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Numerical Studies of Plasmapause Boundary Layer Instabilities

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The Plasmasphere Boundary Layer (PBL) is the transition layer between cold dense plasma population of the plasmasphere and hot tenuous plasmas of the plasmasheet and ring current. The PBL is characterized by sharp density and temperature gradients providing favorable conditions for excitation of surface waves that can potentially break (like breaking ocean waves) and cause an intermixing of the plasma populations in the vicinity of the boundary (like air/water mixture in breaking ocean waves). Such an inter-mixing of plasma populations could help explain anomalous cold-plasma losses from the plasmasphere (due to so-called long-lived drainage plumes) and the aurora-like emissions recently discovered by amateur "aurora-chasers" that have been dubbed STEVE.

In this work we conduct a study of instabilities and their nonlinear evolution which can get excited at the plasmapause boundary. We use newly developed and tailored for this problem linear and nonlinear MHD solvers and we apply them to study analytic 3D MHD equilibrium of the plasmapause with realistic magnetic field and density profiles. We compare our results with previous semi-analytical results from the literature, which include numerous simplifications of fully non-local equilibrium. The results suggest that non-local effects are crucial to identify unstable regimes.

We further use a unique kinetic Spectral Plasma Solver (SPS) code which can smoothly transition between fluid and kinetic regimes making comparisons against MHD results and identification of kinetic effects simpler. SPS is applied to slab-geometry 2D kinetic equilibria where effects of magnetic field curvature are included via an effective force. The parameters of the kinetic equilibria are motivated by selected unstable 3D MHD equilibria.