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Giant Planet Magnetodiscs and Aurorae—An Introduction

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Magnetodiscs are large current sheets surrounding Jupiter and Saturn (also Uranus and Neptune) that are filled with plasma principally originating in the natural satellites of these worlds. They are also solar system analogues for astrophysical discs. Magnetodiscs are special features of the fast rotating giant planets, a special feature of rotationally driven magnetospheres. Their structure is modified by variability in their plasma sources and by the solar wind. Auroral signatures in the optical and radio wavebands allow a diagnostic of these dynamical processes and enable the visualisation of these large plasma and field structures.

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The objective of this workshop was to address outstanding issues in the structure and dynamics of magnetodiscs using a comparative approach (see details under topics). More specifically, we aimed to review current understanding of magnetodiscs and auroral responses to magnetodisc dynamics; characterise and understand radial plasma transport in magnetodiscs; determine how magnetic reconnection works in magnetodiscs, and describe the effects on plasma transport; describe the associated auroral responses to internal and external magnetospheric processes; characterise how the solar wind influences magnetodiscs and the auroral responses to solar wind-driven dynamics; characterise the spectral and spatial properties of auroral emissions produced by magnetodisc dynamics; answer the question of whether there are significant differences between solar wind- and internally-driven dynamics; and determine the sources of local-time asymmetries in magnetodiscs.

This volume is a unique synthesis of all aspects of the giant magnetospheres and their aurorae; it provides an interdisciplinary approach to understanding the coupled system from the solar wind to the atmosphere; it combines the latest observations with current theory and models; and it also contains sufficient breadth for students of magnetospheric and space physics to use as a reference for future research.

A few topics in detail:

Radial plasma transport: How does plasma get from its (primary) sources near Io at Jupiter and Enceladus at Saturn into the magnetodisc and out of the magnetosphere? Of particular interest are the timescales for these transport processes, how they might vary with position, the physics of the transport process in the magnetodisc, and how radial transport varies with magnetospheric activity. To address this topic we will exploit the latest data, models and theory together with auroral observations.

Reconnection: Reconnection is a major process by which mass is lost from the magnetosphere and, as such, it is important to characterise reconnection in the magnetodisc. An important unanswered question is how reconnection is triggered in the magnetodisc and the interconnection between the Dungey and Vasyliunas cycles. In terms of remote diagnosis of reconnection, can specific details of the reconnection process (e.g., reconnection of closed or open flux) be identified in auroral observations?

Dynamics: Plasma production, radial transport, reconnection and solar wind influences are sources of dynamics in the magnetodiscs at Jupiter and Saturn (Uranus and Neptune as well). These and other dynamical events, such as injections, produce optical/radio auroral emissions. Here we will examine dynamical events in magnetodiscs, comparing and contrasting Jupiter and Saturn, and use auroral imaging and radio emissions as remote monitors of dynamics. Can the spectra and spatial distributions of various auroral emissions be used to diagnose different types of dynamic event? Can we develop an understanding of Space Weather at the giant planets using knowledge of variability in plasma production, radial transport, instability, and solar wind influences in very large systems?

Solar wind influences: Evidence for solar wind influences on the magnetodisc of Jupiter is substantial; Saturn's magnetodisc appears to respond even more strongly to the solar wind. The mechanisms behind these solar wind effects are not fully understood but involve a combination of Dungey cycle driving, angular momentum conservation and solar wind pressure effects. The dusk flank magnetosphere of Saturn has been studied in far more detail than the corresponding region of Jupiter's magnetosphere and provides an excellent and unique dataset for the study of asymmetries. What can be learned about the solar wind influence by in situ observations and monitoring the location, spectra and strengths of auroral emissions? How much are the magnetospheric structure, magnetospheric dynamics and the aurora of an outer planet influenced by the solar wind?

Sources of local time asymmetries: Magnetodiscs and aurorae at Jupiter and Saturn are known to have structure which is asymmetric in local time. There are asymmetries in magnetodisc location, thickness, field structure, and presumably stress balance. It is not clear what generates these asymmetries. Is it purely driven by the solar wind or do internal processes such as mass loss play a significant role?