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INTRODUCTION TO
A SPECIAL SECTION

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Special Section:

Inner Magnetosphere
Coupling: Recent Advances

Key Points:

- The dynamics of the inner magnetosphere is strongly governed by the interactions between different plasma populations
- Our understanding of the coupling processes in the magnetosphere is still incomplete
- This special issue contains a collection of papers advancing our knowledge of the processes affecting the inner magnetosphere

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Inner magnetosphere coupling: Recent advances

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Abstract The dynamics of the inner magnetosphere is strongly governed by the interactions between different plasma populations that are coupled through large-scale electric and magnetic fields, currents, and wave-particle interactions. Inner magnetospheric plasma undergoes self-consistent interactions with global electric and magnetic fields. Waves excited in the inner magnetosphere from unstable particle distributions can provide energy exchange between different particle populations in the inner magnetosphere and affect the ring current and radiation belt dynamics. The ionosphere serves as an energy sink and feeds the magnetosphere back through the cold plasma outflow. The precipitating inner magnetospheric particles influence the ionosphere and upper atmospheric chemistry and affect climate. Satellite measurements and theoretical studies have advanced our understanding of the dynamics of various plasma populations in the inner magnetosphere. However, our knowledge of the coupling processes among the plasmasphere, ring current, radiation belts, global magnetic and electric fields, and plasma waves generated within these systems is still incomplete. This special issue incorporates extended papers presented at the Inner Magnetosphere Coupling III conference held 23–27 March 2015 in Los Angeles, California, USA, and includes modeling and observational contributions addressing interactions within different plasma populations in the inner magnetosphere (plasmasphere, ring current, and radiation belts), coupling between fields and plasma populations, as well as effects of the inner magnetosphere on the ionosphere and atmosphere.

1. Introduction

Since *Chapman and Ferraro* [1930] put forward the idea that the interaction of the Sun-emitted plasma (also known as the solar wind) and the Earth's magnetic field forms a cavity called the magnetosphere, and *Dungey* [1961] further proposed that the inflow of solar plasma happens in a periodic manner (the Dungey convection cycle), it has become clear that the Sun, the solar wind, the magnetosphere, and the ionosphere should be considered as a whole complex system.

The solar wind and the interplanetary magnetic field it carries determine the shape of the magnetosphere and the location of its boundary (the magnetopause) and modulate the magnetic field within the magnetospheric cavity. The interaction of the solar wind and the Earth's magnetic field also creates a global electric field that causes inward motion (injection) of particles from the magnetospheric tail toward the inner magnetosphere and their resulting energization [e.g., *Li et al.*, 1993]. The spatial nonuniformity of the magnetic field results in the longitudinal drift of energetic charged particles trapped within the magnetosphere, which in turn creates one of the major magnetospheric current systems, the ring current, carried mostly by ~ a few to 100 keV hydrogen, helium, and oxygen species [e.g., *Kozyra and Liemohn*, 2003, and references therein]. This region is also collocated with the most energetic magnetospheric particle population, the outer radiation belt composed of the relativistic, ~MeV electrons [*Van Allen and Frank*, 1959]. The ring current and the outer radiation belt partially overlap the cold plasma population, the plasmasphere originating from the ionosphere. The boundary of the plasmasphere, the plasmopause [*Carpenter*, 1963], is also determined by the global-scale electric field. Parallel, field-aligned currents associated with particle motion along magnetic field lines close on the ionosphere, so that magnetosphere-ionosphere coupling plays an important role for both of the spheres.

In the inner magnetosphere, different particle populations are also coupled across a wide energy range as lower energy particles provide a seed population for higher-energy populations. The seed population can be energized due to inward radial motion as well as interactions with various plasma wave modes that can be excited in the magnetosphere. These plasma waves are often generated due to interactions with the solar wind, e.g., large-scale ultralow frequency (ULF) waves can result from the Kelvin-Helmholtz instability at the flanks of

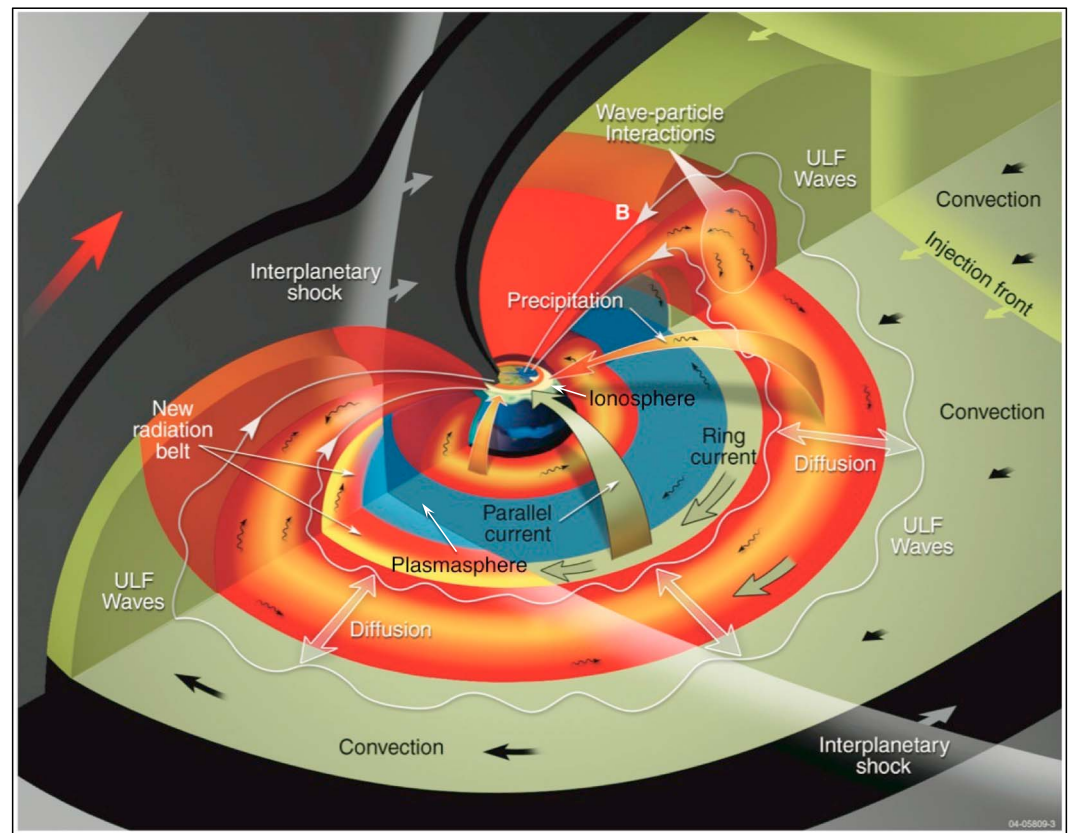


Figure 1. Processes coupling the solar wind, the inner magnetosphere, and the ionosphere adopted from *Mauk et al.* [2013].

the magnetosphere [e.g., *Mathie and Mann*, 2001, and references therein] or compression of the magnetosphere by the solar wind [e.g., *Takahashi et al.*, 1988]. Small-scale plasma waves, e.g., whistler mode chorus and hiss or electromagnetic ion cyclotron (EMIC) waves, are believed to be generated by kinetic instabilities, on a timescale of particles' cyclotron motion. In particular, chorus waves may energize lower energy ~ 30 keV electrons up to \sim a few MeV energy and thus couple different-energy electron populations [e.g., *Summers et al.*, 2002]. At the same time, EMIC waves excited by ring current ions may interact with relativistic electrons and cause their precipitation into the atmosphere [e.g., *Thorne and Kennel*, 1971] and, as a result, provide cross energy and cross-species coupling between the ring current and the outer radiation belt. The effectiveness of these interactions depends on the background plasma density providing an additional link to a cold plasmaspheric particle population. Energetic particle precipitation couples the solar wind to the Earth's atmosphere through production of odd nitrogen (NO_x) and odd hydrogen (HO_x) in the upper atmosphere, which can affect ozone chemistry and modulate Earth's climate [e.g., *Turunen et al.*, 2009]. A schematic illustrating the processes described above and coupling the solar wind, the magnetosphere, and the ionosphere is shown in Figure 1.

This special issue contains a collection of papers advancing our understanding of the processes affecting the inner magnetosphere, its dynamics, and the coupling between its key populations. It addresses questions such as the magnetic field configuration, the plasmasphere refilling, the dynamics of different-energy electrons in the inner magnetosphere, electron acceleration and loss, resonant wave-particle interactions, ULF wave modeling, statistical characteristics of EMIC waves, the energization of ring current oxygen species during magnetic storms, etc.

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Erratum

Two changes have been made to this article from the originally published version. Y. Y. Shprits' department affiliation has been corrected, and a sentence has been added to the Acknowledgment section describing the funding received from the European Union's Horizon 2020 program. This version may be considered the authoritative version of record.