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Investigating the laser heating of underdense plasmas at conditions relevant to MagLIF[1]

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The magnetized Liner Inertial Fusion (MagLIF) scheme has achieved thermonuclear fusion yields on Sandia's Z Facility by imploding a cylindrical liner filled with D2 fuel that is preheated with a multi-kJ laser and pre-magnetized with an axial field B_z =10 T. The challenge of fuel preheating in MagLIF is to deposit several kJ's of energy into an underdense ($n_e/n_{crit}<0.1$) fusion fuel over $\sim$ 10 mm target length efficiently and without introducing contaminants that could contribute to unacceptable radiative losses during the implosion. Very little experimental work has previously been done to investigate laser heating of gas at densities, scale lengths, modest intensities ($I\lambda^2 \sim 10^{14}$ watts-μm^2 /cm^2) and magnetization parameters ($\omega_{ce}\tau_e \sim 10$) necessary for MagLIF. In particular, magnetization of the preheated plasma suppresses electron thermal conduction, which can modify laser energy coupling. Providing an experimental dataset in this regime is essential to not only understand the dynamics of a MagLIF implosion and stagnation, but also to validate magnetized transport models and better understand the physics of laser propagation in magnetized plasmas. In this talk, we present data and analysis of several experiments conducted at OMEGA-EP and at Z to investigate laser propagation and plasma heating in underdense D_2 plasmas under a range of conditions, including densities (n_e = 0.05-0.1 n_c) and magnetization parmaters ($\omega_{ce}\tau_e \sim$ 0-10). The results show differences in the electron temperature of the heated plasma and the velocity of the laser burn wave with and without an applied magnetic field. We will show comparisons of these experimental results to 2D and 3D HYDRA simulations, which show that the effect of the magnetic field on the electron thermal conduction needs to be taken into account when modeling laser preheat.

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