Kinetic Alfvén Waves and the Acceleration of Auroral Particles

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Kinetic Alfvén waves propagate along auroral field lines in the Earth's magnetosphere and play a major role in auroral particle acceleration. Such waves carry energy from the outer magnetosphere to lower altitudes where they accelerate the precipitating electrons and ions that cause the aurora. There are two distinct modes of electron acceleration in the auroral zone: a nearly monoenergetic acceleration of electrons through a static potential drop, and the time-dependent acceleration by kinetic Alfvén waves, known as the Alfvénic aurora. The Alfvénic aurora can be basically understood as resulting from the parallel electric fields that develop in the kinetic Alfvén wave. Quasi-static electric fields require an energy source that is most easily provided by kinetic Alfvén waves; however, the process by which the Alfvénic aurora can transition to a quasi-steady state is not well understood. In addition, these acceleration processes lead to ion outflow that creates a density cavity in the auroral zone. These density cavities themselves can enhance the parallel electric field, leading to a positive feedback. The plasma processes in the auroral acceleration region are inherently kinetic and so are not well described by magnetohydrodynamic (MHD) theory alone, although large-scale MHD processes are still important in providing the energy supply. A linearized two-fluid model has been developed that can describe many important features of auroral dynamics. This model describes the transition from the moderate beta regime, where electron pressure and Landau damping are associated with the development of parallel electric fields to the low-beta regime where electron inertia is more important. These results will be compared with observations of the precipitating electrons that cause the aurora.