A Laboratory Investigation of the Dynamics of Shear Flows in a Plasma Boundary Layer

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At naturally occurring plasma boundaries in the near-Earth space environment, such as the magnetopause and the plasma sheet boundary layer, strong sheared plasma flows are often observed. As plasma boundary layers begin to relax from a compressed state, the ratio of the ion gyro-radius to the shear scale length decreases. At these layers, broadband electrostatic noise has been observed where the frequency ranges from well below the ion cyclotron frequency to the electron plasma frequency. Simulations have confirmed that the free energy in the sheared plasma flows can excite Kelvin Helmholtz instabilities, ion cyclotron-like instabilities, and lower hybrid modes. Kinetic theory described by G. Ganguli (G. Ganguli, M. Keskinen *et. al*., J. Geophys. Res., A5, 8873, 1994) discusses the three distinct instability regimes in the context of the ion gyro-radius and the shear scale length. The ratio of the ion gyro-radius to the shear scale length acts as a surrogate for the magnitude of stress that a plasma layer is subjected to and determines which mode is dominant.

In a recent laboratory experiment, an interpenetrating plasma configuration is used to create a transverse velocity shear profile in a magnetized plasma column. For the first time, the continuous variation of the ratio of the ion gyro-radius to the shear scale length, and the associated transition of the instability regimes driven by the shear flow mechanism, is demonstrated in a single laboratory experiment. This is the first time that a laboratory experiment has reproduced the actual space observation of broadband emission, which is a characteristic signature of boundary layer crossings by a satellite. These results confirm the basic theory that plasma is unstable to transverse velocity shear in a broad frequency range, and provide evidence for theory predicted two decades ago by G. Ganguli (G. Ganguli, M. Keskinen *et. al*., J. Geophys. Res., A5, 8873, 1994), which proposes that the relaxation of a compressed boundary layer in a collisionless plasma leads to broadband electrostatic noise that is commonly observed by satellites.