Geophysical Research Abstracts,
Vol. 11, EGU2009-3825, 2009
EGU General Assembly 2009

A model of the modulation of SKR power by Saturn's rotating cam currents

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The power in kilometric radio emissions from Saturn (SKR) varies in intensity at a period close to that of planetary rotation. Magnetospheric particles and fields also manifest periodicities at the same (slowly drifting) period. SKR differs from other periodic phenomena that have been reported because its source appears to be fixed in local time (in the morning sector) whereas magnetic field and particle periodicities appear to be fixed in a frame rotating at the period of SKR modulation. Measurements of phenomena with such properties are conveniently described in terms of a phase corrected for spacecraft local time.

We suggest that the localization of peak SKR emission arises because of a unique feature of the global magnetosphere in the morning sector. The feature to which we allude is the rotation of the magnetic field across the interface between the quasi-dipolar inner magnetosphere (where field lines diverge little from meridional orientation) and the outer magnetosphere (where field lines drape strongly in the anti-solar direction). The anti-solar draping is particularly extreme in the morning sector where viscous interactions with the solar wind augment the effect of corotation lag.

Field rotation implies current; it follows that sheets of field-aligned current flowing on quasi-dipole L-shells in the range 10-15 and converging at the equator, are systematically present in the morning sector. We refer to these currents as sweep-back currents. They flow on the range of magnetic shells that carry the rotating cam current system described by Southwood and Kivelson (2007). As the cam currents rotate, the intensity of currents in the morning sector varies and SKR power, known to be governed by strength of the current flowing out of the ionosphere, also varies. The most intense currents will be present at the time in each rotation period when the cam current augments the sweepback current, i.e., when the most intense cam current rotates into the morning sector.

Various features of this model are consistent with observations. Localized currents upward from the south are observed by Cassini at high latitudes in the morning sector on L-shells mapping to about 72 degrees invariant latitude. They are most intense when encountered at the phase of the peak upward cam current and the timing is consistent with being at the peak phase of SKR. SKR power is thought to be dominated by emissions from the southern ionosphere, consistent with these observations. A good correlation between solar wind speed and SKR intensity has also been reported, and that is consistent with the suggestion that increased viscosity, possibly through Kelvin-Helmholtz waves on the boundary, increases the strength of sweepback currents.

One reported property of SKR, the observation that the emissions from north and south peak in-phase, seems to be inconsistent with the model. From the model, one would predict that half a cycle after the emissions from the southern hemisphere peak, when the cam current flows upward from the northern ionosphere in the morning sector, there would be a peak in northern hemisphere emissions. The northern peak would be less intense because of differing ionospheric conductances. However, if the peak emissions from the northern hemisphere arise as parasitic emissions from electron beams whose principal acceleration occurs in the southern hemisphere, the two peaks would be in phase. The concept of parasitic emissions is suggested by recent evidence (Bonfond et al., 2008) that at the foot of the Io flux tube electron acceleration into one ionosphere is accompanied by electron acceleration into the conjugate ionosphere.