

REDUCED VLASOV SIMULATIONS OF TRANSITION LAYERS
AND ASSOCIATED STRUCTURES IN THE IONOSPHERE: EF-
FECT OF FINITE ION MAGNETIZATION

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The existence of *transition layers* (including *laminar double layers*) in the downward current region of the ionosphere is observationally well established by satellites such as FAST. Associated with the transition layers are nonlinear structures such as phase-space electron holes, and waves at the hydrogen ion cyclotron frequency and its harmonics. In order to understand the interactions between the double layers, holes and waves, we perform electrostatic Vlasov-based simulations in two spatial dimensions. The phase-space dynamics parallel to the geomagnetic field \mathbf{B} is typically very complex and is therefore modeled using the full Vlasov equations. The perpendicular magnetized ion dynamics are modeled by a *reduced* algorithm, using a ring of modes in the transverse velocity plane. The radius v_{\perp} of the ring is proportional to the nominal perpendicular thermal velocity. The simulations are initialized with counterstreaming Maxwellian distributions of strongly magnetized electrons and finitely magnetized ions, each drifting at their respective thermal velocities. In order to seed the double layer, a charge-neutral density depression is introduced at the midpoint in the direction parallel to \mathbf{B} and uniform perpendicular to it.

Simulation results indicate a turbulent double layer developing at the location of the initial density depression, and producing electron phase-space holes (bipolar in the parallel electric field) that are localized in both dimensions and propagate away from the double layer. These have been seen in previous 2-D simulations. The new feature resulting from the finite ion magnetization is the appearance of diagonal wave fronts in the perpendicular electric field. These are ion Bernstein waves resonantly driven by the electron holes. This identification is corroborated by the power spectrum of ion density fluctuations, which indicate ion waves with wave vector approximately perpendicular to the magnetic field oscillating near the ion cyclotron frequency and its harmonics, in agreement with kinetic theory and consistent with observations. Thus the present simulation results suggest a mechanism, that of resonant excitation of the waves by electron holes, that provides an explanation for the observations, although other mechanisms may play a role as well. The present simulations will be compared with previous simulations with unmagnetized and strongly magnetized ions.

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