented. Both n- and l-changing inelastic transitions are considered, and more comparisons of theory with available experimental data and the Born approximation are given.

In Chapter 9, the theories from the previous chapters are used further as the basis for the analysis of spectral line broadening and shifts of Rydberg atomic series induced by collisions with neutral and charged particles. Particular attention is paid to thermal collisions with rare-gas and alkali-metal atoms, to perturber-core effects and to inelastic electron collisions in a plasma.

This book collects together an up-to-date account of theoretical methods for describing collisional processes involving Rydberg atoms with neutral and charged particles, transitions between Rydberg states, and finally spectral line-broadening and shifts of Rydberg atomic series in gases, as well as low- and high-temperature plasmas. The book focuses on these aspects, and does not deal with the many other aspects of this intensively developed field of atomic physics. Numerous useful references are, however, given. The book is recommended for theoreticians and experimentalists active in research or the study of atomic and molecular physics, plasma physics, spectroscopy and astrophysics.

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Dynamical Systems, Plasmas and Gravitation, edited by P. G. L. Leach, S. E. Bouquet, J.-L. Rouet and E. Fijalkow. Springer-Verlag, Berlin, 1999. Hardcover DM128, ISBN 3 540 65467 4. £49, US$95.

A meeting celebrating the 50th anniversary of the research career of Marc Feix was held in Orléans in 1997, and this book contains selected papers presented on this occasion. Amongst plasma physicists, Marc Feix is well known for his many contributions to the theory and numerical simulations of plasmas, including his introduction of the water bag model for the simulation of nonlinear processes. His seminal contributions are well described in the general introduction to this volume written by Serge Bouquet and in a paper by Pierre Bertrand called 'Honouring Marc Feix'. There is also a paper by Charles Birdsall, another pioneering figure in plasma simulations, outlining the early development of this field.

The remaining papers, some 35 in number, cover a wide range of topics, reflecting the wide interests of Marc Feix and the contributions he has made to different areas of mathematical physics. The papers of most direct relevance to readers of this journal are devoted to various nonlinear problems in plasma physics and to numerical techniques for their study, but there are also papers on gravitating systems and on a variety of topics in dynamical systems.

The book is a pleasing tribute to Marc Feix. The plasma physicist should find in it articles of direct interest, as well as others that deal with less familiar problems and indicate the impressively wide range of Feix's interests.

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