BOOK REVIEW

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.

Principles of Magnetohydrodynamics

Authors Hans Goedbloed and Stefaan Poedts

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Reviewer Ian Hutchinson

Magnetohydrodynamics (MHD) governs plasmas insofar as they can be described as conducting fluids. Perhaps because of its relative simplicity compared with kinetic theory descriptions, it is one of the most successful subdisciplines of plasma physics in predicting and explaining much equilibrium and stability behavior in varied contexts that range from fusion energy research to space weather and astrophysics. The present book, written by two MHD theorists, sets out to teach the fundamentals of MHD while conveying the broad range of its applications by treating both magnetic plasma confinement and solar physics. I found the combination a delightful opportunity to learn some background outside my own primary speciality (fusion plasmas). The combination works—and that alone is high recommendation.

Principles of Magnetohydrodynamics is a book in which mathematics is predominant, reflecting the expertise of its authors. The sense in which it should be considered a textbook (given that the topic would represent a highly specialized graduate course) is primarily that it does not take for granted excessive background knowledge (of the behavior of differential equations for example) but carefully leads the reader through the mathematics at the appropriate stage of the development. Examples where this is very helpful include: formal treatment of MHD wave dispersion in elegant matrix notation, demonstration of the self-adjoint properties of the MHD force operator, and the treatment of the singularities leading to the MHD continuum. The authors also sometimes give more than one approach for key results, which is an excellent way to gain depth of insight and understanding. This relatively formal approach to the development of MHD lends itself well to the systematic development of MHD spectra, and waves and instabilities in inhomogeneous plasmas. The reader's engagement in physics is promoted by grounding the discussion in questions about the hydrodynamics of the solar interior, and the magnetized gravitating slab, as well as a whole more-descriptive chapter about magnetized plasma dynamics in the context of the sun, solar system, and planetary magnetospheres. A chapter on cylindrical plasmas provides a solid introduction to equilibrium and the stability theorems relevant to magnetic confinement that are associated with the name of Newcomb. The result overall is a fine work of reference to many of the classic results of the field.

One difficulty with the rigorous pursuit of the mathematics is the sheer length of the book that results. By the end of its 600 pages, we still have not reached the point of addressing directly the current forefront topics of MHD equilibrium and stability relevant to tokamaks. The authors plan to bring out a second volume titled *Advanced Magnetohydrodynamics* in which they will treat nonideal MHD. But even such crucial ideal MHD topics as toroidal kinks, ballooning formalism, beta limits, and toroidal eigenmodes are absent from the first volume. It must therefore be considered to provide a formal rather than a practical education in MHD. The overall length would have been helped by omitting most of the first 128 pages, which introduce plasma physics in general but do so in a way that is not pedagogically very useful. It would have been better, I think, for the authors to have jumped straight into MHD and left the plasma physics introduction to other books. Readers will improve their experience by skipping straight to Chapter 4. A most unfortunate blemish on the book is a serious muddling of the calculation of ideal MHD resonant absorption in Chapter 11, which will be badly misleading to the neophyte.

Setting aside the few shortcomings, the most attractive characteristic of *Principles of Magnetohydrodynamics* is the elegance of its mathematical approach. The luminosity of the exposition is truly a pleasure. It gives a glorious sense of the wonder of both classical physics and the classical mathematics that is its foundation as well as its offspring. It shows how mathematics, especially through differential equations and Hilbert spaces, unifies the mostly classical world of plasmas with quantum theory. And it communicates the authors' appreciation for the beauty and "clues on the coherence of the universe" that are contained in magnetohydrodynamics.

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