Preface

The Sun and stars rotate in different ways and at different velocity rates. The knowledge of how they rotate is important in understanding the formation and evolution of stars and their structure. The closest star to our Earth, the Sun, is a good laboratory to study in detail the rotation of a G star and allows to test new ideas and develop new techniques to study stellar rotation. More or less massive, more or less evolved objects, however, can have a very different rotation rate, structure and history.

In recent years our understanding of the rotation of the Sun has greatly improved. The Sun has a well-known large-scale rotation, which can be measured thanks to visible features across the solar disk, such as sunspots, or via spectroscopy. In addition, several studies cast light on differential rotation in the convective zone and on meridional circulation in the radiative zone of the Sun. Even the rotation of the core of the Sun can now be studied thanks to various methods, such as dynamics of the gravitational moments and of course, helioseismology, through g-modes analysis.

Moreover, the magnetic field is strongly linked to the matter motions in the solar plasma. The solar magnetic field can be measured only at the surface or in the upper layers. It is the product of the internal dynamo or of the local dynamos if they exist – in any case magnetic field and rotation cannot thus be separated.

The wide variety of stars, however, offers an equally wide variety of rotation rates and rotational evolution. From the slowly rotating stars to stars rotating close to their breakup velocity (such as Be stars), different techniques and models have to be developed to study rotation and its effects on physical aspects of stars.

This book, while not attempting to answer all questions about rotation – given that many issues still have to be further investigated, focuses on the basic and some particular aspects and aims to show why it is important, from a physical point of view, to study stellar rotation. Specifically

- The first chapter (J.P. Zahn) compares the Sun to other slowly rotating stars, investigates the angular momentum history of the Sun and reviews the physical processes responsible for its internal rotation profile.

- The second chapter (J.P. Rozelot) develops the current issues raised from observation of the shape of the Sun and shows the interest of the sub-surface layers.
- The third chapter (M.J. Goupil) explains effects of rotation on p-modes of pulsations.
- The fourth chapter (M. Rieutord) develops the basic knowledge needed to understand the properties of the low-frequency spectrum of rotating stars.
- The fifth chapter (S. Turck-Chièze) presents the current knowledge of the rotation of the solar core, including very recent results.
- The sixth chapter (G. Meynet) reviews the effects of axial rotation in stellar interior models and their important role at low metallicity.
- The seventh chapter (A. Domiciano de Souza) presents the advent of interferometry in the study of rotation for various types of stars.
- The eighth chapter (Ph. Stee and A. Meilland) considers Be stars and the need for critical rotation to trigger the Be phenomenon.
- The ninth chapter (F. Royer) details the effects of gravity darkening and differential rotation with particular attention to the case of A-type stars.
- Finally, the last chapter (V. Bommier) presents the next step to be made after introducing the effects of rotation in stellar models: the detailed study of magnetic fields, with the Sun as a prime example. Indeed, in the most upper layers of the solar photosphere, where the magnetic field begins to play an active role well marked by prominences (or other streams), this magnetic field shows a global structure linked to the differential rotation (within the leptocline, which is the seat of the structured magnetic field in connection with the differential rotation and the change of the radial gradient of rotation).

Based on tutorial lectures given at a graduate school on the same topic held under the auspices of the CNRS (France), we foresee that our book will be of interest and useful to a rather broad audience of scientists and students – in particular for the latter as a kind of high-level, yet accessible introduction – as we currently witness a complete renewal of astrophysical ideas about stellar rotation, mainly due to the development of new models including high-order effects of rotation and magnetism. In this context it appeared important to confront the experience of solar astronomers with that of stellar astronomers. Transposing progresses obtained in the field of solar physics (e.g. from helioseismology to asteroseismology) has always been a fruitful way to proceed.

We thus hope that our book will contribute to get many astronomers and students interested in studying the rotation of the Sun and stars and its interaction with other physical processes. At this point, we would like to thank the authors for their commitment to this endeavour.

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