OMEGA-EP EXPERIMENTS TESTING LASER PREHEAT AND FUEL MAGNETIZATION AT CONDITIONS RELEVANT TO MAGLIF

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The MAGnetized Liner Inertial Fusion (MagLIF) scheme has achieved thermonuclear fusion yields on the Z Facility[1,2] by imploding a cylindrical liner filled with D2 fuel that is preheated with a multi-kJ laser and pre-magnetized with an axial B_z=10 T magnetic field. Preheating (T_e = 100-200 eV) and pre-magnetizing (10-30 T) the fuel serves to reduce the implosion velocity required to achieve multi-keV fusion-relevant temperatures at stagnation with modest radial convergence. The conditions in MagLIF-relevant plasmas are in the so-called magneto-inertial fusion parameter regime, intermediate[3] to tokamaks and traditional laser-driven ICF plasmas, and so are less well studied. Specifically, the laser intensity ($I\lambda^2$ ~10^{14} watts-μm^2 /cm^2), long scale lengths (L~10 mm) and initial fuel density (n_e/n_{crit}< 0.1) of the plasma at the time of preheat are outside the typical parameter space for other magnetic and inertial confinement schemes, and the relevant physics has not been extensively explored experimentally.

We have developed a new platform[4] using the high-energy OMEGA-EP laser at the Laboratory for Laser Energetics for a detailed study of laser preheating and magnetization at MagLIF-relevant plasma conditions. A series of experiments have been conducted to test the energy coupling of 0.35 μm laser energy into the D2 fuel and the ability of an applied B_z field to suppress thermal conduction characterized by a suite of x-ray diagnostics. Experiments have investigated laser coupling into magnetized and unmagnetized underdense plasmas and the factors that affect this, such as laser duration and power, beam smoothing, plasma density and laser entrance hole (LEH) design. Experiments have also begun to explore the effect of applied magnetic fields on electron thermal conduction and beam propagation, observing plasma heating and laser propagation in a D2 plasma with modest magnetization parameters ($\omega_{ce}\tau_e \sim 2$). Experimental results will be presented and compared with two and three Dimensional HYDRA simulations. Future experiments aim to extend this work to investigate the equilibration and cooling of magnetized laser-heated plasmas over multiple ns. The findings and challenges will be discussed.

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