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Saturn's Magnetosphere: Sub-corotation and Magnetosphere-Ionosphere Interaction

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Our investigation using Cassini measurements of the azimuthal magnetospheric field component, B_Φ, has two complementary objectives. First, to test the validity of the model, introduced by Hill(1973) for Jupiter and modified by Cowley and Bunce (2003) to apply to Saturn, based on the outflow of plasma from the inner magnetosphere (Enceladus) and the interaction between the ionosphere and sub-corotating magnetosphere. Second, to replace assumed model parameters with values obtained from observation. We test the model quantitatively using the equation relating the ionospheric Pedersen current, I_P, the height- integrated Pedersen conductivity, Σ_P, the rotation rate of the neutral atmosphere, Ω_S^*, the Saturn Kilometric Rotation (SKR) rate of the magnetic field, Ω_S, the rotation rate of the magnetospheric field, ω, and G, a parameter dependent on the ionospheric co-latitude, θ_i, and the ionospheric magnetic field vector, B_i. The B_Φ measurements and Ampere's law are used to derive, I_P, as a function of θ_i. This analysis has so far been restricted to part of 13 identical Cassini orbits (August through October, 2008) inside a distance ,r, of 10 Saturn radii, R_S, and the midnight local time sector, 24 +/– 2 hours. This choice suppresses spatial changes in favor of temporal/ dynamical dependences.

It is found that I_P/G is well represented by a simple exponential, A exp(-B θ_i). Important implications are (1) the rotation rate of the neutral atmosphere, Ω_S^* is equal to Ω_S, the SKR magnetic field rotation rate, (2) parameter, A = Σ_P, (3) parameter, B =1-ω/Ω_S, (4) $I_P(\theta_i)$, corresponding to the exponential, is found from A exp(-B θ_i)x G, and (5) although, for each orbit, the exponential fit has a correlation coefficient exceeding 0.99, implying A and B are constant, A and B undergo large variations from orbit to orbit as do all the above parameters revealing a significant magnetospheric- ionospheric variability with time. These results are used to test the model and are compared with published results using a complementary approach, energetic particle and plasma measurements of $V_\Phi = \omega$ r.