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BOOK REVIEW

Plasma Physics for Astrophysics. By R. M. Kulsrud. Princeton University Press, 2004. 456 pp. Hardback: ISBN 0-691-10267-8. £65.00 or $99.50. Paperback: ISBN 0-691-12073-0 £29.95 or $45.00.

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Plasma physics and astrophysics have grown into rather specialized and separate (from the rest of physics and from each other) fields. A run-of-the-mill modern textbook in either area often amounts to little more than an introduction to the jargon followed by a collection of technical prescriptions written in that jargon. That is most definitely what Russell Kulsrud's book is *not*. "I set my goal in this book" he says in his preface "to present plasma physics as a comprehensible field of physics that could be grasped largely on the basis of physical intuition and qualitative reasoning, in a way similar to other fields of physics." Just so: Kulsrud's book is first and foremost a physics text in that it strives to teach its reader to make sense of the observed phenomena in the way physicists have always done: to start from fundamental physical laws and, guided by reason and intution through a succession of minimal models, to approach reality. This reality never acquires the overwhelming taxonomic complexity of a space zoo, where multitudinous objects, scales, processes, features, and, yes, species (of particles), all coexist and require copious amounts of nomenclature to be identified and distinguished from each other (a prominent astrophysicist once quipped to me on this subject: "We make up all these terms to keep the physicists out"). The astrophysical problems discussed in Kulsrud's book stay simple in their appearance, but, in treating them, the author brings forth physical concepts, ideas and methods that possess a degree of universality. Mastering these will help the reader develop a physicist's view of astrophysical plasmas.

Most of the luminous matter in the Universe is plasma. Treating it as a fluid, which has been the dominant approach in much of theoretical and most of computational research in astrophysics, is appropriate only if particle collisions are strong, i.e., if the particles' mean free path/collision times are smaller than all spatial/temporal scales of interest. In astrophysical problems, this turns out to be false more often than not, and so, an astrophysicist must understand plasma physics beyond the fluid approximation: a panoply of plasma waves, wave–particle interactions, effects of magnetic fields on the transport of momentum and heat, collective phenomena, etc. All this can be quite off-putting for those brought up with a view of the equations of compressible magnetohydrodynamics (MHD) as the Alpha and Omega of theoretical astrophysics. In Kulsrud's book, the readers with a fluid mechanics background will find a wise and friendly guide to all the plasma phenomena mentioned above and – most importantly – to the way in which they fit together and which is important when.

Kulsrud starts with the elementary laws of charged particle motion in a magnetic field. He then introduces the magnetohydrodynamic approximation and gives a basic course of MHD: flux freezing, conservation laws, waves, shocks, and, finally, the stability theory (it will be the readers' priviledge to learn the energy principle from one of its creators). He goes on to discuss collisions and collisional transport in magnetized plasmas (the Braginskii theory). This establishes the limits of applicability of the MHD description and so the circumstances in which collisionless effects become important. The latter – in particular, cold-plasma waves and Landau damping – are introduced next. All this adds up to a very well-designed basic course of plasma physics, which culminates in a chapter discussing some theoretical approaches to nonlinear phenomena: the quasi-linear kinetic theory of wave–wave and wave–particle interactions and a phenomenological theory of MHD turbulence.

Many astrophysical applications are brought up along the way and fit seamlessly into the text: indeed, *Plasma Physics for Astrophysics* is that rare textbook that affords its reader a chance to learn physics from a genuine physicist: curious about the fundamental nature of things but always in touch with the physical reality. Thus, no calculation is allowed to run away into realms of cold asymptotic abstraction, as the author is never shy of substituting numbers and tackling a practical problem to show that the formal developments actually do say something about the real world.

Finally, the first 300 odd pages build up a sufficient theoretical foundation to allow the author, in the last three chapters, to discuss several topics that are at the forefront of current research: cosmic rays, turbulent generation of magnetic fields (astrophysical dynamos) and magnetic reconnection. Many problems in these areas remain unsolved and are the subject of a steady stream of papers in astrophysics and plasma physics journals. Kulsrud's chapters are more a personal view than a review of the literature, but, since he has contributed more than most to all three areas, both student and expert will benefit from this pedagogical account of his current views on the issues involved.

All chapters are followed by short sets of rather inventive problems – often toy versions of real astrophysical problems – which should prove both enjoyable and helpful to the readers who wish to gain active command of the material.

The book is accessible to anyone with a basic training in undergraduate physics, at least if it is read in the way recommended by the King of Hearts: "Begin at the beginning and go on till you come to the end: then stop." Except there is no need to stop: this book can be the beginning of a successful career in plasma astrophysics for an aspiring student or of a new chapter in the work of an established researcher.

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