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Birth and Acceleration of Energetic Particles and Relation to Current Systems, Aurorae and Radio Emissions at Earth, Saturn and Jupiter

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Abstract

The occurrence of energetic (∼10 keV - 1 MeV) charged particles seems to be a universal phenomena of planets with a sufficiently strong magnetosphere. Energetic particle acceleration is well-known to exist at Earth, but has also been found at Saturn, Jupiter [*Mauk et al.*, 1997; *Krupp et al.*, 1998; *Woch et al.*, 1998] and Uranus [*Mauk et al.*, 1987] (a presence of energetic particles has been confirmed at Neptune, but substorm-like acceleration events appear to be absent [*Mauk et al.*, 1991]). In this presentation we discuss the particle acceleration mechanism associated with global, substorm-like reconfigurations of the magnetic field at Earth, Saturn and Jupiter, and how those are related to auroral and radio emissions.

During terrestrial substorms, field dipolarizations are accompanied by planetward motion of plasma [*Sauvaud and Winckler*, 1980], particle intensities increases in the inner magnetosphere as seen by energetic neutral atom (ENA) as well as in-situ measurements and auroral intensifications [*Brandt et al.*, 2002]. Terrestrial substorm onsets are also very well correlated with the Auroral Kilometric Radiation (AKR) [*Liou et al.*, 2000]. The particle intensificiations appear more dramatic for heavy ions (O^+) than for protons as can readily be seen in ENA images [*Mitchell et al.*, 2003; *Ohtani et al.*, 2005]. Model-data comparisons have shown that it is the violation of the first adiabatic invariant for O^+ ions that is responsible for the initial dramatic intensification, which is followed by an adiabatic energization due to planetward transport [*Delcourt*, 2002; *Fok et al.*, 2006]. The resulting energetic particle pressure is generally localized around midnight and drives the 3D partial ring current (PRC), which connects through ionosphere and gives rise to ionospheric electric fields that feed back on magnetospheric transport and dynamics [*Brandt et al.*, 2008].

At Saturn, particle acceleration events occur quasi-periodically in the midnight magnetosphere have been observed to give rise to particle intensifications as well as changes in spectral slope, again more dramatic for heavy ions [*Carbary and Krimigis*, 1982]. ENA, UV and observation of Saturn Kilometric Radiation (SKR) from the Cassini mission show that all three phenomena are tightly related [*Mitchell et al.*, 2009] and most likely linked to release of plasmoids [*Jackman et al.*, 2009]. Simultaneous ENA images and magnetic field measurements reveal that the localized plasma pressure associated with the accelerated energetic particles can account for the observed field periodicities [*Khurana et al.*, 2009; *Brandt et al.*, 2010].

At Jupiter, quasi-periodic acceleration events with a period of ∼3 days have been observed on the nightside, mid-tail region accompanied by changes in both particle intensity and spectral slope, that appear more prominent for heavy ions [*Krupp et al.*, 1998; *Woch et al.*, 1998]. Quasi periodic temporal variations observed in the FUV auroral emissions are correlated with the general state of the Jovian magnetic field [*Prange et al.*, 2001] and the Jovian broad-band kilometric radiation (b-KOM). The recurrence period during the limited FUV observations was slightly longer (ranging from 4-5 days to 8-10 days) than that of the particle injections (∼3 days), but the two observational studies did not overlap.

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