National Aeronautics and Space Administration

Understanding the Ice Giant Magnetospheres

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Program: FY21 R&TD Strategic Initiative **Strategic Focus Area: Ice Giant Science Leadership**

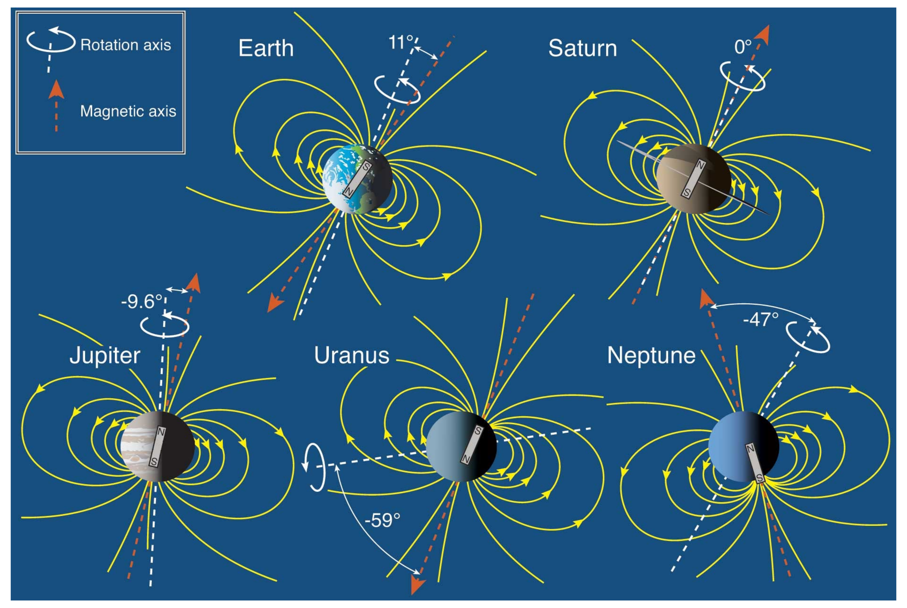
Significance/ Benefits to JPL and NASA

The Ice Giant Science Leadership initiative would enable JPL to play an effective role in future Ice Giant missions, with the possibility of capturing a future flagship mission. The objective of this particular task is to develop leadership in the field of Ice Giant Magnetospheres at JPL.

Task Objectives

The objective for Year 1 was to analyze the magnetometer and plasma spectrometer data from Voyager 2 to better understand these magnetospheres, and with our Co-Is at Michigan – initiate a magnetohydrodynamic simulation of Uranus.

Background



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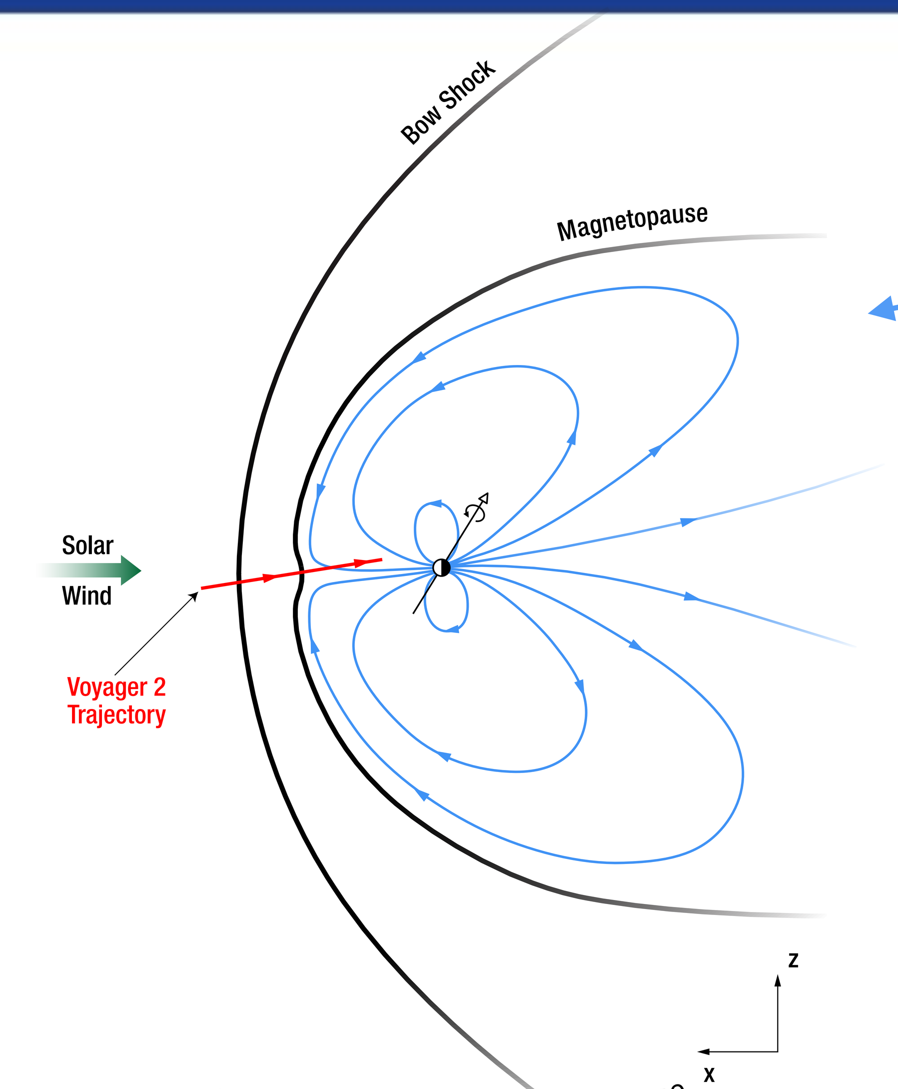
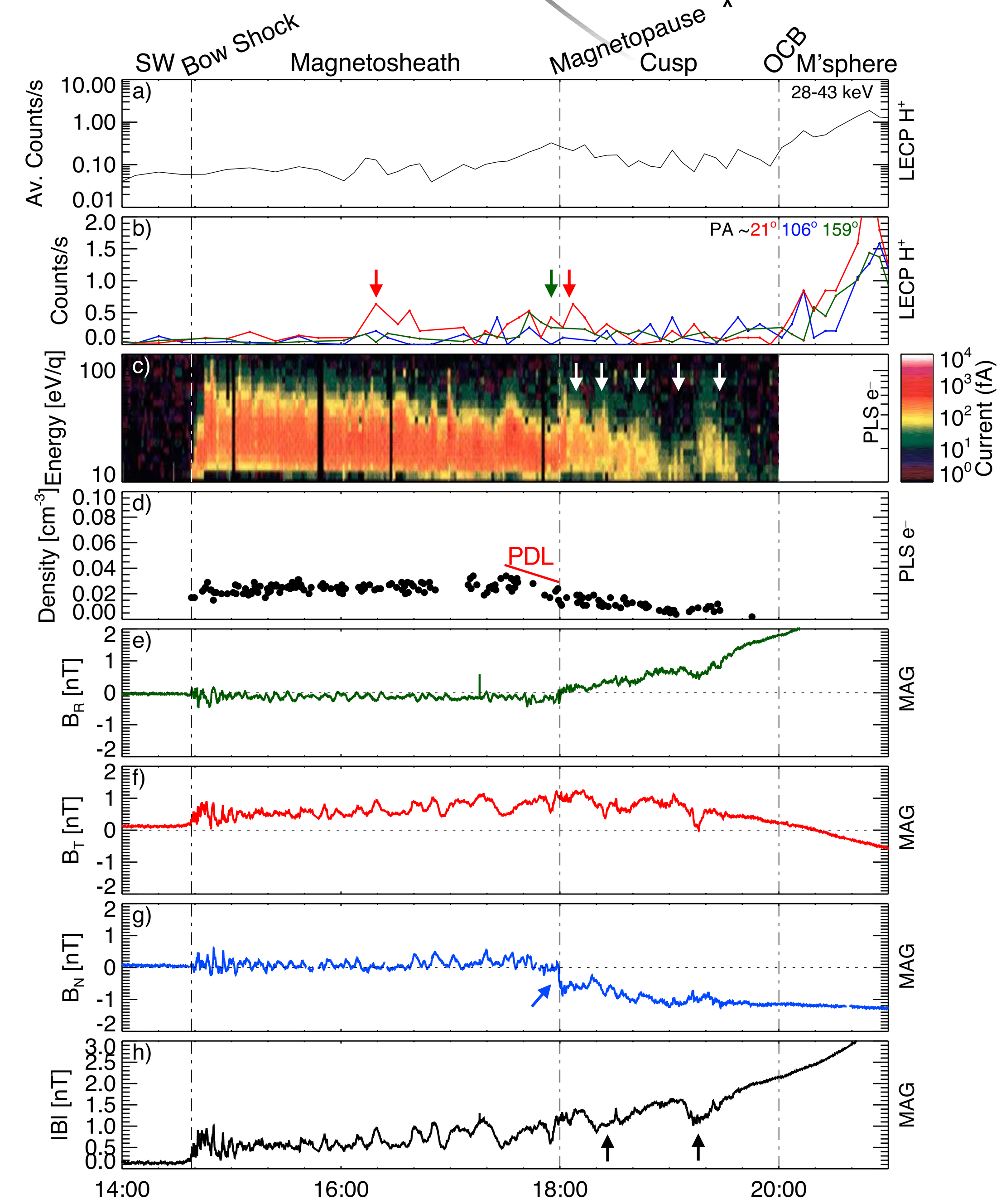
The high obliquity of the magnetic field to the rotation axis, results in dramatic reconfigurations of the magnetosphere every ~8 hours (half a planetary rotation; Figure 1). Uranus and Neptune can be seen to have offset dipoles which also have large angles between the rotational axis and the dipole moment axis (in comparison to the other planets). Uranus also has the largest obliquity (98º) which is the angle between the rotation axis and the orbital axis. (Credit: Fran Bagenal and Steve Bartlett).





Voyager 2 *in situ* measurements for the Neptune flyby on August 24th 1989. The different regions are labeled (with the solar wind labeled as "SW" and magnetosphere as "M'sphere"), and the boundaries of the bow shock, magnetopause and the open-closed field line boundary (OCB) marked by vertical dashed lines. "PDL" identifies the plasma depletion layer.

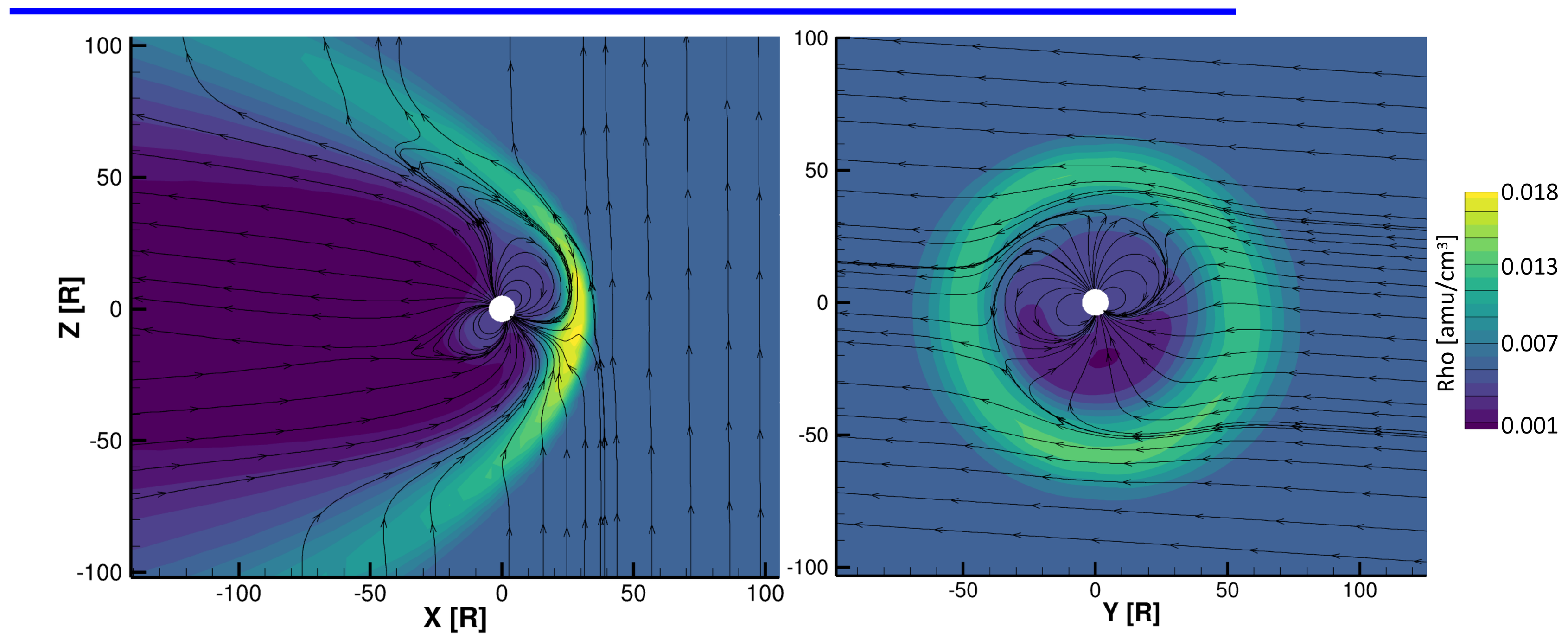
Approach and Results

The "pole-on" configuration occurs when the polar magnetosphere of a planet is directed into the solar wind velocity vector. Such magnetospheric configurations are unique to the Ice Giants. This means that magnetic reconnection, a process which couples the magnetosphere to the solar wind, will be different at the Ice Giants when they are aligned pole-on.

We analyzed the data from the Voyager 2 crossing of Neptune's dayside magnetosphere when it was orientated pole-on. We showed that magnetic reconnection was opening the dayside magnetosphere at Neptune. Furthermore, we showed that during the pole-on configuration, reconnection will not depend on the orientation of the interplanetary magnetic field as is the case at other planetary magnetospheres. Instead, reconnection will be "equal" at the magnetopause for different IMF orientations.

This will likely drive the "switch-like" dynamics observed in simulations of the Ice Giants, where the magnetosphere goes through stages of being open or closed to the solar wind.

Simulations



We have initiated global magnetospheric numerical magnetohydrodynamic simulations for Uranus and Neptune (figure is an output for Neptune) using the BATSRUS code. Future work will continue developing these models to better understand these magnetospheres.

Publications

Jamie Jasinski, Neil Murphy, Xianzhe Jia and James Slavin, "Neptune's pole-on magnetosphere: dayside reconnection observations by Voyager 2" Geophysical Research Letters. Under Review.

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