Computational Modeling of Dipolarization Front Associated Waves and Particle Energization

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Dipolarization Fronts (DFs) are characterized by an enhanced geomagnetic field north-south component and sharp gradients of plasma density and pressure on the scale of the ion inertial length. DFs are usually embedded in an earthward bursty bulk flow (BBF) which is believed to be generated by magnetotail reconnection. Broadband wave activity has been observed at DFs from below the lower hybrid frequency to the electron cyclotron frequency. These waves are believed to play critical roles in the energy conversion and particle energization in the magnetotail and auroral region. The generation mechanisms for these waves are still not well understood, however the free energy in the strongly inhomogenous plasma within the DF is expected to a critical role. The electron-ion hybrid (EIH) instability has been found to be unstable for small spatial scale inhomogenous plasma configurations comparable to the ion gyro radius based on kinetic theory. The waves generated by the EIH has important consistencies with waves observed at DFs. Using a magnetic field configuration and plasma parameters from observational data of DFs, a 2.5-D electrostatic (ES) Particle-in-Cell (PIC) model is discussed and used to simulate the development of the EIH instability at DFs. Characteristic wave modes of the lower hybrid frequency and wavelength on the order of the shear scale length are observed in the simulation, which is consistent with theoretical predictions and DF observations. The particle energization is also discussed. The extension of the electrostatic model to the electromagnetic (EM) regime to further evaluate wave signatures on the whistler branch driven by the EIH instability is discussed as future work. PIC simulation of the inhomogeneities in DFs is expected to provide new insights of the role of kinetic instabilities in the wave generation and particle energization.