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A. Satya Narayanan

An Introduction to Waves and Oscillations in the Sun







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A. Satya Narayanan

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A. Satya Narayanan Indian Institute of Astrophysics Bangalore, India

ISSN 0941-7834 ISBN 978-1-4614-4399-5 ISBN 978-1-4614-4400-8 (eBook) DOI 10.1007/978-1-4614-4400-8 Springer New York Heidelberg Dordrecht London

Library of Congress Control Number: 2012946177

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Dedicated to
Professor Bernard Roberts (Bernie)
With Respectful Regards

Preface

Waves and oscillations are present everywhere. In particular, the Sun, which is the nearest star (whose disk is clearly visible), compared to the other stars in the Milky Way and those in other galaxies, has a variety of waves and oscillations. The classification of these waves depends on the external forces acting on the Sun. It is a natural plasma laboratory, in which both experimental and theoretical studies of plasma can be applied and verified with observations. The most important waves that are present in the Sun are the Alfvén wave and the fast and slow magnetoacoustic wave, which arise due to compressibility effects.

The first chapter provides a brief introduction to the Sun and its structure and composition, such as density, pressure, temperature, and other plasma parameters. Also dealt with are the different features and their morphology. The second chapter introduces basic ideas of electromagnetics, to pave the way for the subsequent discussions on magnetohydrodynamics (MHD). In addition to the waves and oscillations present in the Sun, there are other dynamic phenomena taking place in the Sun. A brief discussion of the basic concepts of MHD, its equations, and assumptions is introduced. Some simple analytic solutions of the complicated MHD equations, under simplified, yet physical situations, are discussed. Notably, the concepts of flux tubes, current-free and force-free magnetic fields, a simple model of the prominences, and the relationship between the vorticity and the induction equation are mentioned in passing. Finally, the Parker solution, which describes the phenomenon of solar wind, is introduced.

Chapters 4 and 5 deal with the theoretical aspects of waves and oscillations in homogeneous and nonhomogeneous structured media. Chapter 4 has more relevance to Alfvén and sound waves. The effect of gravity, shear flows, is mentioned briefly. Observational signatures and nonlinear studies on waves in homogeneous media are mentioned briefly. Chapter 5, which deals with waves in a nonuniform media, discusses waves in interfaces (magnetic, density discontinuities), uniform slab, and cylindrical geometries. A brief introduction to waves in an annulus and twisted magnetic flux tube is included in this chapter.

Waves and oscillations, in general, exhibit instabilities. Theoretical studies of instabilities are rather difficult. However, a brief introduction to well-known

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instabilities, such as the Rayleigh-Taylor instability, Kelvin-Helmholtz instability, and parametric instability, is presented in Chap. 6. Also, the magnetic buoyancy (Parker) instability and its importance in astrophysical flows are included.

The importance of the waves and oscillations present in the Sun from an observational point of view is reviewed in Chap. 7. There are discussions of waves in sunspots, the 5-min oscillations, chromospheric oscillations, and oscillations in the corona. An introduction to Moreton and EIT (Extreme ultraviolet Imaging Telescope) waves is included at the end of the chapter. Chapter 8 deals with helioseismology, a branch of solar physics. This method helps in getting a clear picture of the internal structure of the Sun, based on the analysis of the several modes (global) of oscillations present in the Sun.

Bangalore, India

A. Satya Narayanan

Acknowledgments

This book includes some of the works by the author. However, the immense contribution of several experts working in the field has helped the author greatly. He has had personal interaction with some and knows the others through their work. The author wishes to acknowledge the following people: E. R. Priest, B. Roberts, M. Goossens, J. L. Ballester, M. S. Ruderman, R. Erdelyi, V. M. Nakariakov, M. J. Aschwanden, J. C. Dalsgard, T. Sakurai, N. Gopalswamy, K. Somasundaram, S. S. Hasan, P. Venkatakrishnan, B. N. Dwivedi, H. M. Antia, C. Uberoi. He has also utilized figures generated by some of these authors for this book. To those who are not mentioned explicitly, he renders his apology.

The author expresses his sincere thanks to his colleagues, R. K. Chaudhuri, M. V. Mekkaden, A. V. Raveendran, and S. K. Saha, who encouraged him in this endeavor and gave him confidence.

Special thanks are due to R. Ramesh, who went through the whole manuscript, for his positive criticisms and suggestions. Baba Varghese, C. Kathiravan, and Indrajit Barve are thanked for their help in generating diagrams and images.

The author wishes to convey his heartfelt regard to Dr. Sreepat Jain, whose encouragement and efforts made the book possible. He is grateful to the reviewers for the positive recommendations and suggestions. Many thanks to Maury Solomon and Megan Ernst of Springer for their initiative and support. The publisher, Springer, has done a wonderful job, and the author is thankful to them.

Finally, no author can hope to write a book without the support of the family. The author had the able support of his wife (Sukanya) and son (Prahladh S. Iyer). To both of them, he owes a lot.

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