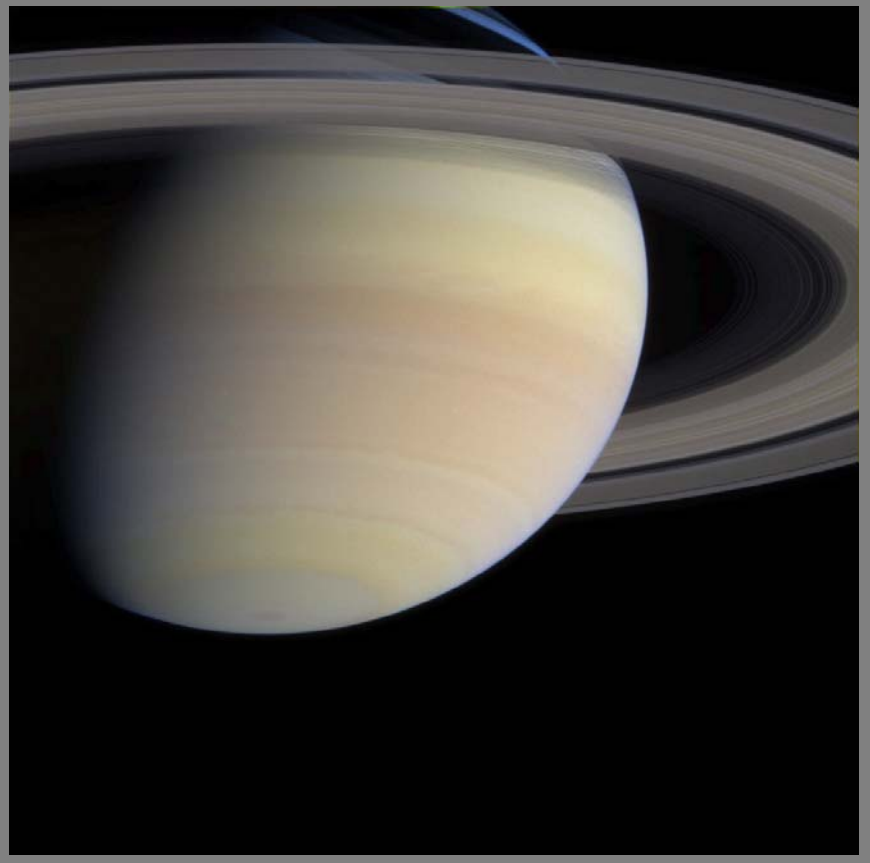
Plasma Vorticity in the Saturnian Magnetosphere



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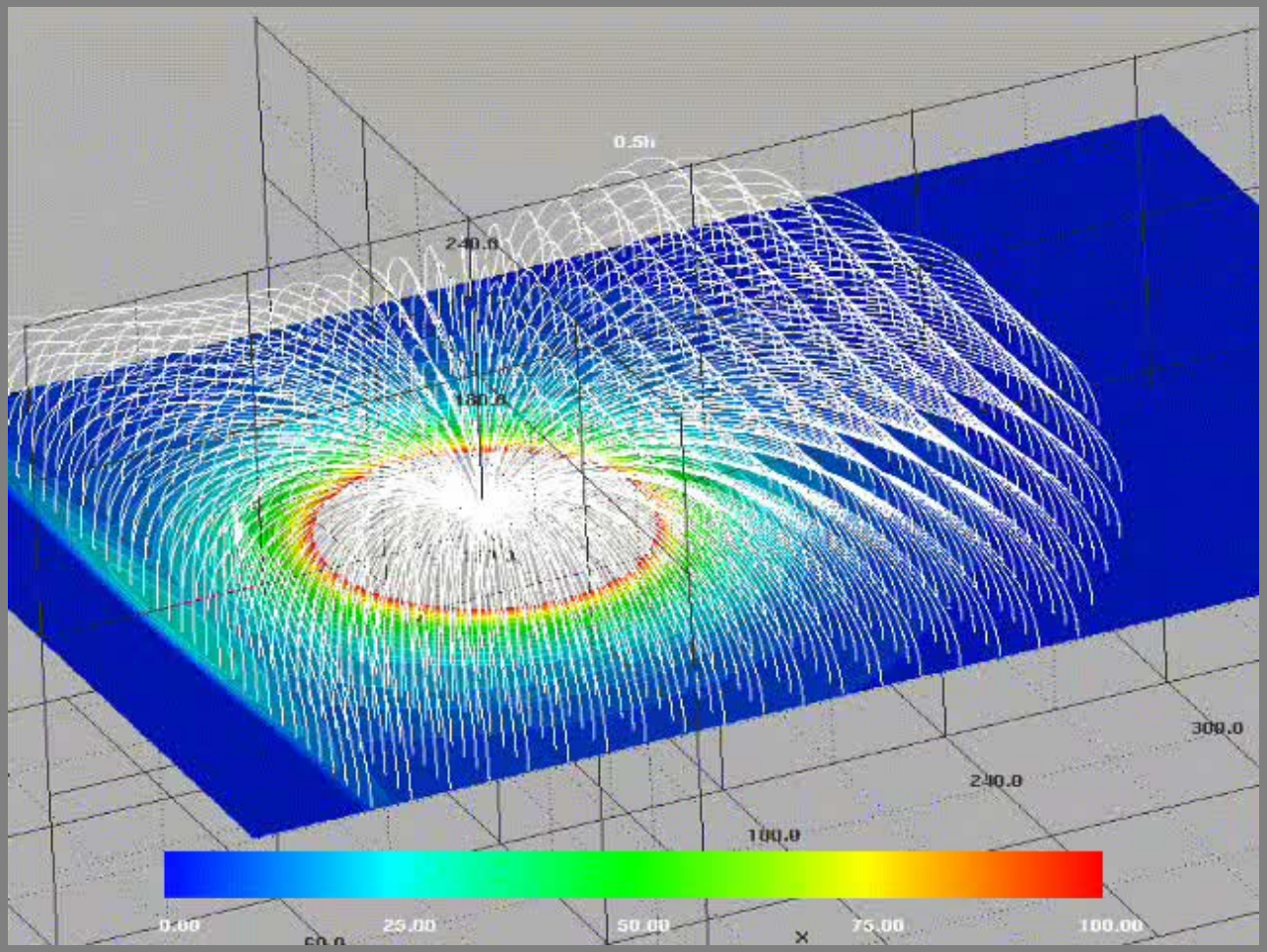
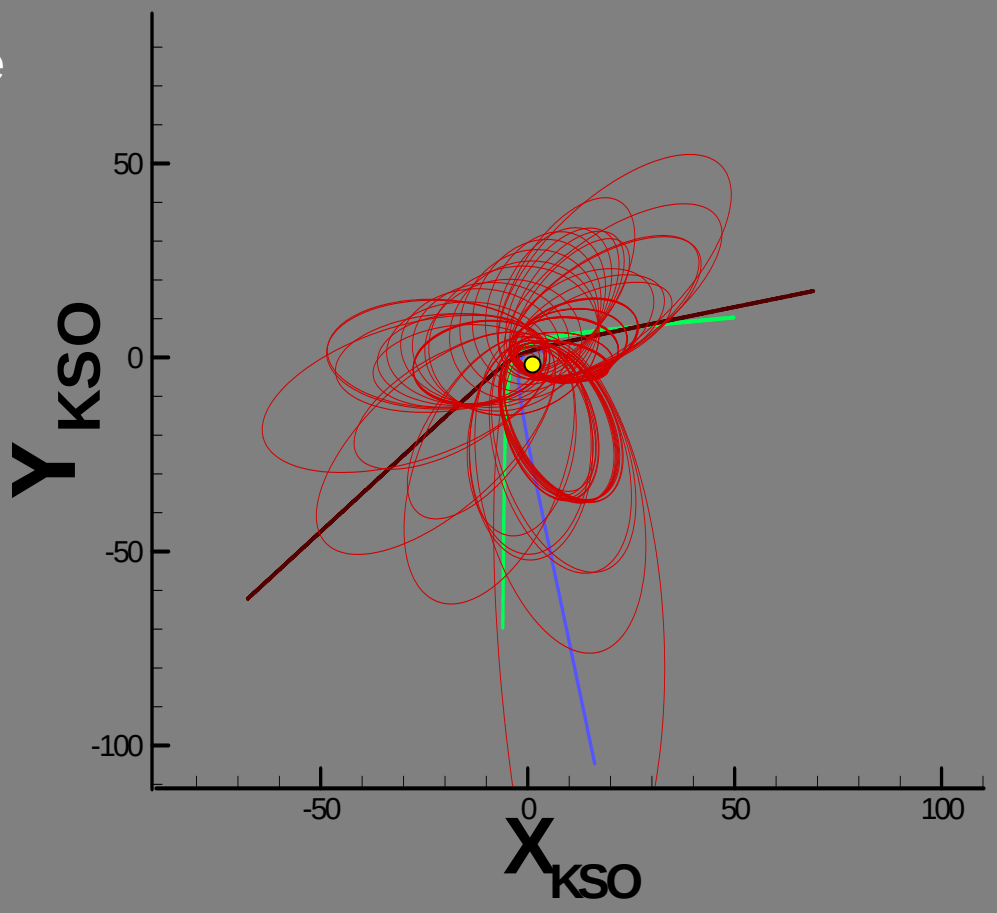
A Simulation of Saturnian Magnetic Dynamics



The Spacecraft that have Shaped our Understanding of Saturn's Dynamics

- Pioneer 11: Attaining Saturn in 1979, gave us the first true look at Saturn, with sufficient data to have some sort of understanding of the planet. It was only a flyby mission. Pioneer is in blue.
- The Voyager Spacecraft: In 1979 and 1980 Voyager 1 and 2 flew by Saturn respectively. The Voyager 1 and 2 trajectories are in black and green.
- Cassini : Arriving at Saturn in 2004, it sought to answer many of the questions left by Pioneer 11 and Voyager concerning Saturn. The Cassini orbits are in red.



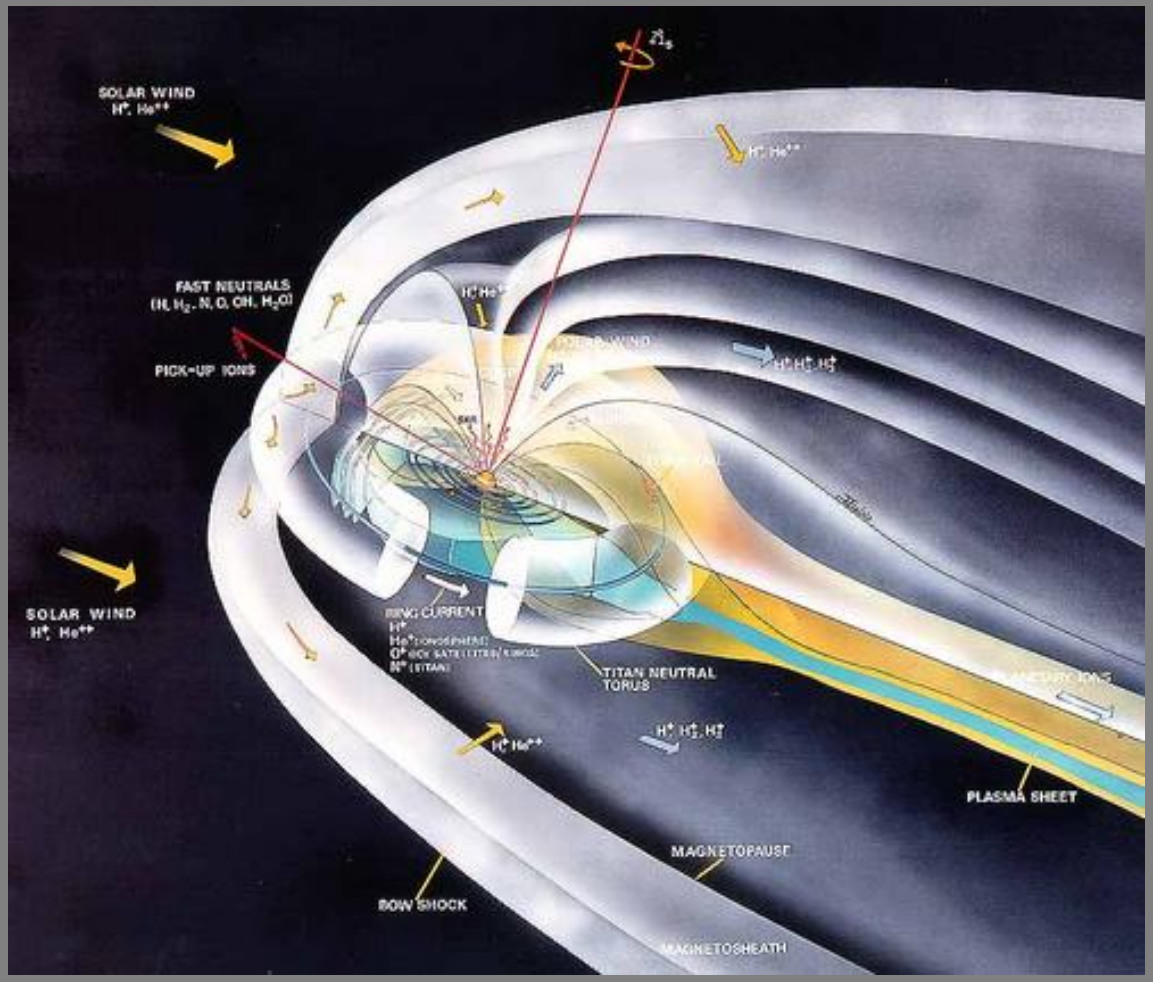
Basis on Which Magnetic Rotations May Be Analyzed

- Frozen in Flux law : The magnetic flux in a moving flux tube is constant. This means that we can learn about the plasma motion by studying the changes in the magnetic field. The general equation reaches a simplified form of:

$$\mathbf{V} = \frac{(\mathbf{E} \times \mathbf{B})}{\mathbf{B}^2}$$

Basic Shape of Saturn's Magnetosphere

Here is the basic shape for the magnetosphere

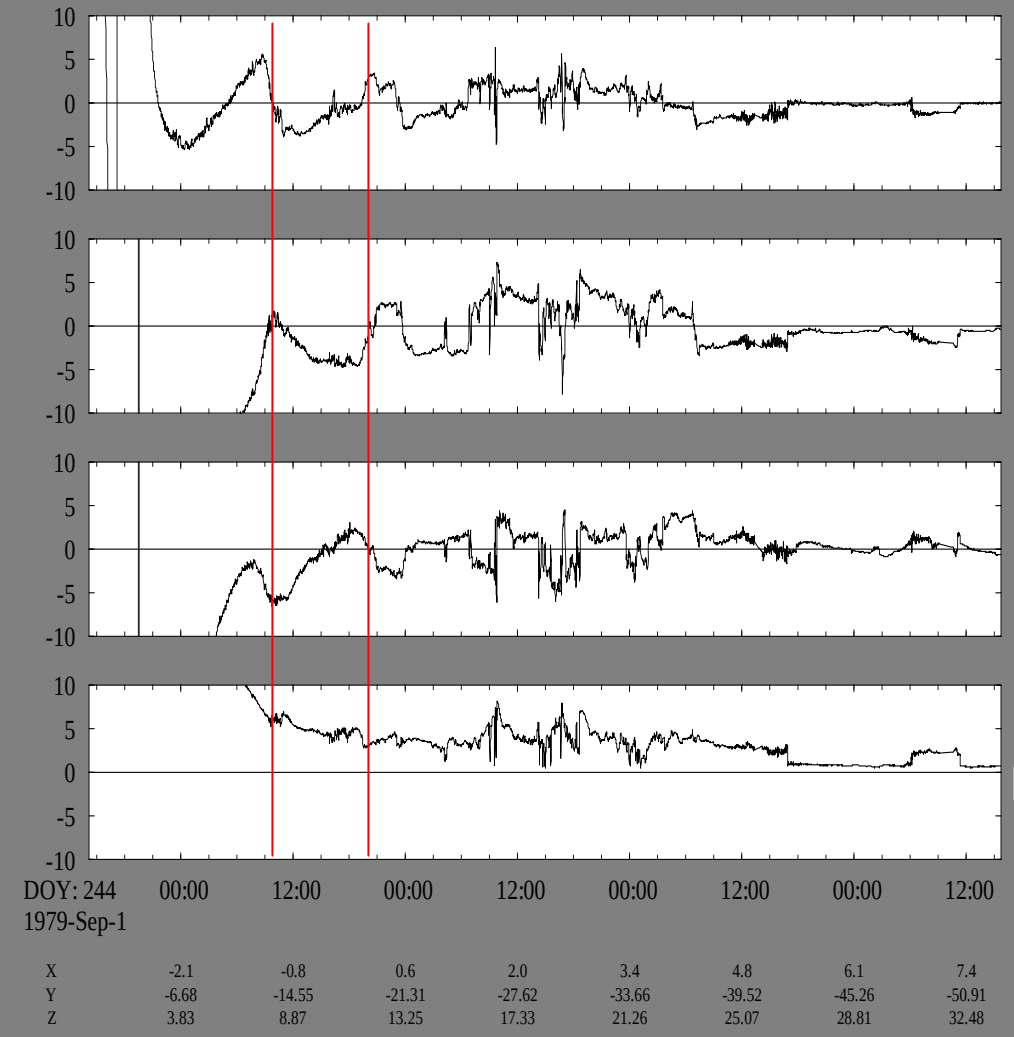


Approach

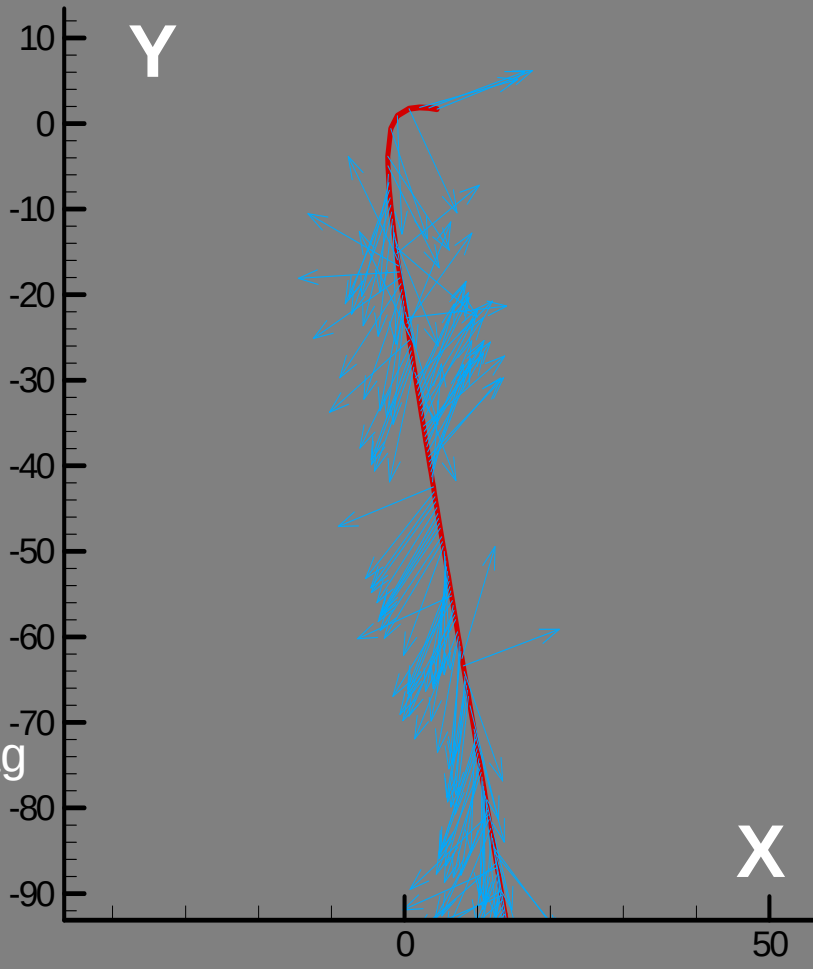
- 25 years ago Dr. Walker and Dr. Kivelson took a look at Pioneer 11 and found rotations in the magnetic field. We decided to start off redoing the work with Pioneer 11 to confirm the results. More precisely we looked at the HVM instrument data stream and constructed a background magnetic field model for the magnetic behavior. We then examined the changes along the trajectory, confirming the previous results by Walker and Kivelson.

Pioneer 11

11 hour periodicity



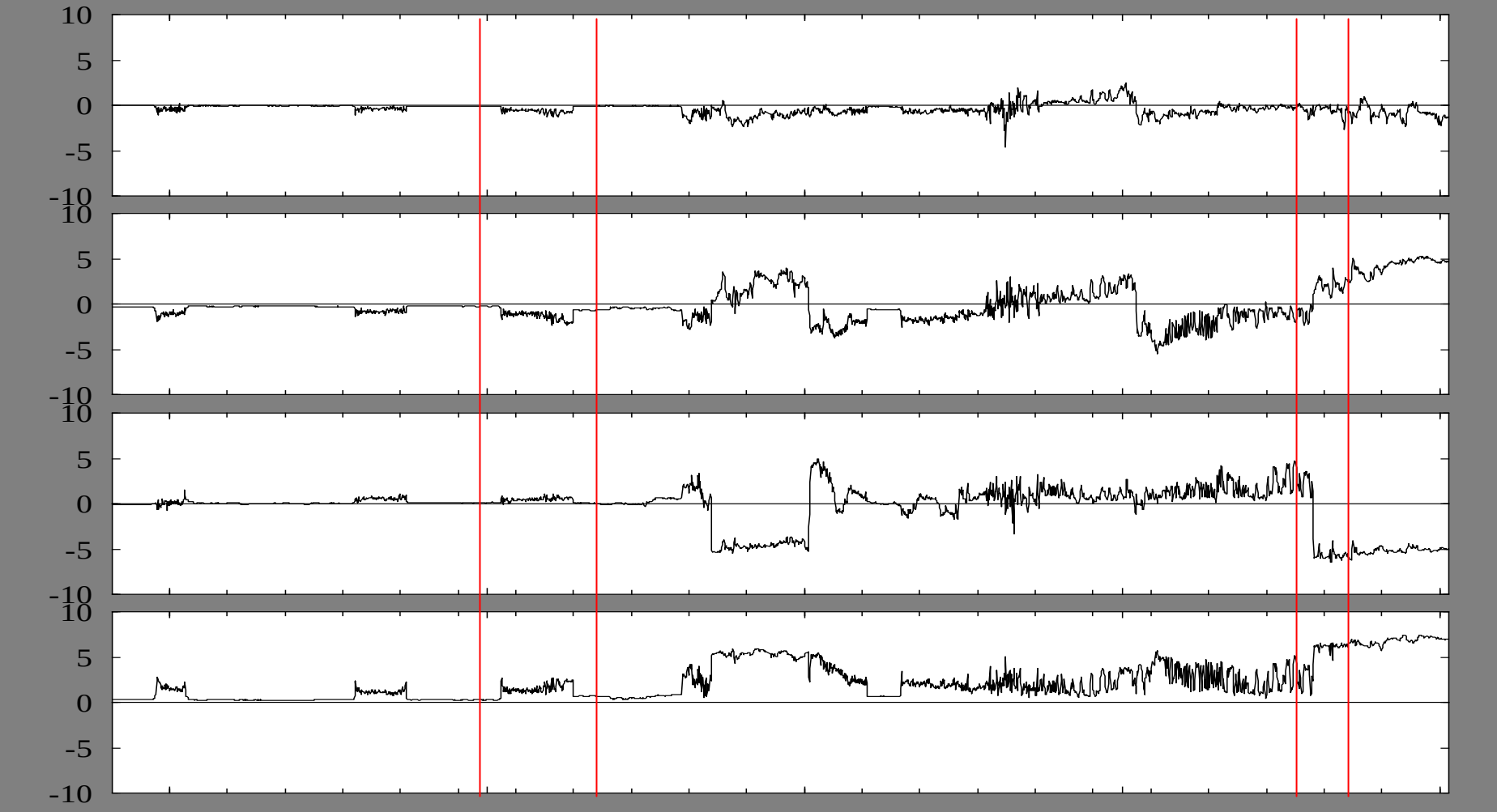
The magnetic rotations



Analysis

- Once we completed work with the Pioneer 11 data, we began attempting to find similar rotations in the Cassini data.
- It was important to know when the spacecraft was inside the magnetosphere, for this is where we believe the rotations take place.
- The boundaries were located based on the raw data stream at 1 minute resolution. The results were compared with Steve Arridge's magnetopause crossings .

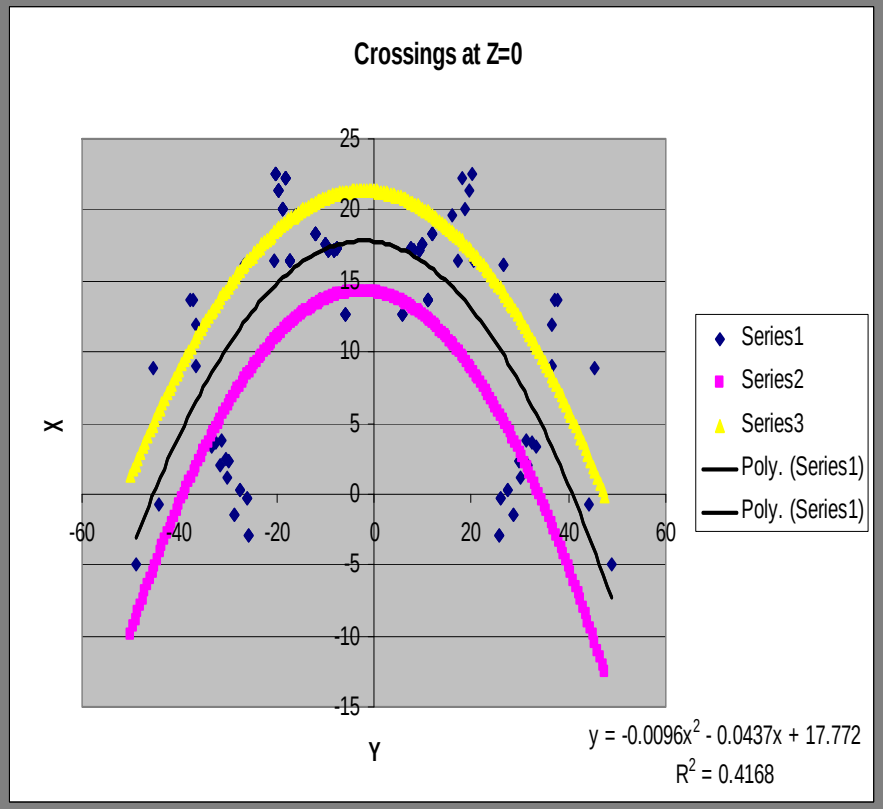
Locating Magnetopause Crossings



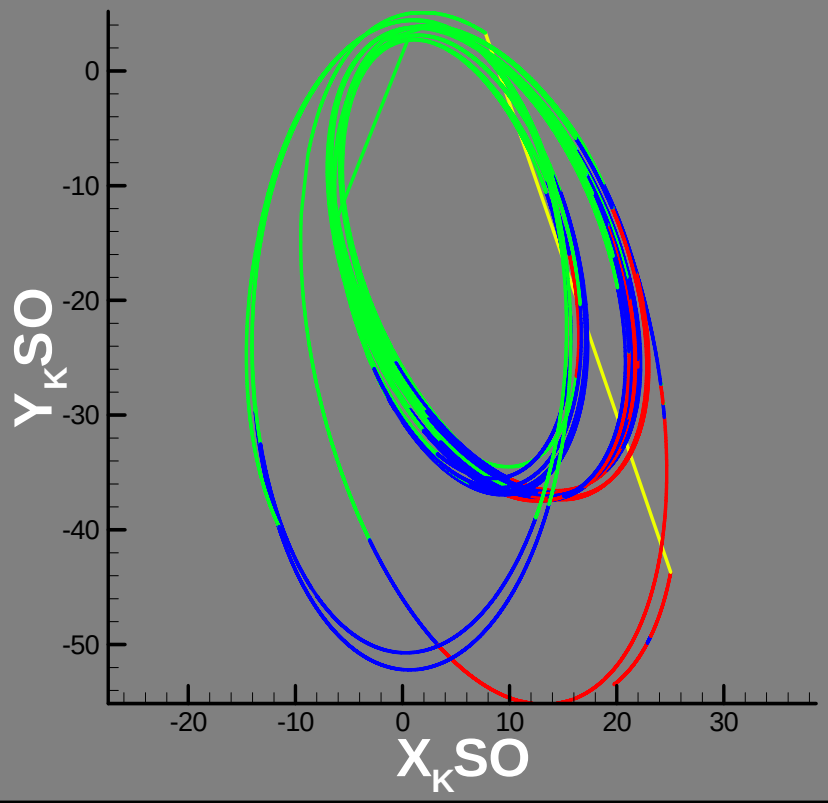
X_KSO	20.96	20.34	19.44	18.17	16.40
Y_KSO	-19.70	-17.15	-14.36	-11.30	-7.93
Z_KSO	4.11	3.57	2.99	2.35	1.64
OC_HR	8.90	9.10	9.40	9.70	10.10

Cassini Crossings

Crossings were fit by examining raw data.



Trajectory with Crossings inputed for 2005 1 min data, done with Steve Arridge's magnetopause crossing times.

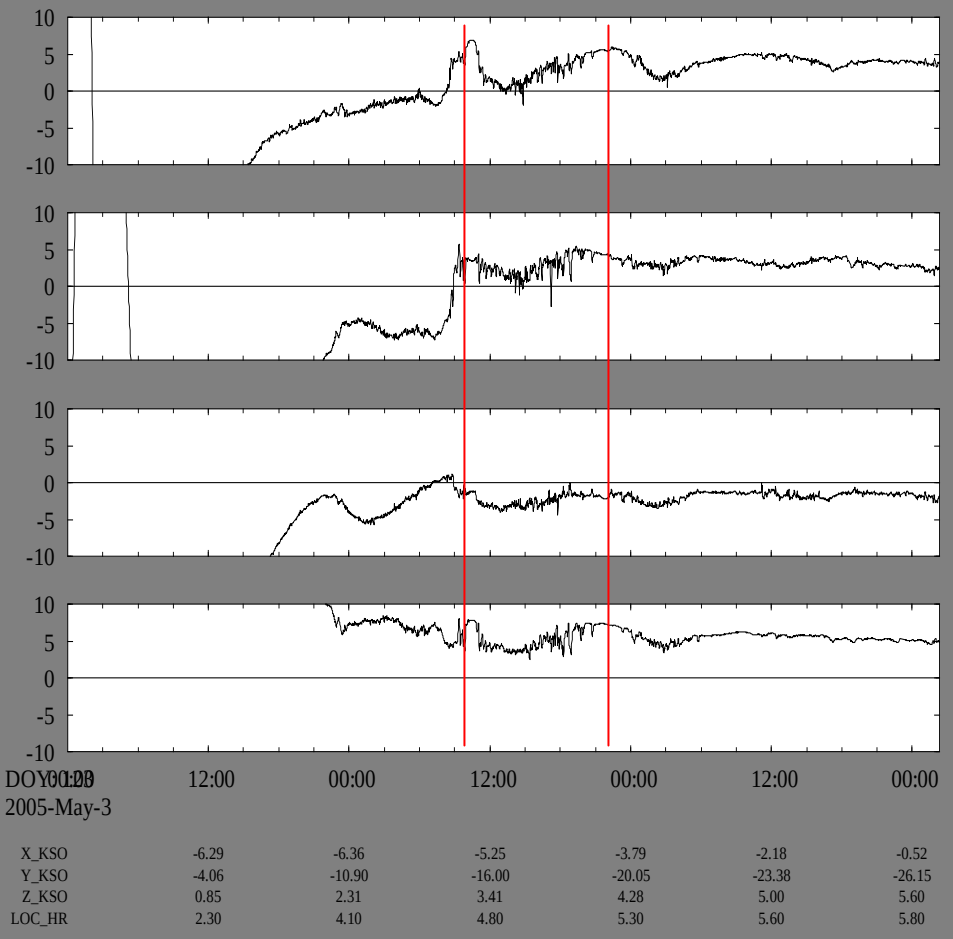


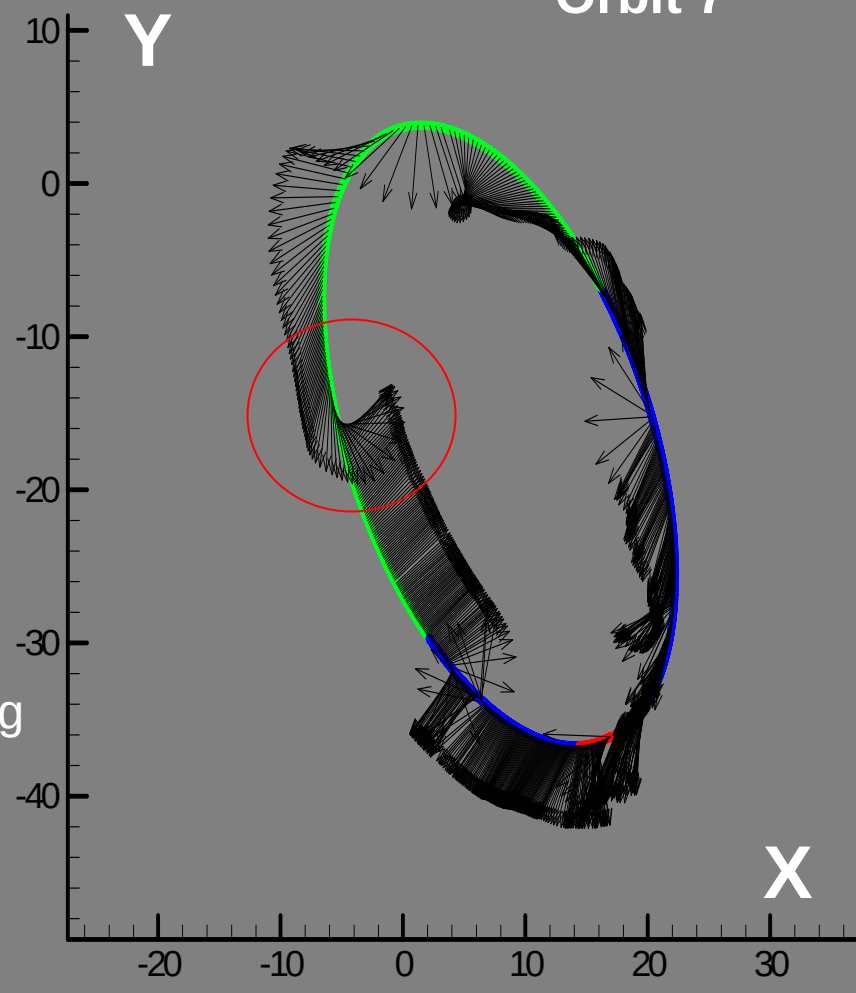
Legend: Green- Magnetosphere Blue- Magnetosheath

Red- Solar Wind Yellow- Data Gap

Dawn-Side Behavior with Cassini

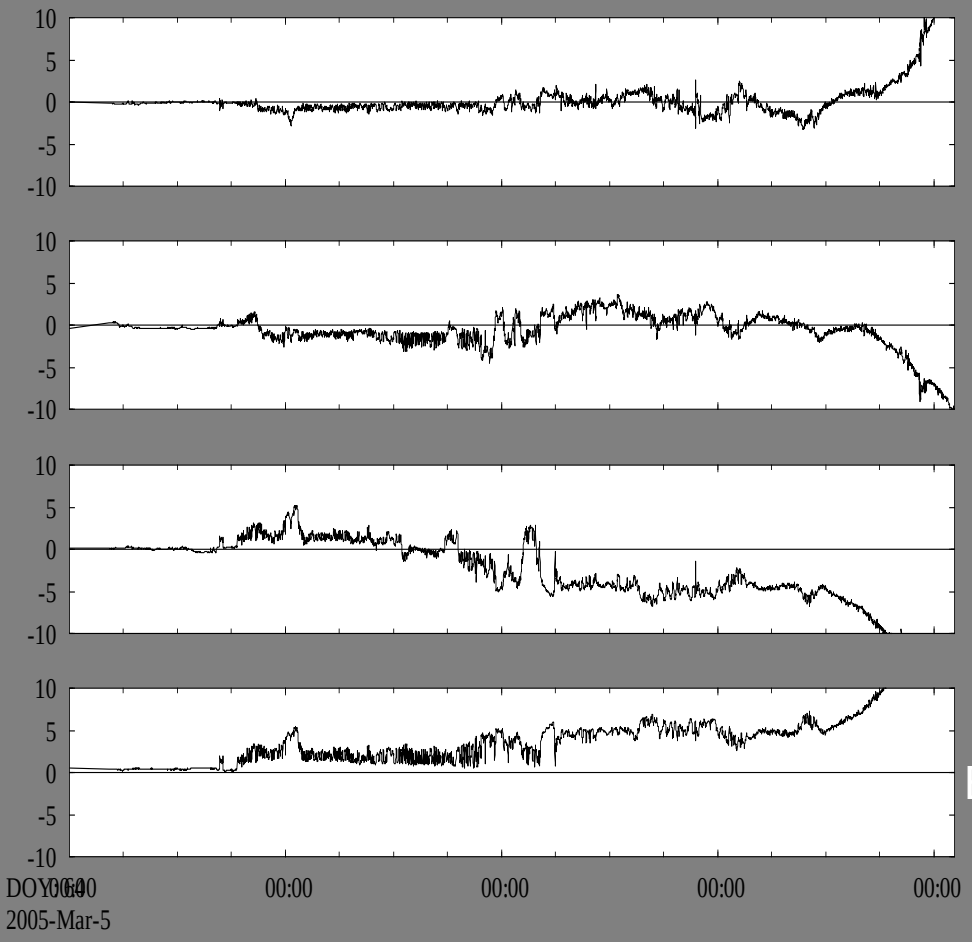
- Probably not vorticity. Note 11 hour periodicity. Thought to be caused by plasma sheet motion over Cassini.
- Perhaps our initial ideas for Pioneer were false

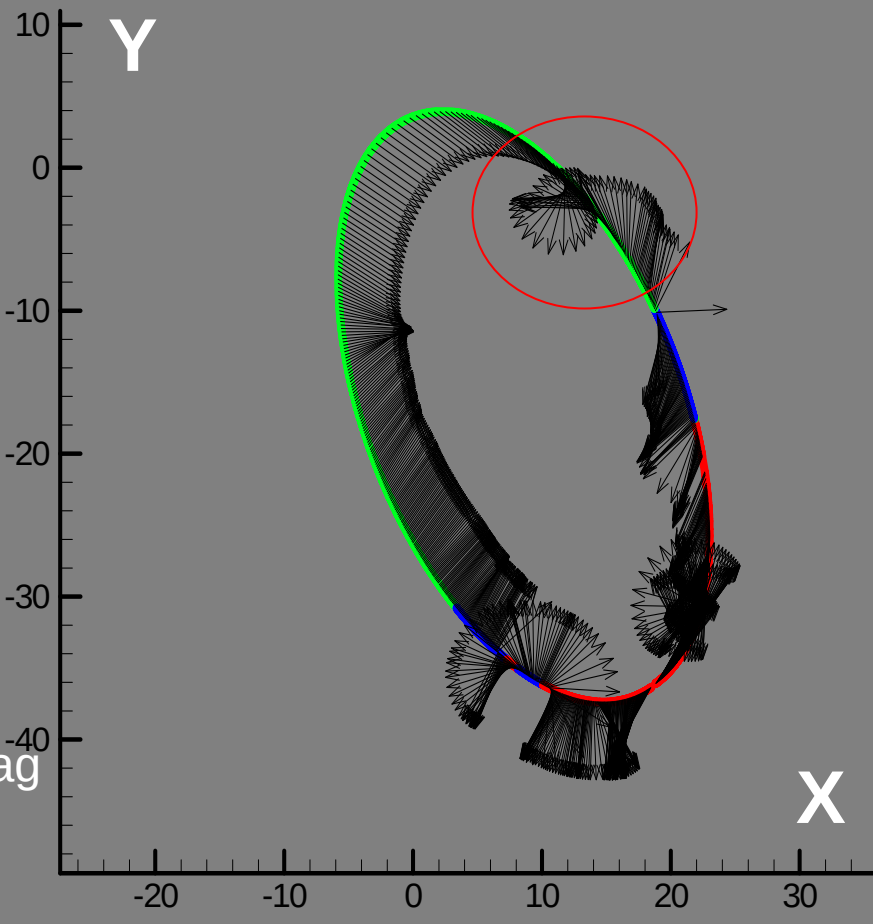




Cassini Magnetic Dynamics

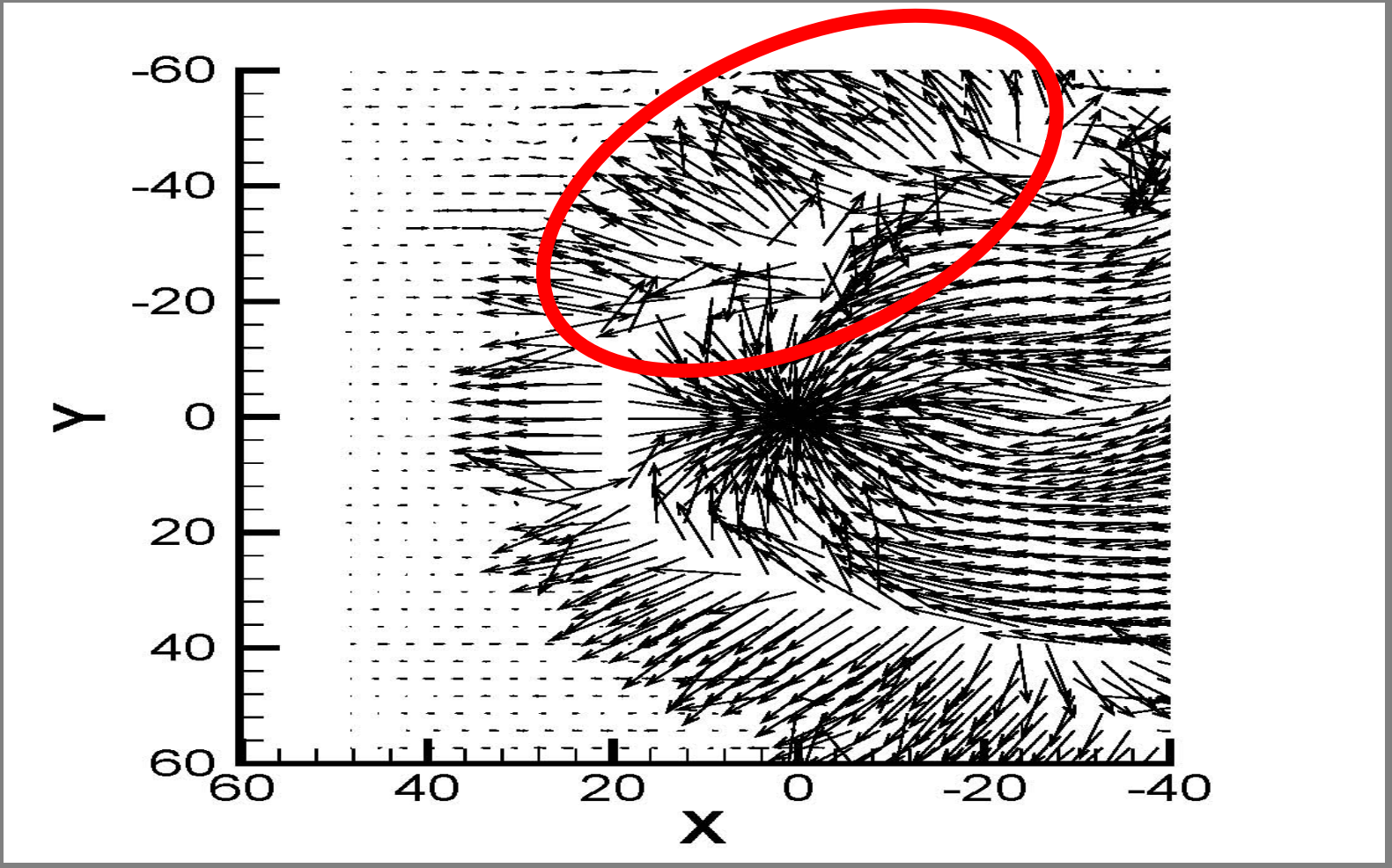
Magnetic field rotations were found near the dayside magnetopause.





Magnetosphere Modeling

Dayside rotations from
the MHD simulation.



Future Pursuits

- Continuing our research we seek to work with simulation models, and see how they are verified by the data we have observed.

- So far we have concluded that the behavior recorded by Pioneer 11 on the dawn-side was not vorticity, but most likely a current sheet crossing. Yet we have seen waves originating near the magnetopause on the day side.

- We will continue examining the Cassini data as well as the ones produced by the Voyager spacecrafts. The source of the behavior we see having the 11 hours periodicity remains controversial.