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BOOK REVIEW

Electron Acceleration in the Aurora, by D. A. Bryant. Institute of Physics, Bristol and Philadelphia, 1999, 311 + xvii pages. Hardcover, ISBN 07503 05339. £90. $150.

This book, written by a well-known, retired Rutherford Appleton Laboratory scientist, is a combination of a clear and simple exposition of physical phenomena with the author's pet theses. Mathematics is kept to a minimum. Simplicity and humour accompany the reader throughout. There are three computer programs (QBasic) as well as some questions and answers at the end. The book is rounded off with nine pages of references, three dozen or so to the author's own work.

There are 11 chapters. Chapter 1, entitled 'Acceleration principles', comprises more than a quarter of the text. This is an absolute jewel of an introduction to the subject. Acceleration of electrons, both as a concept and as a laboratory process, is described with a simplicity that only a deep understanding can generate. Particle distributions and the relevant functions are explained. Louville's theorem is illustrated by numerous examples. The difficult concept of entropy fails to frighten the reader. Diagnostics by electron multipliers and analysers are explained and illustrated.

Humour lightens this introduction to the field. To quote two random examples: electrons are likened to racing yachts; the predominance of head-on collisions over overtaking ones is illustrated by a windscreen becoming wetter than a rear car window.

In contrast to most of the book, Chapter 1 is non-controversial and can be recommended to all. My only criticism here is of technical mistakes. First editions are rarely free of error, but when figures are lost, this is serious (Fig. 1.4 has gone astray). The first equation on page 17 is not even dimensionally correct.

Chapter 2 starts the core of the book. First, a plasma state is defined in detail. The interaction of the solar wind plasma with magnetic field lines is gone into in great detail, including explanations of attendant paradoxes. This is followed by an up-to-date panorama of the Earth's magnetic field and its charged-particle inhabitants.

Chapter 3, on electron acceleration towards and in the aurora, once again constitutes more than a quarter of the entire text. Here the author gets down to considering how electrons are accelerated as they move down to the Earth to cause the appearance of the aurora. His own research is quoted. Distribution functions found by rockets are quoted at great length (both upgoing and downgoing electrons have been targeted by rockets for some time). Most readers' curiosity about details such as when these distributions are peaked in energy and when not is more than satisfied. Acceleration is argued to be largely field-aligned. These considerations are followed by refutations of existing theories of how electrons move down towards the Earth. Now we are deep into the author's own views. He believes Landau damping to be responsible. The

damped wave involved here is the lower-hybrid mode. Although this is almost propaganda, simplicity in exposition is never abandoned.

Conclusion of Chapter 3, which is more of a review article than its predecessors, brings us into the last third of the text. Therefore, our summary of the remaining eight chapters will be more cursory.

Chapter 4 is on the shock wave, called the bow shock, upstream from the Earth's magnetosphere. The auroral model of electron acceleration, outlined in Chapter 3, is modified so as to serve in this context. Chapters 5 and 6 are on the release of clouds of lithium and barium in the solar wind and related experiments. Chapter 7 treats the magnetopause, the boundary between the perturbed solar wind and the Earth's magnetosphere. Moving down a bit, Chapter 8 is on the electron populations in the magnetosphere. Theories of electron acceleration are summarized. Chapter 9 treats acceleration processes at the surface of the Sun. These processes produce the solar wind and solar free electrons. Chapter 10 is on cosmic rays. The two last-mentioned chapters treat phenomena about which very little is known. Speculations are summarized, among them those of Fermi (acceleration of cosmic rays by magnetic mirrors that arise from the galactic magnetic field). Here the author adds his own conclusions.

In Chapter 11, Dr Bryant stresses the tentative character of much of the book, though he does once again plug his Landau-damping theory of aurora electrons. This theory is (supposedly) confirmed by the finding of lower-hybrid waves in the acceleration region, just as the text went to print. These waves were found in association with downward accelerated auroral electrons (FAST satellite, 1998). Similar mechanisms are claimed to appear at the Earth's bow shock. Difficulties pertaining to understanding solar wind and solar flare electrons are summarized.

All in all, this is a good book. It is to be recommended to anyone interested in electron acceleration anywhere between himself and the Sun. The first chapter can be enjoyed by almost any classical physicist.

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