Use of a Hybrid Code for Global-Scale Simulation of the Earth's Magnetosphere

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An understanding of the Earth's magnetosphere and the magnetospheric substorm requires an ability to simulate kinetic processes in a global context. To this end we have developed a hybrid code with a number of innovative features: (1) The code uses a general curvilinear coordinate grid enabling it to accommodate disparate size scales. (2) The cold, dense plasma inside the plasmapause, where kinetic effects are unimportant is treated in the fluid approximation. There is a seamless interface between the fluid and kinetic descriptions. (3) The field update is subcycled to the particle update to circumvent the Courant condition with respect to the propagation of Alfven and whistler mode waves.

An animation will be shown of the results of a two-dimensional simulation in the midnight meridian plane of the substorm expansion phase. An unbalanced Maxwell stress across the plasma sheet accelerates a fast earthward flow. Intense turbulence is generated in the region where the fast flow is arrested by the dipole field. This turbulence is radiated away along magnetic field lines as shear Alfven waves. These waves propagate to the auroral ionosphere where they produce filamentary field-aligned currents of the type associated with discrete auroral arcs. Generation of the plasma sheet turbulence is a kinetic process. Its significance can only be seen within the context of a global-scale simulation.

We are now in the process of developing a full three-dimensional simulation of the coupled magnetosheath, magnetosphere, and ionosphere system. The Earth's ionosphere will constitute one of the boundaries. The simulation domain is made up of seven discontinuously joined curvilinear coordinate patches, each of which are further subdivided to run on a massively parallel computer. The presentation will provide a brief description of the code architecture.