Geophysical Research Abstracts
Vol. 19, EGU2017-5786, 2017
EGU General Assembly 2017

The Source of Planetary Period Oscillations in Saturn's Magnetosphere

Krishan K. Khurana (1), Jonathan L. Mitchell (2), and Ingo C. F. Mueller (3)

(1) Department of Earth, Planetary and Space Sciences and Institute of Geophysics and Planetary Physics, UCLA, United States (kkhurana@igpp.ucla.edu), (2) Department of Physics, Westmont College, Santa Barbara. U.S.A, (3) Department of Physics, Imperial College, London, U.K.

In this presentation, we resolve a three-decades old mystery of how Saturn is able to modulate its kilometric wave radiation and many field and plasma parameters at the planetary rotation period even though its magnetic field is extremely axisymmetric. Such waves emanating from the auroral regions of planets lacking solid surfaces have been used as clocks to measure the lengths of their days, because asymmetric internal magnetic fields spin-modulate wave amplitudes. A review by Carbary and Mitchell (2013, Periodicities in Saturn's magnetosphere, Reviews of Geophysics, 51, 1-30) on the topic summarized findings from over 200 research articles, on what the phenomena is, how it is manifested in a host of magnetospheric and auroral parameters; examined several proposed models and pointed out their shortcomings. The topic has now been explored in several topical international workshops, but the problem has remained unsolved so far.

By quantitatively modeling the amplitudes and phases of these oscillations in the magnetic field observed by the Cassini spacecraft, we have now uncovered the generation mechanism responsible for these oscillations. We show that the observed oscillations are the manifestations of two global convectional conveyor belts excited in Saturn's upper atmosphere by auroral heating below its northern and southern auroral belts. We demonstrate that a feedback process develops in Saturn system such that the magnetosphere expends energy to drive convection in Saturn's upper stratosphere but gains back an amplified share in the form of angular momentum that it uses to enforce corotation in the magnetosphere and power its aurorae and radio waves. In essence, we have uncovered a new mechanism (convection assisted loss of angular momentum in an atmosphere) by which gaseous planets lose their angular momentum to their magnetospheres and outflowing plasma at rates far above previous predictions. We next show how the $m = 1$ convection system in the upper atmosphere generates the observed plasma and magnetic field periodicities.

This breakthrough in our understanding of an important planetary physics problem has immediate and extensive applications in fields as diverse as theoretical fluid dynamics, planetary angular momentum loss, maintenance of corotation in planetary magnetospheres, astrophysical magneto-braking and future telescopic observations of planets and exoplanets.