

Preface

This volume synthesizes the work carried out by several French teams and their international collaborators during SIROCO (SeIsmology for ROTation and CONvection), a project funded by the French *Agence Nationale de la Recherche* (ANR), from 2007 to 2010. This work was driven by the need for theoretical insight into the huge quantity of high-quality observational data recently provided by space experiments such as CoRoT and Kepler.

Ultra-high precision photometry is now available for thousands of stars, from main-sequence to red-giant stars and spanning the Hertzsprung–Russell diagram with an unprecedented completeness. As the SoHo mission unveiled the solar interior, the CoRoT and Kepler missions constitute a new dawn for asteroseismology, allowing a detailed probing of stellar interiors. This enables our understanding and modeling of stellar structure and evolution to be tested as never before. In particular, stellar masses, radii, and ages can be derived with an unprecedented accuracy.

It has long been known that the main uncertainties in stellar structure and evolution are those related to hydrodynamical processes, in particular to those of stellar rotation and the transport of energy by turbulent convection. In the context of CoRoT and Kepler this project came at a propitious time, since the convergent efforts in developing theories and numerical models for rotating stars and their oscillations provide a crucial step in the progress of our knowledge of stellar interiors.

For instance, rotation is known to have significant impact on the structure of stars and their evolution. Many issues regarding the modeling of such an impact needs to be investigated. Centrifugal distortion of fast rotating stars requires fully two-dimensional studies to properly infer the effect of rotation on oscillations, and this was one of the SIROCO objectives. This is particularly important for massive stars such as O and B stars, many of which are fast rotators, in particular the very rapidly rotating Be stars, and for intermediate-mass rapidly rotating stars such as the delta Scuti stars. Both exhibit complex and puzzling features in their oscillation frequency spectra that call for a solid theoretical background to aid their interpretation.

The second SIROCO topic was related to turbulent convection, a cornerstone of any realistic stellar model, but which up to now had been lacking tight observational constraints. Mode frequencies can be used for this purpose, but mode ampli-

tudes provide more powerful seismic diagnostics since they depend on the dynamical properties of turbulent convection. It is only the recent space observations that have provided data with sufficient precision for such theories to bear fruits.

The focus of the SIROCO project on these two fundamental problems, with the aim of providing a solid theoretical background, has enabled the development of adapted seismic diagnostics. This is a crucial step toward a complete and fruitful exploitation of the wealth of data provided by the CoRoT and Kepler spacecrafts.

The first part of the book concentrates on rotation and associated seismology. The first four chapters present the modeling of rotating stars; in particular, they examine the impact of rotation on massive-star evolution, the different transport processes in stellar interiors, the 2D modeling of rotating stars, and the influence of initial conditions on the rotation history. Then, four chapters present models for the oscillation of rotating stars. The first two consider the properties of the oscillation modes through 2D numerical calculations and asymptotic theory, and the next two discuss low-frequency oscillations and prospects for asteroseismology in rapidly rotating stars.

The second part of the book deals with convection and associated seismology. First, the connections between stellar oscillations and turbulent convection are examined; next, a chapter investigates semi-convection; finally, experimental and numerical investigations of internal gravity waves excited by turbulent penetrative convection are presented.

The audience targeted by this book consists of researchers, PhD students, and postdocs. This book is based on tutorials and discussions held at the SIROCO workshop in Paris (France) in May 2011, which has allowed us to give a progress report on the very latest asteroseismological developments in stellar rotation and convection. It is our hope that this book will stimulate further research in this fascinating field.

The editors sincerely thank the authors for the high quality of their contributions.

Paris, France

M.J. Goupil
K. Belkacem
C. Neiner
F. Lignières
J.J. Green

Studying Stellar Rotation and Convection

Theoretical Background and Seismic Diagnostics

Goupil, M.; Belkacem, K.; Neiner, C.; Lignières, F.; Green, J.J. (Eds.)

2013, XI, 261 p. 85 illus., 46 illus. in color., Softcover

ISBN: 978-3-642-33379-8