

Preface

In the week of May 12–15, 2014, the Observatory of Besançon (France) welcomed a scientific community willing to develop new ways on how stars could be resolved and mapped to confront theory and observations. The cartography of the surface of the stars requires diverse skills, technique of analysis, and advanced modeling, i.e., the collaboration of scientists with various expertises. About 25 physicists and astronomers were able to debate, exchange, and share their knowledge in that rapidly developing field. Specific sessions were devoted to practical exercises, which encountered a real success. Following tradition, as this book is the fourth of a series, the speakers of this school were asked to supply a written version of their talks. Two additional chapters were added to provide a broader vision of the topic.

A particular attention has been paid to the Sun, with the invitation of solar experts in this area, because the Sun, due to its proximity, is a valuable laboratory for the mapping of all other stars. The knowledge gained on the Sun and the techniques developed are thus very important for scientists working on other stars.

Even in the best weather conditions, the instrumental diffraction limits drastically the angular resolution to perform astronomical imaging outside our solar system. Today, new techniques allow us for the first time to obtain nice images of stars. In particular, interferometry, combined with adaptive optics, recently allowed to reconstruct images of several stars. Already seven stars have been resolved in detail, in addition to the Sun of course.

This book takes stock of what was achieved with interferometry so far in Chile, on the ESO VLTI instrument and in the United States on the CHARA instrument. Physical aspects of the observations are important, especially in the case of rapidly rotating stars, for which the flatness and gravity darkening of the photosphere constrain models.

In addition to interferometric techniques, this book highlights mapping of surfaces of stars using Doppler or Zeeman–Doppler imaging methods, i.e., the use of spectroscopic or spectropolarimetric data to map spots, abundance, or magnetic fields at the stellar surface. It is also possible to resolve close binary stars by eclipse methods, which gives access to the interacting components.

This book also reports on the best images of the solar surface and connects the observable differential rotation to the underlying physical parameters. Recent measurements of flattening of the solar surface by SDO showed that its shape is linked to the rotation of its core. Such a result can probably be applied generally to stars.

The General Overlook of This Book Is as Follows. Chapter 1 by Aimé and Theys presents the basics of image reconstruction in astrophysics. Chapter 2 by Kosovichev and Zhao deals with the reconstruction of solar subsurfaces through local helioseismology from the GONG network and two space missions SOHO (Solar and Heliospheric Observatory) and SDO (Solar Dynamics Observatory). Chapter 3 by Lanza and Chap. 4 by Hiremath present results obtained from space photometry through helioseismology to map surface spots and thermal and magnetic field structures of the Sun. Chapter 5 by Rieutord shows how physical processes lead to the observed surface inhomogeneities. Chapters 6, 7, and 8, by Kervella, Perrin, and Domiciano de Souza, respectively, show the use of interferometric techniques to infer the shape, surface spots, and rotation of more distant stars. Finally, Chap. 9 by Kochukhov explains how spectroscopy and spectropolarimetry allow us to produce images of stars and, in particular, of their spots, abundance maps, and magnetic field configuration.

The authors wish to express their gratitude to all participants and speakers as the Besançon workshop permitted to anticipate the development of this particular branch of astrophysics, not only through future formal publications but also, and in many cases, through detailed discussions between specialists of different disciplines. The authors would also like to thank Jeff Kuhn, from the Institute of Astronomy of the Hawai University, for his plenary lecture, which could not be transcribed in this book.

We sincerely hope that all scientists, doctors, and students will be happy to find here the base of this new field of research, aimed at revealing the surface of stars.

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