SIMULATION AND THEORY OF BUNEMAN INSTABILITIES IN INHOMOGENEOUS AND TIME-VARYING SPACE PLASMAS

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Buneman instabilities and their kinetic variants (which include ion-acoustic instabilities) occur when the relative drift between electrons and ions exceeds a threshold value. Thus, these are *current-driven* instabilities that can play a key role in the evolution of current sheets. For example, in recent 3-D simulations of magnetospheric reconnection (J. F. Drake et al., *Science*, **299**, 873, 2003) electron holes produced by Buneman instabilities were observed inside the reconnection current sheet.

To illustrate the fundamental linear and nonlinear stages of Buneman-like instabilities driven by currents that vary in space and/or time, we will present and interpret the results from a series of electrostatic Vlasov-based simulations for a range of plasma conditions, including the degree of ion and electron magnetization. First, we consider 1-D simulations in which an initially current-free plasma is driven by a weak electric field. The current is observed to increase linearly until the Buneman threshold is exceeded ($v_d \approx 2v_e$, where v_d and v_e are the electron drift and thermal velocities, respectively), after which the Buneman-unstable waves grow and saturate through trapping and electron hole formation. Subsequent electron heating coupled with a decrease in the electron drift (due to momentum exchange with ions) results in the plasma no longer being Buneman-unstable, until the electric field again causes the current to exceed the *new* Buneman threshold in the hotter plasma.

In 2-D simulations with strongly magnetized electrons and differing ion magnetization states, a current sheet (localized perpendicular to $\mathbf{B}$) can either be imposed as an initial condition or driven by an inhomogeneous parallel electric field. If the current in the center of the sheet exceed the Buneman threshold, linearly unstable waves described by non-sinusoidal *global* eigenfunctions in the direction of the current inhomogeneity (i.e., *velocity shear*) begin to grow. The form of these eigenfunctions can be determined using a *Mathieu function* analysis for weak shear with a time-independent sinusoidal velocity profile, and numerically for stronger shear and other profiles. The nonlinear evolution is dominated by electron holes that in some cases are preferentially localized to particular regions of the shear profile. Such localization has also been found in related simulations in which the electrons are weakly magnetized.

1. (a)
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2. H - Waves in Plasma

3. (a) S-G/H3

4. I - Invited Paper, Program chair: M. Oppenheim

5. No special instructions