Project Details

ROSES ID: NNH08ZDA001N
Selection Year: 2009
Program Element: Focused Science Topic

Topic: Integrate Non-MHD/Kinetic Effects on Magnetic Reconnection, Particle Energization, and Plasma Heating into Global Models.

Project Title:
Multiscale Gyrokinetics in the Magnetosphere

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Summary:
The importance of kinetic effects on low frequency, global oscillations in the magnetosphere is a grand challenge in space physics. Ion gyroradius, electron inertial, and electron pressure effects can lead to dispersion in global Alfven resonances, while electron trapping and ion Larmor radius effects can significantly affect the stability of the ballooning mode in the magnetotail and field-aligned electron acceleration in Alfven wave pulses and Alfvenic turbulence. We propose to develop a nonlinear gyrokinetic simulation model for low frequency waves and instabilities in the global magnetosphere. The model will be based on a cutting-edge electromagnetic gyrokinetic simulation code

developed at Princeton Plasma Physics Laboratory for slab geometry. The model uses a split-weight scheme that accounts separately for the adiabatic and nonadiabatic response of particles in the fluctuating fields, which allows for proper treatment of electron and ion Landau damping over a wide range of plasma beta.

The model will be adapted to realistic global magnetospheric geometry in a systematic manner. First, we will adapt the slab model to magnetospheric parameters typical of the magnetopause where non-MHD effects are important for transport processes. Second, the model will be adapted from slab to cylindrical geometry to include the effects of particle mirroring in a flux tube and the transition from high to low beta along magnetic field lines. Third, the model will be adapted to dipole geometry, and finally, the model will be adapted to a three-dimensional flux coordinate system based on the three-dimensional MAG3D equilibrium developed at Princeton Plasma Physics Laboratory. The code will be systematically used to study the kinetic effects on low frequency, magnetospheric oscillations and ballooning instabilities. Once

developed, the code would be useful to examine a wide range of slowly varying (less than the ion gyrofrequency) global magnetospheric phenomena that includes many kinetic effects such as Larmor radius effects, magnetic drifts, and wave-particle interactions.

The proposed project will benefit the goals and objectives of the LWS program. In particular it will address the focused science topic (d) to integrate non-MHD effects into global models because our objective is to adapt a gyrokinetic simulation code (that includes non-MHD effects) to global magnetospheric geometry. The proposal will also further NASA's Strategic Goals 3B: ``Understand the Sun and its effects on Earth and the solar system'' in Table 1A of NASA Publication NNH08ZDA001N. In particular it will advance subgoal 3B to understand the sun and its effects on earth and solar system. The proposed work will further research objective 3B.1 to understand fundamental physical processes of the space environment from the Sun to Earth to other planets

because the simulations will lead to better understanding of transport of mass, momentum, and energy which to a great extent controls the dynamics of the magnetosphere. It will also further research objective 3B.3 to develop the capability to predict extreme and dynamic conditions because field-line resonances and ballooning instabilities have been linked to auroral acceleration and substorms.

Publication References:

no references