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BOOK REVIEWS

Magnetic Field Generation in Electrically Conducting Fluids. H. K. Moffatt. Cambridge University Press, London/New York, 1978. x + 343 pp. $29.50.

Unlike the gravity field of a planet, which is dominated by hydrostatics, the magnetic field provides information on the internal dynamics and structure. Despite the obvious importance of such data in understanding the structure and evolution of planets, the interpretation of planetary magnetic fields is still at a primitive stage. Dynamo theory is generally thought to provide the explanation for large magnetic fields in most cosmic bodies, particularly the Earth, the Sun, and Jupiter, and Professor Moffatt has partially filled a gap in the scientific literature by providing the first monograph devoted to this theory.

Dynamo theory is presently in the unfortunate position of offering very little predictive power. The absence of a systematic theoretical basis for the interpretation of observations had led to the persistence of phenomenological recipes such as the "magnetic Bode's law," and to the continuing interest in alternative, more exotic theories. Nevertheless, the understanding of dynamo theory is rapidly advancing, and this rapid advance is well represented in Moffat's book, where over half the references are from 1970 or later. The dynamo problem is one of quite severe mathematical complexity, in which physical intuition and dimensional analysis are powerful tools but inadequate by themselves. The approach Moffat uses is based on a course of lectures given by him to graduate students reading Part III of the Mathematical Tripos at Cambridge University, and it is not therefore surprising that the emphasis is on mathematical rigor, sometimes at the expense of physical reasoning or relevance. However, there is one recurring idea in the book which probably has profound relevance to astrophysical bodies: the importance to dynamo generation of fluid flows which lack reflexional symmetry. The simplest expression of this property is "helicity," defined as the dot product of velocity and vorticity. A nonzero average helicity can arise in rotating fluids where, for example, the flow is topologically symmetric or there is a density gradient.

Helicity alone or together with differential rotation can ensure dynamo generation, provided the flow has sufficient amplitude. Aside from the essential role of rotation, the crucial development in the theory was the realization that the helicity of small-scale motions can generate a large-scale field. Although this effect (now called the α-effect) was present in Parker's work of the mid-1950s, Moffatt correctly emphasizes the dramatic developments of the East German school of Steenbeck, Krause, and Rädler in the mid-1960s, which led to the new subject of mean field electrodynamics. In addition to being mathematically tractable, the theory is physically appealing, in view of the turbulent character of fluid planetary cores.

The strongest features of this book are the subjects to which Moffatt has made important contributions: mean field electrodynamics and the statistical description of small-scale velocity and magnetic fields, waves influenced by Coriolis and Lorentz forces, and helicity generation. These sections are balanced by a description of laminar dynamo theory and an excellent survey of the known analytical and numerical dynamo models. An up-to-date description of the geomagnetic and solar magnetic fields is also provided.

Planetary scientists might be disappointed at the brevity of Moffatt's three-page discussion of planets other than the Earth. No mention is made of the controversy between Russell and Dolginov concerning the magnetic fields of Venus and Mars, the references to the field of Mercury and the structure of Jupiter do not adequately represent the state of the art, and the Moon is not even mentioned. Moffatt treads carefully in his discussion of controversial issues such as the relative roles of external driving (such as precession) and internal driving (such as thermal convection) in planetary dynamos. He also repeats the often stated view that the slow rotation of Venus precludes a dynamo, despite the fact that large-scale motions in Venus of comparable velocity to those in the Earth's core (10^{-2} cm/sec) would still be much less rapid than the rotational velocity of the core, indicating that even the slow rotation of Venus can be dynamically important. A crucial issue such as this requires clarification, since there may be alternative explanations for the small field (such as the possible absence of an inner core).

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The final chapter is on dynamically consistent dynamos in which the equations of motion and induction are simultaneously solved. This highly nonlinear problem is obviously where the future of dynamo theory lies, since it is only by understanding the dynamic and energetic constraints that we can hope to interpret the magnitudes and spectra of planetary magnetic fields. It is too early yet to discern the outlines of a predictive dynamo theory that is relevant to planets and usable by planetary physicists, and it may be that the planets in our solar system are too dissimilar for an all-encompassing scheme, but the path is clear.

The layout, clarity of expression, and absence of typographical errors conform to the usual high standards of Cambridge University Press. Moffatt has done an excellent job in covering the present state of the theory, and his work will be invaluable to students and researchers who are interested in this difficult and challenging problem.

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Radiative Process in Meteorology and Climatology. G. W. Paltridge and M. R. Platt. Elsevier–North Holland, Amsterdam and New York, 1977. 318 pp., $41.95.

This book presents a survey of the aspects of radiative transfer bearing on the evaluation of heating rates and energy fluxes in atmospheres. A wide range of topics is covered—for example, there are chapters on aerosols and clouds and sections on nocturnal cooling and ground fog. Chapter 1 begins with a nice survey of energy balances and energy fluxes from a global point of view. After discussion of terminology and a brief treatment of the nature of the solar output, Chapter 4 presents a standard development of radiative transfer fundamentals. Two chapters on absorption and scattering of solar radiation follow, and one on modern long-wave transfer treatment methods. The complexities introduced by clouds and aerosols are discussed in the next two chapters. The final chapter is too broadly titled "Radiation and General Dynamics"—it discusses the height of the tropopause, the radiative boundary layer, and, briefly, cloud dynamics.

I feel that this is a fine introductory book, or a useful reference for those such as dynamicists who can benefit from a readable but not extremely detailed survey. The references to more detailed work seem to be reasonably complete. I have used portions of the book as a text in a graduate radiative transfer course, with success. It is more up to date and I would judge more useful to planetary scientists than Kondratyev's book, but people really involved in calculations will need to consult Goody's book, Hansen's papers, or other sources.

As usual these days, the price of the book is a real problem. In this case, since the level of detail is not sufficient for research users and students are clearly priced out of the market, it is not clear just who will be the purchasers.

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A Short Course in Cloud Physics. R. R. Rogers. Pergamon Press, Elmsford, N.Y. 227 pp. $14.50.

This little book is an excellent introduction to traditional cloud physics with a good balance of mathematical, descriptive, and pictorial material that makes for good lecture material. The author presents concise discussions of all of the topics usually covered in other cloud physics texts, except electrical phenomena, with the addition of more recent data and theory, an excellent discussion of the thermodynamics of mixing and convection, and a brief summary of recent numerical modeling results. Each of the fourteen chapters ends with a problem set which illustrates, emphasizes, and supplements the main points of the chapter. The line drawings and photographs are numerous, high quality, and very informative. The reference list is a complete and up-to-date (1975) guide to the literature, while the subject index is a detailed guide to the text. This book would find good use as part of an introductory undergraduate course in physical meteorology.

The first four chapters (25% of the book) are a very clear discussion of the thermodynamics of Earth's atmosphere used by meteorologists. The illustrations of the use of the meteorological thermodynamic charts are especially helpful to meteorology students, although these charts are not really required for later chapters. The only quibble I have concerning these chapters is the use of the term "convective instability" in Chapter 3 to refer only to the instability of a volume of air after it has been lifted by large scale motions. This may prove confusing to many readers.

The next five chapters (40% of the book) cover the heart of the cloud physics, namely, the microphysics of both liquid water and water ice clouds