EPSC Abstracts
Vol. 10, EPSC2015-149, 2015
European Planetary Science Congress 2015

Statistical Study of Plasma-depleted Flux Tubes in Saturnian Magnetosphere

H.R. Lai (1), C.T. Russell (1), H.Y. Wei (1), M.K. Dougherty (2), and Y.D. Jia (1)
(1) Department of Earth, Planetary and Space Sciences, University of California, Los Angeles, USA (hlai@igpp.ucla.edu) (2) Imperial College London, The Blackett Laboratory, London, UK

Abstract

We have surveyed the occurrence of flux tubes with both enhanced and depressed field strength relative to their surroundings as observed in Cassini magnetometer data. Consistent with earlier studies, enhanced field flux tubes are concentrated near the equator while depressed field flux tubes are distributed in a larger latitudinal region. For both types of flux tubes, their occurrence rates vary with the local time in the same pattern and they contain the same magnetic flux. Therefore, we suggest that those two types of tubes are just different manifestations of the same phenomenon. Near the equator with high ambient plasma density, the flux tubes convecting in from the tail are compressed, resulting in increased field strength. Off the equator, these flux tubes expand slightly, resulting in decreased field strength. The enhanced flux tubes gradually break into smaller ones as they convect inward. Inside an L value of about 5, they become indistinguishable from the background.

1. Introduction

Every second, 100s of kilograms of water group neutrals and plasma are added to the Saturnian magnetosphere from Enceladus. The newly added plasma is accelerated to the rotational speed of the planet and convects outward. The plasma is lost through magnetic reconnection in the tail. The 'empty' reconnected magnetic flux must return from the tail back to the inner magnetosphere in steady state. In early studies [e.g., 1 and 2], flux tubes with both enhanced and depressed field strength relative to their surroundings have been detected. However, the relationship between the two types of phenomena is unclear. Here we have systematically surveyed all the available 1-sec magnetic field data measured by Cassini and use the statistical properties of the flux tubes to improve our understanding.

2. Statistical Properties

We select all the flux tubes distinguishable from their neighbours by a difference in field strength detected inside 15 Saturn radii and lasting from 30 seconds to 15 minutes. As Figure 1 shows, the enhanced field flux tubes are concentrated in a latitudinal and L-shell region where the surrounding plasma density is high; while the depressed flux tubes are distributed in a larger latitudinal and L-shell region. Figure 2 shows that the occurrences of both types of flux tubes vary with the local time in the same pattern.

If we assume the cross section of the flux tube is a circle and the diameter is the product of duration and rotational speed, we can estimate the flux contained in each flux tube. Here we employ 10km/s as the speed at the surface of equator. As Figure 1 shows, the medians of magnetic flux contained in both types of flux tubes are the same.

We further classify the enhanced flux tubes, which are much easier to identify, into four different groups based on their shapes. Figure 3 shows the occurrence ratio of different types as a function of L-shell number. We can see that simple and single flux tubes are more frequently observed when the L-shell number increases while complex and clustered flux tubes are more frequently observed when the L-shell number decreases.

3. Figures

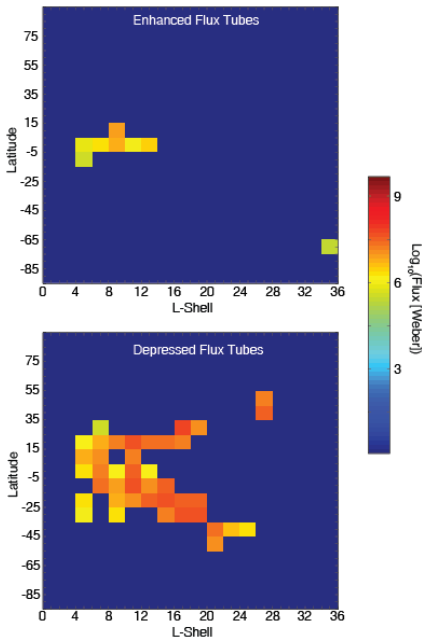


Figure 1. Medians of magnetic flux contained in enhanced (upper) and depressed (lower) flux tubes.

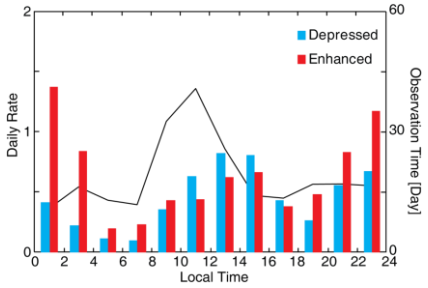
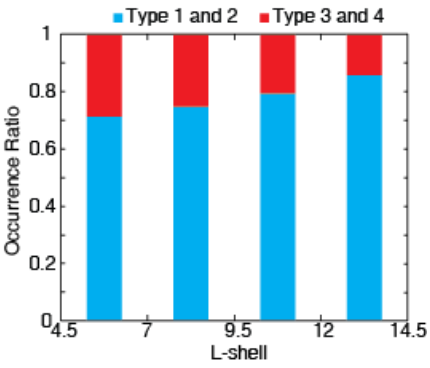
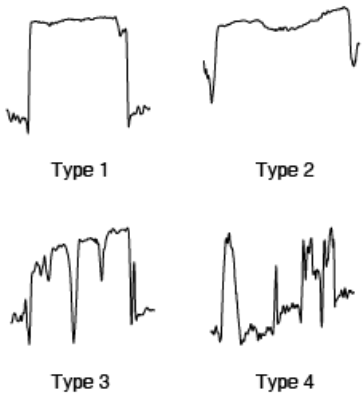


Figure 2: Daily rate of enhanced and depressed flux tubes as a function of local time.



(a)



(b)

Figure 3: Occurrence ratio (a) of different types (b) of enhanced flux tube as a function of L-shell.

4. Summary and Conclusions

Based on the flux estimation and the occurrence variation with local time, we suggest that both enhanced and depressed flux tubes are the same phenomenon detected at different plasma conditions. Near the equator in the range of the E region torus, where the ambient plasma density is high, the flux tubes are compressed and field strength increases; while when the ambient plasma density is low off the equator, the flux tubes slightly expand and the field strength decreases. As the enhanced flux tubes convect inward, they break into smaller flux tubes and disappear inside L value of about 5.

References

[1] Russell, C.T., Leisner, J.S., Arridge, C.S., Dougherty, M.K., and Blanco-Cano, X.: Nature of magnetic fluctuations in Saturn's middle magnetosphere, J. Geophys. Res., 111, A12205, doi: 10.1029/2006JA011921, 2006.

[2] Andre, N., et al., Magnetic signatures of plasma-depleted flux tubes in Saturnian inner magnetosphere, Geophys. Res. Lett., 34, L14108, doi: 10.1029/2007GL030374, 2007.