Experiments on the Expansion of a Dense Plasma into a Background Magnetoplasma

W. Gekelman, M. VanZeeland\textsuperscript{1}, P. Pribyl, A. Colette
Department of Physics and Astronomy, UCLA
\textsuperscript{1} General Atomics, San Diego CA.

There are many situations, which occur in space (coronal mass ejections), or are man-made (upper atmospheric detonations) as well as the initial stages of a supernovae, in which a dense plasma expands into a background magnetized plasma, that can support Alfvén waves. The LArge Plasma Device (LAPD) is a machine, at UCLA, in which Alfvén wave propagation in homogeneous and inhomogeneous plasmas has been studied. We describe a series of experiments, which involve the expansion of a dense (initially, $\frac{\delta n_{lp}}{n_0} >> 1$) laser-produced plasma (llp) into a ambient highly magnetized background plasma capable of supporting Alfvén waves will be presented. The 150 MW laser is pulsed at the same 1 Hz repetition rate as the plasma in a highly reproducible experiment. The interaction results in the production of intense shear Alfvén waves and large density perturbations. The waves propagate away from the target and are observed to become plasma column resonances. In the initial phase the background magnetic field is expelled from a plasma bubble. Currents in the main body of the plasma are generated to neutralize the positively charged bubble. Fast electrons generate Alfvén waves through Cherenkov radiation. Spatial patterns of the wave magnetic fields waves are measured at over $10^4$ spatial locations and thousands of timesteps. As the dense plasma expands across the magnetic field it seeds the column with shear waves. Most of the Alfvén wave energy is in shear waves, which become field line resonances after a machine transit time. A second wave with frequency larger than the ion gyrofrequency is confined to the dense plasma. In a recent experiment two llp’s are forced to collide in the center of the plasma column. This also results in the production of shear waves, which have a complex current system. The currents appear to be merging and separating ropes. Dramatic movies of the measured wave fields and their associated currents will be presented. When the current systems evolve the helicity is observed to rapidly increase and then decay. The relative helicity density was calculated and will be compared in movies to the topology of current ropes.

Data of the current system from the colliding plasmas as well as an image of the collision is shown below.