Project Details

ROSES ID: NNH10ZDA001N
Selection Year: 2011
Program Element: Focused Science Topic

Topic: Incorporating Plasma Waves in Models of the Radiation Belts and Ring Current

Project Title:
Including Quasilinear and Nonlinear Wave-Particle Interactions in Global Radiation Belt Models

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Summary:
We propose a 4-year project in which a new methodology will be used to include nonlinear wave-particle interactions in kinetic simulations of radiation belt electrons, based on a survey of large-amplitude chorus wave data that we will perform using THEMIS satellite data.

The specific scientific problem addressed in this proposal is modeling the large-scale dynamics of the outer electron radiation belt, coupled to a large-scale kinetic ring current code. The effects of quasi-linear and nonlinear wave-particle interactions are described, using a newly developed technique, as diffusion and advection coefficients respectively, in both energy and pitch angle. The importance of this work lies in the fact that properly treating wave-particle interactions is crucial to understanding, modeling, and predicting the behavior of this energetic, geomagnetically trapped population, and the usual quasi-linear treatment alone cannot capture the specific effects that nonlinear interactions are known to cause. It is necessary to model the ring current accurately for two reasons: it provides the "seed" electrons which become energized to radiation belt energies, and it generates the chorus waves responsible for much of the energization.

The work in this proposal is directly relevant to the scientific objectives of the Focused Science Topic "Incorporating Plasma Waves in Models of the Radiation Belts and Ring Current," which calls for "the development of improved codes to treat the dynamical evolution of the ring current and radiation belt populations, including both the generation and the effects of plasma waves." The goal of modeling radiation belt dynamics is a well-established NASA objective and is articulated in a number of other documents, including the LWS Science Architecture Team report to SECAS (which specifically aims to "understand the processes responsible for the acceleration, loss, and transport of radiation belt electrons and ions responsible for radiation dose and bulk charging effects," with a 5 - 10 year goal of "constructing models describing the local and regional acceleration processes"), and the 2002 NRC Decadal Survey Report "The Sun to the Earth and Beyond" (Challenge 3, and resulting recommendation: "Understanding the energization of the radiation belts"). It is also one of the primary objectives of the upcoming NASA Radiation Belt Storm Probes (RBSP) mission ("improve and validate physics-based data assimilation and specification models for the Earth's radiation belts").

The approach used in this project avoids the inherent limitations of conventional quasi-linear diffusion, and exploits recently-developed analytical estimates of nonlinear particle behavior to formulate diffusion and advection terms in energy and equatorial pitch angle, which will be directly incorporated in the ring current/radiation belt kinetic formalism of the Ring current-Atmosphere interactions Model (RAM) code. The expressions for the transport coefficients will be evaluated using recent, high time-resolution wave data from the THEMIS spacecraft, and project closure will be obtained by comparing the results of our simulations to actual storms, which so far have only been studied using quasi-linear diffusion.

Publication References:

no references