Project Details

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

Project Title:
Factors that Control the Ion Composition of the Plasma Sheet and Ring Current

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Summary:
The goal of this proposal is to address the factors that affect the heavy ion content of the magnetosphere, in particular O+ and the O+/H+ ratio, from an observational perspective, focusing on the hot (>20 eV) ions. Specifically, we will address the following questions:

- What are the factors that affect the composition of the ion outflow?

- What factors determine the combination of solar wind and ionospheric sources that reach the plasma sheet?

- What is the time scale of the transport of ionospheric heavy ions through the magnetosphere during a storm?

The magnetospheric plasma comes from two basic sources, the ionosphere and the solar wind. The hot ionospheric plasma predominantly escapes into the magnetosphere from two locations: the dayside cusp and the nightside aurora. The cusp ions flow over the polar cap and into the lobes before entering the nightside plasma sheet. The nightside auroral ions have direct access to the nightside plasma sheet. Because of their different transport paths, the ions from these two locations have experienced different acceleration and heating, and their contributions to the plasma sheet vary with radial distance. The solar wind contribution also varies, and although the solar wind does not contain O+, an enhanced solar wind source will change the O+/H+ ratio. Thus, the interplay of the dayside and nightside ionospheric sources and the solar wind must all be taken into account to understand the ion composition changes.

Methodology

The project will use a combination of statistical studies and case studies to address the interplay of the different sources. The FAST/TEAMS data will be used to determine how the ion composition of auroral outflow depends on solar zenith angle and EUV, as well as Poynting flux and electron precipitation. This work will capitalize on a study already completed using FAST that determines the outflow as a function of Poynting flux and electron precipitiation for different solar zenith angles, and add the 3D FAST/TEAMS pitch angle distributions for a definitive determination of the composition of the outflow. The study can then be expanded to more years to determine solar cycle dependence.

The determination of the fraction of solar wind and ionospheric sources that reach the plasma sheet will be done with a combination of AMPTE/CHEM data and MMS/HPCA data. AMPTE/CHEM provides a unique dataset, not duplicated on more recent magnetospheric missions, that includes both the mass and charge state of an ion. This allows solar wind minor species, such as high charge state ((Q>3) oxygen to be measured. Using this dataset the relative contributions of the solar wind and ionospheric plasmas to the 7-9 Re plasma sheet can be determined as a function of geomagnetic activity. While MMS/HPCA cannot measure the high charge state oxygen, it can measured the solar wind ion He++. The He++/H+ ratio in the plasma sheet from MMS will be compared with the solar wind He++/H+ ratio to also determine the fraction of the plasma sheet that is from the solar wind. Combining these measurements with the results from AMPTE, an estimate can also be made of the contribution of the solar wind to the EIS measurements of oxygen. Knowing how much of the H+ and oxygen comes from the solar wind, we can then determine the contribution of the ionospheric component as a function of radial distance. This will be compared with the expectations of models of ion transport to the plasma sheet.

Final, to study the transport times of ionospheric ions, we will identify events in which MMS, Van Allen Probes, and, in some cases, Cluster have measurements that can be used to track the access of O+ to the plasma sheet, and from there to the inner magnetosphere during storms. These observations will be compared with modeling results from the team to test which models are best able to reproduce the observed spectra with the observed timing.

Publication References:

no references