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SUNSPOTS AND STARSPOTS

The past two decades have seen remarkable advances in observations of sunspots and their magnetic fields, in imaging of spots and fields on distant stars, and in associated theoretical models and numerical simulations.

This volume provides the first comprehensive combined account of the properties of sunspots and starspots. It covers both observations and theory, and describes the intricate fine structure of a sunspot's magnetic field and the prevalence of polar spots on stars. The book includes a substantial historical introduction and treats solar and stellar magnetic activity, dynamo models of magnetic cycles, and the influence of solar variability on the Earth's magnetosphere and climate.

This book conveys the excitement of its subject to graduate students and specialists in solar and stellar physics, and more broadly to astronomers, geophysicists, space physicists and experts in fluid dynamics and plasma physics.

JOHN H. THOMAS is Professor of Mechanical and Aerospace Sciences, and Astronomy, at the University of Rochester. He has been the Chair of the Solar Physics Division of the American Astronomical Society, and was a Scientific Editor of the *Astrophysical Journal* for ten years.

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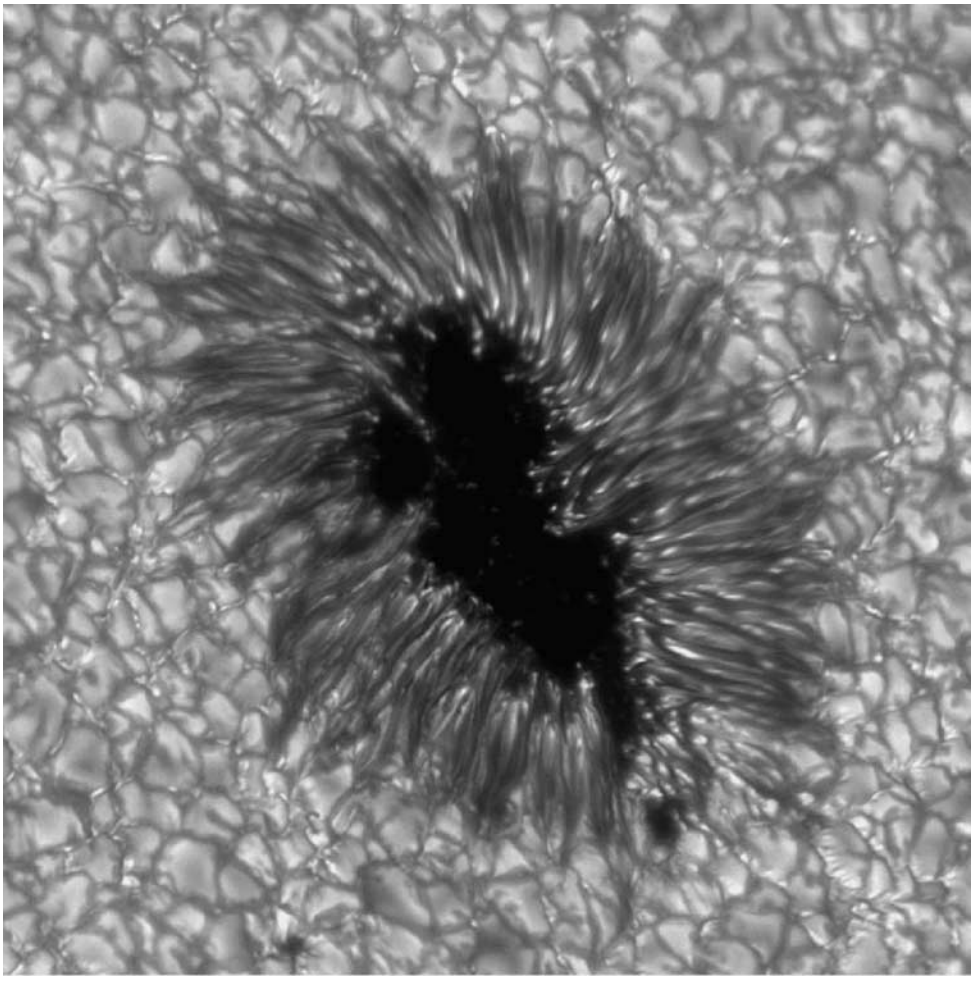

High-resolution image of a sunspot, showing the dark umbra enclosed by a filamentary penumbra, as well as tiny bright points in the surrounding granulation. This image was obtained in the continuum near 436 nm with the Swedish Solar Telescope on La Palma. (Courtesy of L. H. M. Rouppe van der Voort and the Royal Swedish Academy of Sciences.)

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To Lois and Judy

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Preface

In 1858, Richard Carrington wrote, "Our knowledge of the Sun's action is but fragmentary, and the publication of speculations on the nature of his spots would be a very precarious venture." Fifty years later, George Ellery Hale's discovery of the magnetic field in a sunspot ushered in the modern era of research into solar, stellar and cosmical magnetic fields. This book, coincidentally, marks the hundredth anniversary of his discovery. The past century has seen enormous and rapidly accelerating progress in our understanding not only of sunspots but also of starspots and the whole solar–stellar connection. Our purpose here is to bring these advances together and to offer a unified account of sunspots and starspots in the context of solar and stellar magnetic activity.

Our own collaboration goes back more than 40 years, to the academic year 1966–67 when JHT was a NATO postdoctoral fellow in the Department of Applied Mathematics and Theoretical Physics at Cambridge, where NOW was a recently appointed lecturer. In 1991 we organized a NATO Advanced Research Workshop on *Sunspots: Theory and Observations*, which produced an edited volume (Thomas and Weiss 1992a) designed to serve as a monograph on the subject. Progress on sunspots has been very rapid since then, especially in high-resolution observations (both ground-based and from space) and in numerical modelling; meanwhile, with new techniques such as Doppler and Zeeman–Doppler imaging, the study of starspots (treated briefly in the 1992 volume) has emerged as a fully fledged subject of its own. Hence it seems to us that the time has come for a new, comprehensive book on sunspots and starspots that emphasizes recent developments.

Our aim in this book is to convey the excitement of this subject to a readership consisting not only of specialists in solar and stellar physics, but also more generally of astronomers, astrophysicists, geophysicists and space physicists, as well as experts in plasma physics and fluid dynamics with interest in astrophysical applications. We have attempted to give a balanced and self-contained account of observations and of theory. In composing this book, we have had in mind the needs both of established experts and, particularly, of graduate students entering the field.

We wish to thank all those collaborators and close colleagues who, over the span of many years, have enriched our knowledge of sunspots and solar and stellar magnetic activity and have added immeasurably to our pleasure in doing research. They include Tom Bogdan, Tim Brown, Nic Brummell, Paul Cally, Fausto Cattaneo, Al Clark, Lawrence Cram, Leon Golub, Bruce Lites, Leon Mestel, Friedrich Meyer, Benjamin Montesinos, Steve Musman, Bob Noyes, Mike Proctor, Bob Rosner, Hermann Schmidt, George Simon, Alan Title,

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Steve Tobias, the late Peter Wilson, and the late Yutaka Uchida. Special thanks go also to our former graduate students and postdoctoral fellows: (JHT) Toufik Abdelatif, Andrew Markiel, Alan Nye, Colin Roald, Mark Scheuer, and Don Stanchfield; (NOW) Paul Bushby, Dave Galloway, David Hughes, Neal Hurlburt, Paul Matthews, Dan Moore, Neil Roxburgh, Alastair Rucklidge, and Mike Tildesley.

Tom Bogdan, Andrew Collier Cameron and Steve Tobias each read portions of this book in draft form and made many valuable suggestions. The convenient electronic access to scientific papers provided by the NASA Astrophysics Data System has been a very significant aid to us in writing this book. We also wish to thank the numerous authors whose figures are reproduced here, and Amanda Smith for assistance in preparing some of the illustrations.

Our work on this book began during the programme on 'Magnetohydrodynamics of Stellar Interiors' at the Isaac Newton Institute for Mathematical Sciences in Cambridge in the autumn of 2004. In the course of writing the book, we have been supported in many ways by our own institutions: the Department of Mechanical Engineering and the Department of Physics and Astronomy at Rochester, and the Department of Applied Mathematics and Theoretical Physics, Clare College, and Clare Hall at Cambridge. Our own research in the areas covered in this book has been supported over many years by grants from the National Aeronautics and Space Administration and the National Science Foundation in the USA, and the Particle Physics and Astronomy Research Council (now STFC) in the UK.

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