Preface to the Second Edition

The *First Edition* of *The Sun from Space*, completed in 1999, focused on the early accomplishments of three solar spacecraft, *SOHO, Ulysses*, and *Yohkoh*, primarily during a minimum in the Sun's 11-year cycle of magnetic activity. The comprehensive *Second Edition* includes the main findings of these three spacecraft over an entire activity cycle, including two minima and a maximum, and discusses the significant results of six more solar missions. Four of these, the *Hinode, RHESSI, STEREO*, and *TRACE missions* were launched after the *First Edition* was either finished or nearly so, and the other two, the *ACE* and *Wind* spacecraft, extend our investigations from the Sun to its varying input to the Earth.

The *Second Edition* does not contain simple updates or cosmetic patch ups to the material in the *First Edition*. It instead contains the relevant discoveries of the past decade, integrated into chapters completely rewritten for the purpose. This provides a fresh perspective to the major topics of solar enquiry, written in an enjoyable, easily understood text accessible to all readers, from the interested layperson to the student or professional.

The main scientific accomplishments of the *ACE, RHESSI, SOHO, TRACE, Ulysses*, and *Wind* missions, which are included in their 2005 Senior Review Proposals, have been described in Chapter 1 and included in greater detail in the relevant chapters. (*Yohkoh* completed its decade-long scrutiny of the X-ray Sun in 2001, while *Hinode* and *STEREO* were not launched until late 2006.)

Members of the Solar Physics Community were consulted about key discoveries or important reviews during the past decade. Persons who provided important review articles or other significant new information include Loren Acton, Markus J. Aschwanden, Eugene H. Avrett, Sarbani Basu, Paul M. Bellan, Benjamin D. G. Chandran, James Chen, Steven R. Cranmer, George A. Doschek, Murray Dryer, Peter Foukal, Joseph V. Hollweg, Gordon D. Holman, Stephen W. Kahler, James A. Klimchuk, Jun Lin, Donald Liebenberg, Noé Lugaz, Ward Manchester, Scott W. McIntosh, Mark Miesch, Ronald L. Moore, Judit Pap, Eugene Parker, Alexei A. Pevtsov, Arthur I. Poland, Arik Posner, Ilia Roussev, Wilfred Schröder, Leonard Strachan, Yi-Ming Wang, David F. Webb, Thomas N. Woods, Jie Zhang, and Thomas H. Zurbuchen.

Draft chapters were then sent to experts in the field, who have provided important suggestions for changes, deletions, and omissions. They are: Loren Acton, Markus

Aschwanden, George Doschek, Leon Golub, Bernhard Fleck, Arik Posner, Takashi Sakurai, Carolus Schrijver, and Saku Tsuneta for the introductory Chapter 1; each commenting on the spacecraft they are most familiar with; Steven Cranmer for Chapter 2; Thomas Duval, Bernhard Fleck, John Harvey, Rachel Howe, Mark Miesch, and Junwei Zhao for Chapter 3; Loren Acton, Markus Aschwanden, and Steven Cranmer for Chapter 4; Steven Cranmer, John Kohl, Edward Stone, Yi-Ming Wang, and Thomas Zurbuchen for Chapter 5; Markus Aschwanden, Arnold Benz, Richard Canfield, Terry Forbes, Stephen Kahler, Ronald Moore, Alexei Pevtsov, and Jie Zhang for parts of Chapter 6, and Peter Foukal, Stephen Kahler, Alexei Pevtsov, David Webb, and Thomas Woods for Chapter 7.

The combination of Senior Reviews, advice from the Solar Physics Community, and careful reading of individual chapters by experts in the field have assured that the text is fully up to date and complete.

The First Chapter of the *Second Edition* describes the scientific objectives of each of the nine solar missions, together with the instruments that are being used to accomplish these objectives. The Second Chapter retains the historical perspective to studies of the Sun and heliosphere found in the *First Edition*, including seminal contributions to our understanding of the Sun during the past century. The next five chapters present key improvements in our understanding of the solar interior; the heating of the million-degree outer atmosphere of the Sun, known as the solar corona; the origin and nature of the Sun's winds; the cause, prediction, and propagation of explosive solar flares and coronal mass ejections; and all aspects of space-weather interactions of the Sun with either the Earth or with unprotected astronauts and spacecraft in outer space or on the Moon or Mars.

Each of these five chapters ends with Summary Highlights of key ideas and fundamental discoveries in capsule form, followed by a time line of significant events in our understanding of the Sun, updated to include recent results. An Appendix provides Internet Addresses for the spacecraft and the topics of each book chapter. The *Second Edition* of *The Sun from Space* ends with comprehensive references to more than 2,500 fundamental research papers and review articles.

Since the publication of the *First Edition*, the *Ulysses* spacecraft has completed a second orbit over the solar poles, during a maximum in the solar activity cycle. After more than 17 years of pioneering solar science, the *Ulysses* mission ended on 1 July 2008. As shown in this *Second Edition, Ulysses* has therefore determined the distribution of solar wind velocities and, together with other solar spacecraft, helped identify the wind sources at both activity maximum and minimum. The *Second Edition* also presents the results of years of observations of solar oscillations acquired by *SOHO*, which probe the rotation and motions of the solar interior, as well as extensive new *SOHO* data on the magnetic structure of the solar wind sources, and the powerful, explosive solar flares that are triggered and powered by magnetic reconnection in the low solar corona.

The main results of the *Transition Region And Coronal Explorer*, abbreviated *TRACE* and launched on 1 April 1998, are also included in this *Second Edition* of *The Sun from Space*. It has obtained significant new information about the nature of the magnetic loops that thread the solar corona and the sources of heating the million-degree solar corona.

The new edition additionally includes the seminal findings of the *Ramaty High Energy Solar Spectroscopic Imager*, or *RHESSI* for short, launched on 5 February 2002. It has used images and spectroscopy of the high-energy radiation from solar flares to explore the basic physics of particle acceleration and explosive energy release, including new information about magnetic reconnection and the emission of the neutron capture and pair-annihilation lines during solar flares.

The *Second Edition* of *The Sun from Space* provides an account of the initial discoveries of the Japanese *Hinode* (formerly known as *Solar-B*) spacecraft launched on 23 September 2006. It consists of a coordinated set of optical, EUV, and X-ray instruments that study the interaction between the Sun's magnetic field and its high-temperature, ionized atmosphere. They measure the detailed density, temperature, and velocity structures in the visible solar disk, the photosphere, the low corona, and the transition region between them with high spatial, spectral, and temporal resolution, resulting in new information about the Sun's varying magnetism and its relationship to solar flares and the expansion of the solar corona into the Sun's winds.

Also included are significant new findings of NASA's *Solar TErrestrial RElations Observatory*, or *STEREO* for short, launched on 25 October 2006. It is a pair of spacecraft, leading and lagging the Earth in its orbit, which investigates the origin, evolution, and interplanetary consequences of the billion-ton solar eruptions known as coronal mass ejections. The combined observations from the two *STEREO* spacecraft provide a three-dimensional view of these outbursts, from their onset at the Sun to the orbit of the Earth, improving our understanding of these solar explosions and our ability to predict their trajectories and consequences.

This *Second Edition* of *The Sun from Space* emphasizes the human impact of NASA solar missions, with a full discussion of their implications for Sun-driven space weather. Our technological society has become increasingly vulnerable to these storms from the Sun, both on Earth and in the human and robotic exploration of the heliosphere. Solar flares or coronal mass ejections may affect the health and safety of travelers in space, influence the habitability of the Moon or Mars, and damage or disable spacecraft both near the Earth and in outer space.

Instruments aboard *RHESSI, SOHO*, and *Hinode* are, for example, helping us understand and forecast solar flares. These catastrophic outbursts can suddenly flood the solar system with intense radiation and energetic particles, releasing energy equivalent to millions of 100-megaton hydrogen bombs exploding at the same time. The X-rays from a solar flare modify our atmosphere, disrupt radio communications, and alter satellite orbits. The energetic particles that are hurled out into interplanetary space during solar flares can threaten the safety of unprotected astronauts traveling beyond the safety of the Earth's magnetic field to the Moon or Mars. These flare particles can also damage or destroy satellites used for communication, navigation, and military reconnaissance and surveillance.

The instruments aboard *SOHO* and *STEREO* are additionally providing new insights to the mechanisms and prediction of coronal mass ejections; giant magnetic bubbles that expand as they propagate outward from the Sun to rapidly rival it in size. These violent eruptions throw billions of tons of material into interplanetary space, and their associated shocks accelerate and propel vast quantities of high-speed particles ahead of them. They can produce spectacular auroras, create intense geomagnetic storms, and disrupt satellites, radio communications, and Earth's power systems. Energetic particles associated with coronal mass ejections can also be hazardous to spacecraft and astronauts traveling to the Moon or exploring its surface.

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