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Fast Ignition with Ultra-High Intensity Lasers[1]

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One of the critical design constraints for fast ignition targets is the need to have a small cross section for the hot spot at the target core while delivering enough power to the hot spot with hot electrons of the proper energy range, $\sim$ 1-3 MeV, to couple to the core. We use PIC simulations of isolated targets to investigate the feasibility of using 1μm ignition lasers with ultra high intensities, I>5x10^{19}W/cm^2, for fast ignition. The absorption of an intense laser in an overdense plasma and the subsequent energy transport through the overdense plasma is explored by examining the interaction of high intensity ignition lasers, up to 8x10^{20}W/cm^2, with a 50μm radius target using two-dimensional Particle-In-Cell simulations. At these ultra-high intensities, we find that most of the energy transport is in a hot bulk and not in the super-hot tail of the electron distribution. Electrons in a relatively low energy range, below 3MeV, transport 90% of the heat flux through 50μm of 100n_c plasma to the target core. Hot electrons generated at the laser-plasma interface drive plasma turbulence in the background collisionless plasma heating it to MeV temperatures over pico-second time scales. Over the same time scale Weibel instabilities generate large magnetic fields that confine the transverse spread of the heated plasma. The effect of this interaction with the background plasma is to lower the energy of the electrons entering the target core at the cost of energy used to heat the plasma. The fraction of laser power that transits the dense plasma and is deposited into the core increases with laser intensity. At the highest intensity, I=8x10^{20}W/cm^2, 12% of the laser power is deposited in the high density core after 2.5ps and the heat flux into the core is 16% of the incident laser flux.

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