# Flux transfer event observation at Saturn's dayside magnetopause by the Cassini spacecraft

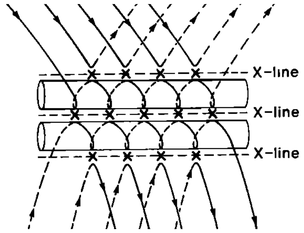
**J. M. Jasinski**[1,2,3,*], J. A. Slavin[1], C. S. Arridge[4], G. Poh[1], X. Jia[1], N. Sergis[5], A. J. Coates[2,3], G. H. Jones[2,3], J. H. Waite Jr[6].

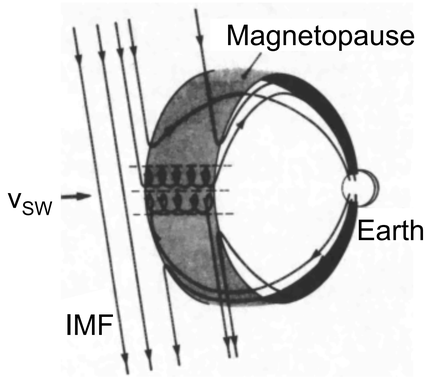
[1]Climate and Space Sciences and Engineering, University of Michigan, MI, USA; [2]MSSL, UCL, UK; [3]Centre for Planetary Sciences, UCL/Birkbeck, UK; [4]Dept. of Physics, Lancaster University, UK; [5]Office for Space Research and Technology, Academy of Athens, Greece; [6]Southwest Research Institute, TX, USA.

*Email: jjasinski@umich.edu

## Introduction

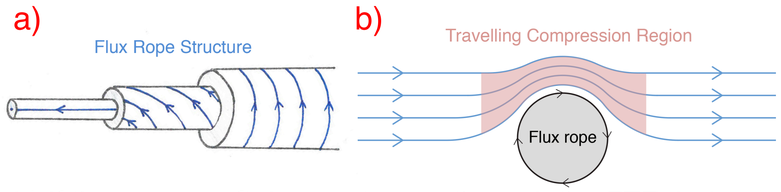
- The process of reconnection occurring at multiple X-lines at the dayside magnetopause, results in the creation of flux transfer events (FTEs).




[Lee and Fu, 1985]

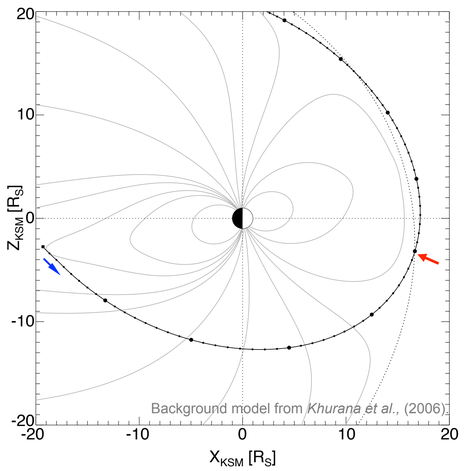
- a) The FTEs twisted magnetic field structure produces a bipolar signature observed in the magnetic field measurements, as well as an increase in magnetic field strength at the centre of the FTE (the typical FTE observational signatures).




- b) If the spacecraft does not cross through the FTE, but passes near the edge, then a travelling compression region (TCR) is observed due to the draping of the magnetic field around the flux rope (red shading above).

- Previous surveys of Cassini data for FTEs at Saturn found none [Lai et al., 2012].

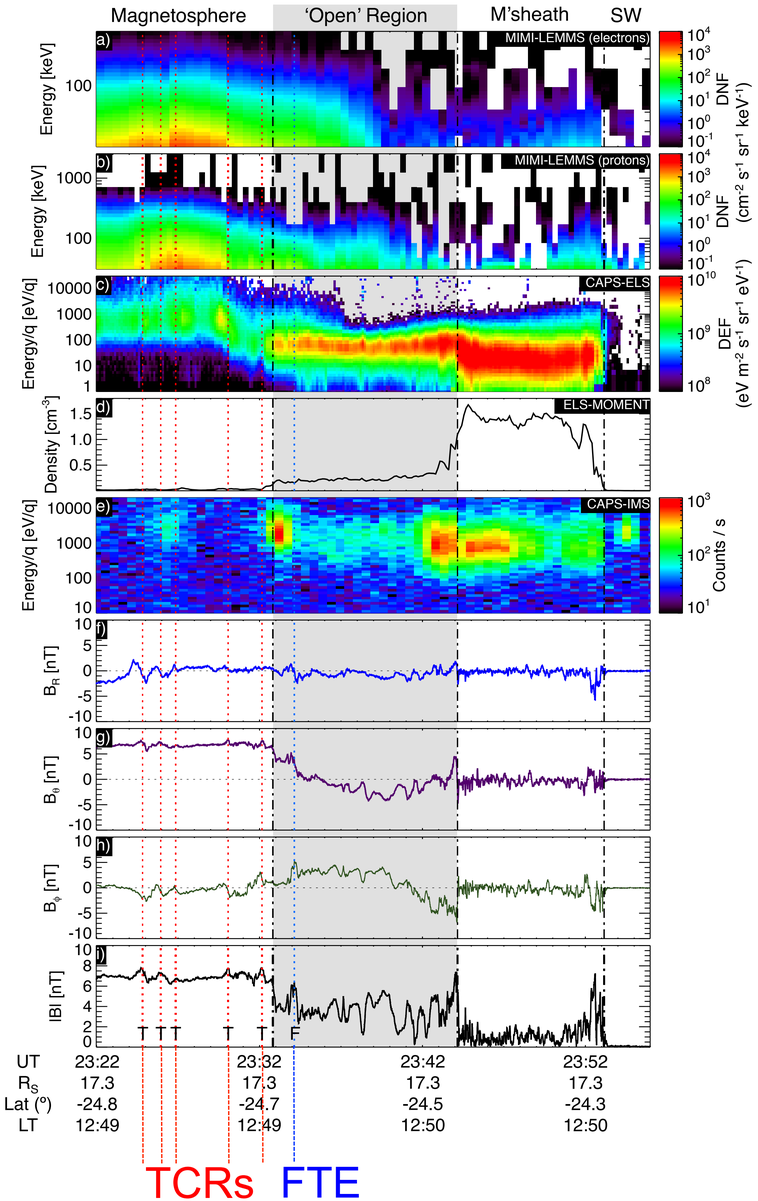
- Cassini observed the FTE near the subsolar magnetopause (at he red arrow) and was traveling equatorward (blue arrow is spaceraft trajectory direction).




## Observations

- Cassini plasma observations are shown below with Cassini in the magnetosphere at the start where it observed 5 TCRs, before it entered a region of open flux, followed by a crossing into the magnetosheath and finally the SW.

- Plasma observations show a mixed magnetosheath and magnetopheric plasma in the region of open flux where the FTE is observed (blue dotted line).

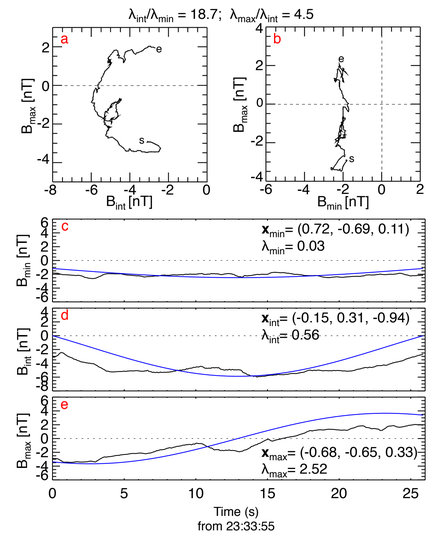



## MVA and flux rope modeling

- Minimum variance analysis (MVA) shows the FTE structure is consistent with a flux rope (black).

- The FTE was compared to a force-free flux rope model first put forward by *Lundquist* [1950] and developed by *Lepping et al*. [1990] (model shown in blue).

- The FTE was estimated to have a radius of 4600-8300 km and a magnetic flux content of 0.2-0.8 MWb.




## Discussion & Summary

- We have presented the first observation of a flux rope at Saturn's dayside magnetopause.

- **This is an important result because it shows that the Saturnian magnetopause is conducive to multiple X-line reconnection and flux rope generation.**

- MVA shows that the measured magnetic structure is consistent with a flux rope. The magnetic observations were also well fitted to a constant-α force-free flux rope model.

- Assuming that the five observed TCRs (in the adjacent magnetosphere) are attributed to FTEs, results in an FTE occurrence of ~2min (6 FTEs in 9 min), which is less that the ~8min and more than the 8s observed at Earth and Mercury, respective [Rijnbeek et al., 1984; Slavin et al., 2012].

- Six FTEs in 9 min would result in a reconnection voltage of ~2-9 kV (attributed solely to FTE generation).

- With an estimated dayside reconnection voltage of ~100-200 kV during solar wind pressure enhancements [Masters, 2015; Badman et al., 2013], it could be estimated that FTEs contribute ~1-9% to the opening of flux at Saturn's dayside magnetopause (during SW compressions).

References: Badman et al., 2013 (Icarus); Jasinski et al., 2016 (GRL); Lai et al., 2012 (JGR); Lee and Fu, 1985 (GRL); Lepping et al., 1990 (JGR); Lundquist, 1950 (Arkiv fur Fysik); Masters, 2015 (GRL); Rijnbeek et al., 1984 (JGR); Slavin et al., 2012 (JGR).