ASTROPHYSICAL FLOWS

Almost all conventional matter in the Universe is fluid, and fluid dynamics plays a crucial role in astrophysics. This new graduate textbook provides a basic understanding of the fluid dynamical processes relevant to astrophysics. The mathematics used to describe these processes is simplified to bring out the underlying physics. The authors cover many topics, including wave propagation, shocks, spherical flows, stellar oscillations and the instabilities caused by effects such as magnetic fields, thermal driving, gravity and shear flows. They also discuss the basic concepts of compressible fluid dynamics and magnetohydrodynamics.

The authors are Directors of the UK Astrophysical Fluids Facility (UKAFF) at the University of Leicester, and Editors of the Cambridge Astrophysics Series. This book has been developed from a course in astrophysical fluid dynamics taught at the University of Cambridge. It is suitable for graduate students in astrophysics, physics and applied mathematics, and requires only a basic familiarity with fluid dynamics.

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Preface

Almost all of the baryonic Universe is fluid, and the study of how these fluids move is central to astrophysics. This book originated in a 24-lecture course entitled 'Astrophysical Fluids' given by one of us (JEP) in Part III of the Mathematical Tripos at the University of Cambridge, comparable in level to a graduate course in the USA. The course was intended as a preparation for research, and the book reflects this. Preparing the lecture course and especially its booklist made it plain that there was a need to bring these ideas together in one place.

The book provides a brief coverage of basic concepts, but does assume some familiarity with undergraduate-level fluid dynamics, electromagnetic theory and thermodynamics. Our aim is to give a flavour of the fundamental fluid dynamical processes and concepts which an astrophysical theorist ought to know. To keep the book to a manageable size, we have had to be selective. In particular, we omit all discussion of dissipative fluid processes such as viscosity and magnetic diffusivity.

As well as covering a range of fluid dynamical concepts, we introduce some mathematical ideas and techniques. None of these is particularly deep or abstract, but some of the implementations do require some moderately heavy but straightforward algebra. Thus the reader will benefit from some familiarity with undergraduate-level mathematical methods, as well as some facility in mathematical manipulation. This takes practice and care, but more than anything it requires the ability to spot a mistake before proceeding too far.

Ideally, of course, one does not make mistakes, and some lecturers like to give their students the misleading impression that this is how research is done. In practice, errors occur all too frequently, and unfortunately some of these make their way into the research literature. The best method for finding errors is to understand the physical processes involved and how these processes are expressed in mathematical formulae. For this reason, this book emphasizes physical understanding and the extraction of relevant physical ideas from a mass of equations. To achieve this we often drastically simplify problems and keep only the physical processes of interest. For example, in the chapters on stellar oscillations we eliminate much of the heavy algebra which appears because real stars are spherical, and instead assume that stars are square (plane-parallel) or at worst (for rotating stars) cylindrical. This lets us get at the underlying physical processes without obscuring them with mathematics.

The problems at the ends of the chapters come both from the problem sheets associated with the course and from the examination questions set for it. They are intended to illustrate the course material further and also to introduce additional ideas. Thus they are an integral part of the book, and the determined reader will benefit from working through them.