Project Details

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Topic: Ion Circulation and Effects on the Magnetosphere and Magnetosphere - Ionosphere Coupling

Project Title:
M-I Coupling Effects on Ion Circulation in the Inner Magnetosphere

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Summary:
This investigation focuses on the M-I coupling effects on the ion population in the inner magnetosphere, addressing one of the essential elements of the LWS Focused Science Topic "Ion Circulation and Effects on the Magnetosphere and Magnetosphere-Ionosphere Coupling." Through data analysis and model calculations, we answer the following three outstanding science questions (SQ) on the density structures in the inner magnetosphere, including the oxygen torus, the warm plasma cloak, and the plasmaspheric plume:

SQ1. Is the oxygen torus distinct from the warm plasma cloak? Are these thermal or non-thermal plasma populations?

SQ2. What are the consequences of ring-current-associated electron heating? Are the resulting ion populations consistent with observations of the oxygen torus or warm plasma cloak?

SQ3. What is the typical mass density of the plume? Are observed plumes consistent with current first-principles simulations? Do the simulations require new physics?

We examine both spacecraft measurements and numerical model results to address the three posed science questions regarding the ion circulation in the inner magnetosphere. The major sources of spacecraft data come from the measurements by the Van Allen Probes and Magnetospheric Multiscale (MMS). Specifically, HOPE and HPCA instruments provide the measurements of warm ions. The charge density is inferred from the measured upper hybrid resonance frequency, and the mass density of the bulk plasma is inferred from the field line resonance frequencies observed by electric and magnetic field instruments. The comparison between mass and charge densities can estimate the ion composition in the bulk plasma. Numerical modeling based on the SAMI3 model with the optional ring current module is performed to investigate the ring current heating effect on O+.

The proposed research addresses longstanding questions about the nature of the torus, cloak, and plume plasmas. This is a necessary step for understanding the response of the inner magnetosphere to storms. This work will impact the development of space weather models, especially models of storm-time phenomena. Predictions of radiation belt growth and decay, of storm-time convection, and of ionosphere electron density gradients will be affected by this work.

The proposed research directly addresses some objectives of the LWS Focused Science Topic "Ion Circulation and Effects on the Magnetosphere and Magnetosphere-Ionosphere Coupling." It is also relevant to the Heliophysics Decadal Survey goal to "determine the dynamics and coupling of Earth's magnetosphere, ionosphere, and atmosphere and their response to solar and terrestrial inputs." The proposed investigation can provide data and model results of ion density and temperature that can assist other investigations in the Focused Science Team.

Publication References:

no references