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BOOK REVIEW

Magnetohydrodynamic Turbulence. By Dieter Biskamp. Cambridge University Press, 2003. 310 pp. ISBN 0521810116. £65.

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Magnetohydrodynamic (MHD) turbulence has a lot in common with ordinary fluid turbulence. Similar concepts apply equally to magnetic and fluid turbulence, such as intermittency, turbulent cascades, and closure approaches, as well as the question of finite time singularities. These are of course also very active topics of current research, which tends to make it hard to present them in textbook style – especially because the author himself has contributed significantly to the field. Nevertheless, this new book by Biskamp presents hydromagnetic turbulence as a very accessible and highly interesting topic both for students and professionals.

The first part of the book could well be used as a general introduction to MHD. The basic equations are explained, rewritten in conservative form, and then used to state a number of conservation laws that are very important in MHD turbulence. Here the equations are also applied to wave problems and to the classic tearing instability. The tearing instability represents one possible avenue to turbulence, as is nicely illustrated by showing results from simulations.

The first real contact with turbulence is rather practical and therefore easy to grasp. Prandtl's mixing length concept may not appear at first sight very relevant to magnetism but once the equations are recast in terms of Elasser variables, turbulent diffusivity and the α-effect can be seen more easily. Among the more MHD-specific aspects are the Alfvén effect and the conservation of magnetic helicity which have no direct correspondence in fluid turbulence, but which can be quite important in dynamos and in decaying turbulence.

Biskamp then turns to the problem of forward and backward turbulent cascades and, in particular, to the problem of anisotropy that is caused by the magnetic field itself. In all these cases, theory is nicely complemented by results from direct simulations, where those of Biskamp himself are amongst the largest available to date. These results are then put into historic perspective by discussing in fair detail the EDQNM closure approach that played an important role in the seventies in connection with the inverse cascade and large-scale dynamo effect.

Of great current interest is the question of intermittency, i.e. the dependence of the scaling exponents on the order of the corresponding moments. The more the dependence of the scaling exponents on the order deviates from a linear relation, the stronger the degree of intermittency. These scaling exponents are one of the most important quantities used to characterise both numerical and laboratory turbulence. However, intermittency is also a topic where important advances have been made just in the last decade: for example the extended self-similarity hypothesis and the log-Poisson model, both originally proposed in connection with fluid turbulence, but then immediately applied to MHD. Biskamp's chapter on intermittency provides an ideal reference both for beginners and experts.

Although turbulence is usually three-dimensional, there can sometimes be circumstances, for example strong stratification and rotation or an externally applied magnetic field, that render the turbulence sufficiently anisotropic that it can be modelled as two-dimensional. More importantly, however, two-dimensional turbulence is also a topic of purely academic interest. In the early days the study of two-dimensional turbulence was partly motivated by the attempt to make turbulence simulations computationally affordable, but since it is in many respects very different from three-dimensional turbulence, it has always been important to understand these differences theoretically. In this sense the corresponding chapter in the book provides an excellent account of what is now known both in fluid and in MHD turbulence.

The remaining four chapters are devoted to the more detailed discussion of various astrophysical applications, including compressible turbulence and convection, solar wind, accretion discs, and the interstellar medium. These chapters are very readable and, like many other chapters in the book, they do not assume complete familiarity with the preceding chapters. The theory of MHD shocks is presented in elementary steps, the effects of compressibility on the She-Leveque relation are highlighted, and some remarks regarding numerical issues are presented. Next, convection and passive scalar turbulence are discussed and briefly related to convective dynamos. The basics of solar wind dynamics and the Parker spiral are explained and the latest Ulysses data are shown and, finally, actual power spectra of solar wind turbulence are discussed. In connection with accretion discs the standard thin disc model is first explained and then reasons against purely hydrodynamic turbulence are given. This chapter culminates in a presentation of the theory of the now famous magneto-rotational instability. Finally, in the chapter about interstellar turbulence the crucial observational facts are discussed and the question of the generation of turbulence is addressed.

In summary, the book is interesting to read for experts in the field who want to compare their own understanding with what one might refer to as the currently accepted common knowledge. The book is also well suited for looking up facts, or for just dipping into sections of interest. The accessibility of the various topics is facilitated by a reasonably long table of contents (4 pages) and an index of 5 pages. The references (15 pages) are a comprehensive list of original literature and further reading material. This book should certainly belong to the compulsory literature of any graduate student working in hydromagnetic turbulence.

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