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Planetary Magnetism—Foreword

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The solar system consists of a wide diversity of objects: other than our central star, the Sun, there are eight planets, six of these with satellites of their own, as well as the innumerable smaller objects we call asteroids and comets. Understanding their structure, composition, environment and internal processes is important, primarily, for understanding the origin and evolution of our own solar system. Increasingly, however, interest in planetary systems beyond ours is becoming a powerful motivation for comparative studies.

The magnetic properties of solar system objects provide important clues to their origin, evolution, parentage as well as to their interior structure and its dynamic aspects. In planetary sciences, the measurement of magnetic fields and their description in terms of models that relate the observations to the objects' material properties and thus explain their origin are important research tools. These are now routinely applied to all solar system objects. Almost all classes of objects have been visited by spacecraft that could measure the magnetic field in their environment. These measurements have been interpreted in the various cases in terms of internally generated magnetic fields or in terms of the interaction of the body with the solar wind, or both.

There has never been a comprehensive volume on planetary magnetism, covering the whole range of solar system objects, although of course there are numerous sources for specific objects, particularly of course the planets. The Earth's magnetic field has been well

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documented over the decades, but for other bodies in the solar system, the discovery of a planetary scale magnetic field awaited, in general, visits by spacecraft equipped with magnetometers. The exception was Jupiter: its kilometric radiation, detected from the Earth, was correctly interpreted as evidence for an intense magnetic field of planetary origin. The first two planets visited, Venus and Mars, have no internal sources. The interpretation of the early measurements was hotly debated, but, eventually, the absence of significant magnetic fields was generally accepted. In the case of Mars, a long-extinct dynamo had left some locally strong crustal magnetization that was only identified in the mid-1990s. Crustal magnetism on the Moon was discovered by the magnetometers carried to the surface by the Apollo landers. Venus is still known as an unmagnetised planet.

The other planets have internally-generated intrinsic magnetic fields, surprisingly so in the case of Mercury, more understandably so in the case of Jupiter, Saturn, Uranus and Neptune (and of course the Earth). Also surprising are the magnetic properties of Jupiter's Galilean satellites: Ganymede with its internal dynamo and Europa with its large magnetic field, interpreted as caused by the currents induced in the electrically conductive medium of a (sub-surface) ocean in Jupiter's fast rotating magnetic field. Some of the asteroids visited so far appear to have had an intrinsic magnetic field shortly after their formation, while others have not. In all cases, the measured magnetic fields are a complex superposition of any internally generated component and of the fields generated by currents that arise from the interaction of the planet or other object with the solar wind.

A Workshop organised by the International Space Science Institute in Bern, Switzerland, held on 1 to 5 September 2008, brought together over forty scientists with an interest in measuring, analysing, modelling and explaining magnetic fields in and around solid bodies in the solar system. The coverage was wide: all objects were reviewed; comparing what we know about the different planets and smaller bodies led to a very rich harvest in insight into the origin and nature of planetary magnetism. The present volume contains a collection of papers that summarise the insight gained and the progress made in understanding the many aspects of planetary magnetism and their inter-relations. While planetary dynamo theory remains a dynamic and evolving topic, the mutual understanding among observers, modellers and theorist that was achieved during the Workshop and that is embodied in several papers in this volume is expected to lead to the better understanding that is needed for future progress in this field.

This Workshop was one of a series of three held by ISSI on magnetism in the solar system. The other two Workshops covered the topics of solar and terrestrial magnetism, respectively. While there is a strong overlap between the scientific communities involved in planetary and terrestrial magnetism, there is generally less contact with the solar magnetism community. To help cross-fertilisation, joint meetings were held by the Convenors of the three Workshops and talks about solar magnetism and the solar dynamo were presented at both the planetary and terrestrial magnetism Workshops, while a talk about planetary dynamos was also presented to the solar magnetism community. In all three cases, these talks were not only well received and discussed, but also led to papers that have been included in the respective volumes. A later Workshop, held in March 2010, addressed large-scale magnetic fields in the Universe, thus extending the coverage of magnetism to a much broader astrophysical context.

The Convenors of this Workshop wish to thank ISSI, in particular its Executive Director Roger-Maurice Bonnet, for the initiative and support for the Workshop and its participants. Essential support was provided by Brigitte Shutte, Saliba Saliba, Silvia Wenger, Andrea Fischer and Katja Schüpbach. The Editors also wish to thank the authors of the papers in this volume who collaborated so splendidly to present the synthesis of current research, based

on the presentations and discussions at the Workshop. Thanks are also due to the reviewers of the papers who helped to make the completed volume to be of the highest standard and one that the Editors hope will be of lasting use to the community.

Participants in the Workshop on Planetary Magnetism, held at the International Space Science Institute, Bern, Switzerland, 1 to 5 September 2008. (1) Pierre Rochette, (2) Nadine Nettelmann, (3) Gauthier Hulot, (4) Wolfgang Baumjohann, (5) Michel Blanc, (6) André Balogh, (7) Benjamin Weiss, (8) Xianzhe Jia, (9) Norman Ness, (10) Tilman Spohn, (11) Gary Glatzmaier, (12) Jack Connerney, (13) Benoit Langlais, (14) Doris Breuer, (15) Joachim Saur, (16) Johannes Wicht, (17) Chris Finley, (18) Gautier Verhille, (19) Ulrich Christensen, (20) Mioara Mandea, (21) Vincent Lesur, (22) Stephane Labrosse, (23) Jonathan Fortney, (24) David Stevenson, (25) Catherine Constable (26) Chris Jones, (27) Sabine Stanley, (28) Jean-Francois Pinton, (29) Nils Olsen (30) Karl-Heinz Glassmeier, (31) Brian Anderson, (32) Andreas Tilgner, (33) Daniel Heyner.