Fast Ion Transport Studies in the Large Plasma Device

Y. Zhang, H. Boehmer, W. Heidbrink (wwheidbr@uci.edu), R. McWilliams, L. Zhao
University of California, Irvine
B. Brugman, T. Carter, D. Leneman, S. Vincena
University of California, Los Angeles

The LArge Plasma Device (LAPD) at UCLA is an 18-m long linear device that produces highly reproducible ~10-ms duration plasmas with $n_e > 10^{12}$ cm^{-3}, $T_e > 1$ eV, and B~1 kG every second. Its large size and excellent diagnostic access accommodate detailed studies of fast-ion physics at reduced parameters. The first fast-ion experiments were conducted with a modified 100-1000 eV argon processing source that was inserted into the plasma. Measurements of energy deceleration and cross-field transport in the quiet "afterglow" plasma are in good agreement with classical Coulomb scattering theory. Recent experiments employ a 200-3000 eV lithium source. Deflection of the beam by shear Alfven waves is observed.

The LArge Plasma Device (LAPD) is a user facility for basic plasma physics research [1]. Computerized probe scans accommodate accurate measurements of fast ions and of wave fields, so the device is well suited for detailed studies of fast-ion physics. The first fast-ion experiments were conducted with a modified 100-1000 eV argon processing source that was inserted into the plasma [2]. It was found that the "spot" size of the beam is smallest when the gyro-angle of the helical fast-ion trajectory is an integer multiple of 2π [2]. This source was used to measure the fast-ion transport of a ~300 eV ribbon beam in the quiet afterglow plasma [3]. The parallel energy of the beam was measured by a two-grid energy analyzer at two axial locations (z = 0.32 m and z =6.4 m) from the ion gun. The calculated ion beam slowing-down time is consistent to within 10% with the prediction of classical Coulomb collision theory. To measure cross-field transport, the beam was launched at 15° with respect to the magnetic field and radial beam profile measurements were performed at different axial locations. The measured cross-field transport is in agreement to within 15% with analytical classical collision theory and the solution to the Fokker-Planck kinetic equation. Collisions with neutrals have a negligible effect on the beam transport but do attenuate the beam current.

The study of shear Alfven waves is a specialty of the LAPD research program [4]. To produce super-Alfvenic beam ions, a new fast-ion source that uses a solid thermionic lithium emitter has been developed (Fig. 1). The lithium source emits ~1 mA of Li^+ ions at energies of <3000 eV. With this source, the speed of the fast ions can match the parallel phase speed of the ~10 G Alfven waves that are launched by loop antennas; the $\omega - k_z v_z = \Omega$ cyclotron resonance is also accessible. In recent experiments, deflections of the beam by ~1 G shear Alfven waves were detected when the fast ions satisfied the cyclotron resonance condition.

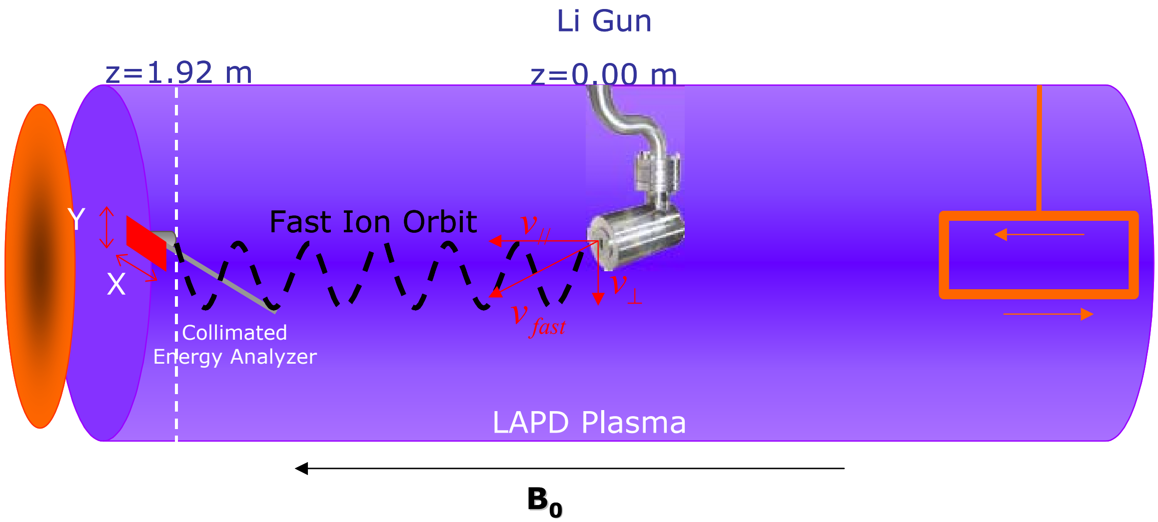

Figure 1. Apparatus for the measurement of resonant interaction of fast ions with Alfven waves. A "picture-frame" antenna launches shear Alfven waves in a helium plasma. A lithium source launches fast ions in the plasma. A collimated energy analyzer measures the response of the fast ions to the waves.

References

[1] *http://plasma.physics.ucla.edu/lapd*
[2] BOEHMER, H., et al., Rev. Sci. Instrum. **75** (2004) 1013.
[3] ZHAO, L., et al., Phys. Plasmas **12** (2005) 052108.
[4] e.g., GEKELMAN, W., et al., J. Geophys. Res. **102** (1997) 7225.