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Dawn-Dusk Asymmetries in Jupiter's Magnetosphere

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ABSTRACT

Local time asymmetries in the structure of a planetary magnetosphere are fundamentally the result of the solar-wind interaction with the magnetosphere. In contrast to the Earth, Jupiter has a rotationally driven magnetosphere with an internal primary plasma source, the moon Io. Nevertheless, local time, particularly dawn-dusk, asymmetries are observed throughout the Jovian magnetosphere. For instance, the configuration of the magnetic field, the plasma flows around the planet, the current distribution, and the current sheet thickness all exhibit discrepancies between dawn and dusk. In addition, the auroral emissions in the ionosphere of Jupiter display these dawn-dusk asymmetries in their shape and their brightness. In this chapter, we review the dawn-dusk asymmetries that have been modeled or observed by the different spacecraft having explored the largest magnetosphere of the solar system.

24.1. INTRODUCTION

Jupiter has the strongest intrinsic magnetic field in the solar system, and it carves out a region in space, called a magnetosphere, that holds off the solar wind. Jupiter's magnetosphere has two major differences from the terrestrial magnetosphere: the importance of rotational stresses and the presence of an internal plasma source. Rotational stresses are important in Jupiter's magnetosphere because of the relatively fast planetary rotation, 10 h compared to 24 h for the Earth, and large distances: the magnetopause standoff distance is 60–90 R_J , depending on the solar-wind conditions [Joy *et al.*, 2002]. As a result, at Jupiter the potential energy from corotation is ~50 times larger than the solar-wind induced cross polar cap potential, suggesting that the magnetosphere is rota-

tionally driven [e.g., *Khurana et al.*, 2004]. Additionally, the moon Io provides the primary source of plasma in Jupiter's magnetosphere, adding ~500–1000 kg/s of sulfur and oxygen ions to the magnetosphere [e.g., *Thomas et al.*, 2004].

Despite the importance of rotation and the internal plasma source in Jupiter's magnetosphere, the solar wind still has some influence, as can be most notably observed in the strong local time, particularly dawn-dusk, asymmetries in various magnetic field and plasma properties. In addition, there is observational evidence suggesting that Jupiter's magnetosphere and aurora respond to changes in the solar-wind dynamic pressure [e.g., *Gurnett et al.*, 2002; *Hanlon et al.*, 2004; *Tao et al.*, 2005; *Nichols et al.*, 2007].

24.2. PLASMA FLOW AROUND JUPITER

The dynamics of the plasma flow in the magnetosphere of Jupiter are primarily governed by the so-called Vasyliūnas cycle, first described by *Vasyliūnas* [1983] and sketched in Figure 24.1. In the dayside of the outer magnetosphere (radial distances outside ~60 R_J), mass-loaded flux tubes are confined by the magnetopause, whose

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