ASYMMETRIC RESPONSE OF A MAGNETIZED PLASMA TO APPLIED E X B DRIFTS

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The response of a plasma to crossed electric (**E**) and magnetic (**B**) fields is one of the most fundamental phenomena in plasma physics. In laboratory and fusion plasmas, strong $\mathbf{E} \times \mathbf{B}$ driven flows are associated with internal transport barriers, enhanced confinement regimes, and the suppression of plasma instabilities [1,2]. By contrast, in magnetospheric plasmas, E x B drifts provide a mechanism for particle acceleration and the generation of ion acoustic and ion cyclotron instabilities [3,4]. In spite of the wide variety of laboratory, space, and fusion plasma phenomena that are observed as a response to crossed electric and magnetic fields, few investigations have sought to develop a unified understanding of these different phenomena.

A recently developed fluid model for $\mathbf{E} \times \mathbf{B}$ flows by Ganguli [5], provides one such unified approach. Key features of this model are the inclusion of the response of the plasma density to the $\mathbf{E} \times \mathbf{B}$ drift and the inclusion of geometric effects (*e.g.*, direction of drift, scale size of plasma, etc.). This model is used as the theoretical framework for a new experimental investigation of $\mathbf{E} \times \mathbf{B}$ drifts in magnetized plasmas. In a plasma with an axial magnetic field in the *z*-direction and a radial electric field in the *r*-direction, an azimuthal (*i.e.*, in the θ-direction) drift of ions in the plasma is established. The zero-order result for this model leads to a modification of the expression for the $\mathbf{E} \times \mathbf{B}$ drift velocity that is dependent upon the direction of the electric field. The first order analysis gives rise to low frequency, of order the ion cyclotron frequency, velocity-shear driven instabilities in the plasma.

Experiments are performed on the ALEXIS device – Auburn Linear Experiment for Instability Studies. ALEXIS is a 180 cm long, 10 cm diameter magnetized plasma column with a peak magnetic field of 1200 Gauss. Plasmas in ALEXIS are generated using three tungsten filaments that are heated into thermionic emission. The typical operation of ALEXIS uses helium gas at neutral pressure of 3 to 8 $\times 10^{-4}$ Torr and an emission current of 100 to 300 mA. This yields plasmas with electron temperatures $T_e \sim 3$ to 7 eV and peak ion and electron densities $n_e \sim n_i \sim 4 \times 10^{16}$ m^{-3}. The goal for the initial series of experiments is to measure changes in the azimuthal drift velocity and the formation of density gradients in the plasma as a function of the applied electric field.

Initial experiments on ALEXIS use two sets of electrodes to modify the potential structure of the plasma. The first is a cylindrical electrode that is concentric with the plasma column. The second is a series of four independently biased rings at the end of the plasma column. A schematic of ALEXIS is shown in Fig. 1. A variety of electrostatic probes (emissive, single and triple Langmuir probes) are used to diagnose the plasma. Preliminary measurements suggest that modification of the potential structure of the plasma, leads to changes in the plasma density, and the generation of low frequency (below ion cyclotron frequency) instabilities as demonstrated in Fig. 2.

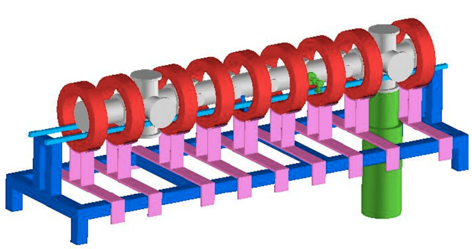

Fig. 1: Schematic of ALEXIS device

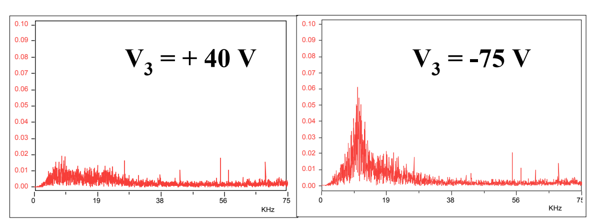

Fig. 2: Impact of the bias voltage on a single ring (all other components grounded) on the formation of waves in the plasma.

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