Preface

Magnetic fields are seen to interweave the fabric of the universe wherever telescopes are directed to. They are observed and measured in such diverse astrophysical objects and scale-sizes as galaxies, interstellar clouds, stars, planets, and compact objects, including the Sun and the Earth. While primordial magnetic fields may have been pre-existent in the early universe, it is believed that most cosmic magnetic fields that we observe nowadays have been, and still are, continuously created by an electromagnetic inductive process known as the dynamo effect. Various types of astrophysical dynamos form the cosmic power plants for the production of magnetic fields. They are a central theme of virtually all kinds of astrophysical research and of planetary physics and geophysics. Here, they are the central topic this book is devoted to.

This monograph is a thorough introduction to astrophysical dynamos, leading up to present-day research questions. It is directed at physics students at the intermediate to advanced level with basic knowledge of hydro- and electrodynamics, for self-study or for study in classes. Also, the advanced astrophysicists may learn to appreciate it as an introduction to, or a reference book on, the foundations of astrophysical dynamos. After familiarizing the reader with the concept and meaning of the magnetohydrodynamic equations, it starts with basic examples of kinematic flows and discusses conditions for the onset of dynamo action. The main part of the book is devoted to the solar dynamo, which is the best studied stellar dynamo with the most precise and longest lasting observational record. Different types of stellar dynamos across the H-R diagram and a brief outlook on compact objects, galaxies, and beyond, complete the book. Each chapter is complemented with an annotated bibliography leading the reader to background information including historical matters, as well as to the more advanced literature and present-day research articles. The book is accompanied by a course Web page, which can be found under http://obswww.unige.ch/SSAA/sf39/dynamos. It contains animations of several figures of Chaps. 2 and 3, to which references are made in the text. Other than ad hoc introduced equations and definitions, all equations can be derived step by step (and should be rederived by the reader for a healthy exercise), often by using the appendices, which contain all

the necessary identities and theorems from vector calculus, and operators and fluid equations in the cylindrical and spherical coordinate systems.

The present book is an extended and updated version of the lectures delivered under the same title by Paul Charbonneau during the 39th "Saas-Fee Advanced Course", which took place in Les Diablerets (Switzerland) from March 23–28, 2009. The course title was "Magnetic Fields of Stars: From the Sun to Compact Objects" and included additional lectures by Sami K. Solanki (Magnetic fields in the atmospheres of the Sun and stars) and Christopher Thompson (Stellar Magnetofluids). Sixty students from 16 countries attended the course and could benefit from the excellent lectures delivered by these top experts. The Eurotel in Les Diablerets provided much appreciated hospitality. Snow, sunshine, and not least skiing and curling were also appropriately enjoyed by the course participants.

The organizers of the course, M. Liebendörfer and F.-K. Thielemann (University of Basel), S. Berdyugina and O. Steiner (Kiepenheuer-Institut, Freiburg i.Br.), and R. Hirschi (Keele University) thank the three speakers for high-standard lectures, Paul Charbonneau for preparing the present lecture notes, and the course students for their active participation and enthusiasm. They also gratefully acknowledge financial assistance provided by the Swiss Society for Astrophysics and Astronomy.

Freiburg i. Br., May 2012 Oskar Steiner

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