Project Details

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Selection Year: 2010
Program Element: Focused Science Topic

Topic: Determine the Behavior of the Plasmasphere and its Influence on the Ionosphere and Magnetosphere

Project Title:
A First-Principles Model of the Plasmasphere

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Summary:
We propose a four-year program to develop a comprehensive first-principles physics model of the plasmasphere-ionosphere system. This will be accomplished by integrating the NRL ionosphere/plasmasphere code SAMI3, the Comprehensive Ring Current Model (CRCM) inner magnetosphere code, and the Lyon/Fedder/Mobarry (LFM) outer magnetosphere code. The primary coupling mechanism is electrodynamic: the electric field is determined by the ionospheric conductances and the Region 1 and 2 current systems. Ionosphere/magnetosphere coupling is essential in order to capture the influence of global electric and magnetic fields on plasmaspheric ion populations.

The important physics issues to be addressed are (1) the density, composition, and temperature of the plasmasphere, (2) plasmaspheric dynamics associated with stormtime erosion and refilling, and (3) the relationship of plasmasphere dynamics to ionosphere dynamics (e.g., SAPS/SED/drainage plumes). In particular, we intend to address the following outstanding science questions:

- How do ionosphere, ring current, and magnetosphere conditions affect the density, composition, temperature, and refilling rate of the plasmasphere?

- What is the influence of the plasmasphere on the magnetospheric ring current and on the TEC?

- What are the necessary conditions for the occurrence of a plasmaspheric plume and a sub-auroral polarization stream (SAPS), and how are they related to each other and to stormtime enhanced density (SED)?

- How closely does He+ track H+ in the plasmasphere during storms?

Over the course of this research, the proposed first-principles plasmasphere model will become an effective tool for data interpretation and for computing the 3D state of the plasmasphere. SAMI3 will therefore provide a significant alternative to the empirical models that are currently used. As part of the LWS Plasmasphere Team, we will provide model outputs for comparison to data. SAMI3 outputs can also be used in computations of phenomena that are beyond the scope of our proposed research, such as electromagnetic ion-cyclotron and whistler chorus waves.

The proposed study directly addresses key elements of the NASA Living with a Star Focused Science Topic "Determine the Behavior of the Plasmasphere and its Influence on the Ionosphere and Magnetosphere." Specifically the program will develop a "first-principles modeling of plasmaspheric density, composition, and temperature that include particle filling and depletion processes and electrodynamic coupling with the ionosphere" and will involve "observational and modeling studies of plasma convection, plasmapause layer dynamics, and plasmaspheric plume formation and transport." Moreover, the aims of this research directly address NASA near-and long-term goals, as outlined in the 2009 Living With a Star Announcement (ROSES 2009), the 2006 NASA Strategic Plan, and the Heliophysics Division Roadmap for Science and Technology: 2005-2035.

Publication References:

Summary: no summary

Reference: Huba, J.; Krall, J.; (2013), Modeling the plasmasphere with SAMI3, Geophysical Research Letters, Volume 40, Issue 1, pp. 6-10, doi: 10.1029/2012GL054300

Summary: no summary

Reference: Krall, J.; Huba, J. D.; (2013), SAMI3 simulation of plasmasphere refilling, Geophysical Research Letters, Volume 40, Issue 11, pp. 2484-2488, doi: 10.1002/grl.50458

Summary: no summary

Reference: Krall, J.; Huba, J. D.; Denton, R. E.; Crowley, G.; Wu, T.-W.; (20140, The effect of the thermosphere on quiet time plasmasphere morphology, Journal of Geophysical Research: Space Physics, Volume 119, Issue 6, pp. 5032-5048, doi: 10.1002/2014JA019850