Project Details

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Selection Year: 2012
Program Element: Focused Science Topic

Topic: Interaction Between the Magnetotail and the Inner Magnetosphere and its Impacts on the Radiation Belt Environment

Project Title:
Energization and Transport of O+ Ions in the Nightside Magnetosphere

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Summary:
The present study will address the LWS/TRT Focused Science Topic interaction between the plasma sheet and the inner magnetosphere focusing on the transport and energization of the O+ ions. The energy density of the O+ ions in the ring current can be comparable to that of the protons during magnetospheric storms. Therefore, through the magnetic deformation and the change of wave environments, the intensification of the O+ ring current makes a significant impact on the dynamics of the radiation belt. However, it still remains to be understood how the O+ ions are transported and energized on their way to the ring current.

In this project we will observationally address the following questions:

Q1. How often and under what conditions are earthward busty bulk flows (BBFs) in the plasma sheet followed by the intensification of the O+ ring current?

Q2. How do the O+ ions enhance in association with the BBFs and dipolarization? What features of the BBFs and dipolarization are essential for the O+ ion enhancement?

Q3. How do the characteristics of the O+ ions change in association with fast tailward flows with southward Bz?

Q4. How do the characteristics of the O+ ions in the nightside magnetosphere respond to the sudden enhancement of geoeffectiveness? How does it depend on the radial distance or on external and internal conditions?

In general, the earthward BBFs play a significant role in the transport of mass and energy in the plasma sheet. In Q1-Q3 we will observationally examine its role in the O+ dynamics. Q1 addresses the access of BBFs to the inner magnetosphere, for which the oxygen ENA enhancement serves as a global indicator. We will statistically examine entropy-related quantities of the BBF flux tube and will test how/if the intensification (or its absence) of the ring-current oxygen ENA emission depends on them. Q2 addresses the local O+ enhancement associated with BBFs in terms of the transport and energization of the O+ ions. We will compare the time sequences of the O+ enhancement with those of local quantities such as electric field and Bz. The regression analysis will also be performed. For Q3 we will conduct the same analysis as for Q2 but for fast tailward flows. Whereas such flows may be regarded as a counter part of earthward BBFs, the total magnetic field does not increase for tailward flows. The comparison of the results for Q2 and Q3 should tell us, for example, the importance of the drift betatron acceleration of O+ in the earthward BBFs. For Q4 we will examine how the O+ population builds up during magnetospheric storms. If the O+ ions are transported through the distant tail, the build-up should be quicker farther away from Earth. We will test such a hypothesis.

The Geotail data will be used as a primary data set for Q1-Q4. IMAGE/HENA data will be used for Q1 for examining the O+ ring current. We will also use RBSP-SPICE data for Q4, and possibly also for Q2, as optional tasks provided the data are obtained as planned.

Each of the proposed tasks is straightforward and does not require any major development of software. Geotail has been operation for 20 years, and because of its equatorial, rather than polar, orbit, Geotail/EPIC provides the largest ever data set of the O+ ion measurements in the near-Earth (9-31 Re) plasma sheet. The IMAGE/HENA data has also been proven in both quality and quantity. The project team members are familiar with both the target science and the data sets. Therefore this project is highly feasible.

This project is proposed as a contribution to the LWS/TRT Focused Science team. Whereas the target science, the O+ ion dynamics, may be unique, the project will share interests in basic physical processes such as the transport and energization of ions by BBFs. The outcome of this project should also be useful for validating modeling efforts and also for setting up boundary conditions.

Publication References:

Summary: no summary

Reference: Lee, D.-Y.; Kim, H.-S.; Ohtani, S.; Park, M. Y.; (2012), Statistical characteristics of plasma flows associated with magnetic dipolarizations in the near-tail region of r < 12 RE, Journal of Geophysical Research, Volume 117, Issue A1, CiteID A01207, doi: 10.1029/2011JA017246

Summary: no summary

Reference: Ohtani, S.; Uozumi, T.; (2014), Nightside magnetospheric current circuit: Time constants of the solar wind-magnetosphere coupling, Journal of Geophysical Research: Space Physics, Volume 119, Issue 5, pp. 3558-3572, doi: 10.1002/2013JA019680

Summary: no summary

Reference: Sitnov, M. I.; Merkin, V. G.; Swisdak, M.; Motoba, T.; Buzulukova, N.; Moore, T. E.; Mauk, B. H.; Ohtani, S.; (2014), Magnetic reconnection, buoyancy, and flapping motions in magnetotail explosions, Journal of Geophysical Research: Space Physics, Volume 119, Issue 9, pp. 7151-7168, doi: 10.1002/2014JA020205