Abstract: Flux rope, often known as plasmoid when the guide field is small, is an important structure to transfer magnetic flux and plasmas in the magnetosphere of terrestrial and planetary magnetospheres. At Saturn, the flux rope can be generated by both ‘Dungey cycle’ and ‘Vasyliūnas cycle’. Where and how a flux rope is formed and its evolution at Saturn is pivotal in understanding the energy and mass transportation in the magnetosphere. In this work, we present the observations of flux rope-like structures at pre-noon sector of Saturnian magnetosphere, which proves that the internally driven reconnection site can exist at dayside magnetosphere. We determine that the magnetic variations when crossing the ‘flux rope’ is caused by planetary rotation, not the traditional ‘reconnection retreat’.

Introduction

Flux ropes formed by both Dungey cycle and Vasyliūnas cycle have bipolar $B_{\phi}$ observational signatures in Saturn's magnetotail [e.g., Achilleos et al., 2005]. The bipolar signature is often explained as a tailward retracting of the flux rope, when it is formed pre-night and is carried to post-night sector by the rotating magnetosphere. For Vasyliūnas cycle, the flux ropes are formed in closed field line. It’s an open question that how the flux ropes in Vasyliūnas cycle evolve and where they eventually go.

Statistical analyses have shown flux-conserving reconnection can occur in the subsolar and dusk sector (Dekhors et al., 2015). How are these "drizzle-reconnection" sites formed and evolved?

Recently, Yao et al., [2017, under review] proposed a 3D co-rotating reconnection picture based on analysis of in-situ data from the Cassini spacecraft in Saturn’s magnetosphere. They explain the bipolar $B_{\phi}$ signature as a result of azimuthal cross of the structure, rather than the traditional radial cross of a structure, based on the fact that the crossing can occur again after one rotating period when X-line rotates back to the spacecraft. This model implies that the X-line and the associated flux rope could drift to noon sector to affect dynamics on dayside magnetosphere.

Motivation

- Does X-line & flux rope exist on dayside magnetosphere?
- What’s the observational feature of flux rope at dayside?

Observation of flux ropes in dayside magnetosphere at Saturn

Ruilong Guo (1) (grl@mail.igcas.ac.cn), Zhonghua Yao (2), and Yong Wei (1)

(1) Key Laboratory of Earth and Planetary Physics, Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing, China
(2) Laboratoire de Physique Atmosphérique et Planétaire, STAR Institute, Université de Liège, Liège, Belgium

The Overview

‘Flux Rope’ on Dayside of Saturn’s M’sphere

A magnetic reconnection related structure was detected by Cassini near the noon sector of the Saturn’s magnetosphere.

- Location: R: 17.6R$_{S}$
- Local Hour: 11.2
- In Northern hemisphere: Br > 0

- Duration: ~6min
- Flux-rope-like features: $B_{\phi}$ < 0 & $|B_{\phi}|$ decreasing
- No identifiable $B_{\phi}$ bipolar signal.
- How to cross the ‘Flux Rope’?

Co-Rotating Model: X-line and flux rope inside the closed field line can drift with the magnetosphere.

At dayside, the motion of the flux rope was mainly in azimuthal direction, and the spacecraft crossed the flux rope along its axis direction. So a $B_{\phi}$ dip, other than a bipolar, was observed.

The current sheet could swing when crossing flux rope, which was indicated by the large variation of $B_{\phi}$.

Additional Co-Rotating Event

- Near noon, signatures of $B_{\phi}$ dip accompanied with $B_{\phi}$ increasing were recorded repeatedly with a period of ~ 11.6h.

Conclusion

- Flux-rope-like features are identified in dayside of Saturn’s magnetosphere, which directly proves that the internally driven reconnection exist at dayside magnetosphere.
- Flux-rope/X-line could co-rotate with Saturn’s magnetosphere several times, which is a strong support to the co-rotating reconnection picture proposed by Yao et al., [2017, under review].