Ion Two-stream Instabilities in the Auroral Acceleration Zone

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Ion beams drifting upwards along magnetic field lines are frequently observed in the auroral acceleration cavity. They mainly consist of H^+ and O^+ ions originating from the ionosphere and are believed to have been accelerated upwards by the same potential. Due to the mass difference, H^+ and O^+ form two distinct beams drifting at different speeds (typically in the hundreds of km/s), whereby two-stream instabilities may develop. In this talk, I will discuss the wave instabilities relevant to the auroral cavity and present 1D and 2D PIC simulations of the interaction between the H^+ and O^+ beams. The simulation model describes an open system where protons and oxygen ions are constantly injected at the boundary, emulating thus the particle influx from the bottom of the cavity. In addition, the model includes a population of plasma sheet protons and hot electrons of magnetospheric origin.

The results evidence two regimes according to the energy K_d of the injected beams. The transition between a low and a high drift regime is given roughly by $E_T \sim T_e$, the electron temperature. For moderate energies, $K_d < E_T$, the unstable waves are of the acoustic type and propagate parallel to the magnetic field. They are strong enough to trap H^+ and O^+ ions, leading to phase-space vortices and the accompanying signatures of ion solitary waves in the electric field. For larger energies, $K_d > E_T$, the parallel acoustic waves remain stable. Instead, oblique oxygen cyclotron waves grow unstable. The waves criss-cross and form a herringbone pattern which energizes the O^+ ions perpendicularly, leading to the formation of drifting conics in the O^+ distribution. The protons, on the other hand are hardly energized perpendicularly. In either case energy is transferred from the protons to the oxygens. Besides the electron temperature the transition energy E_T depends upon the ion composition in the cavity.