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Compact Fast Ignition experiments using Joule-class drive pulses under counterbeam configuration

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Fast Ignition (FI) is a scheme of Inertial Confinement Fusion (ICF). In FI, the ignition and the compression are separated resulting in a reduction of symmetry requirement for hot spot generation. The experiments of FI by lasers so far have been performed using giant laser system at single-shot operation with energy beyond kJ-class.

We have conducted research and development of FI using a joule-class repetitive-operation laser driver HAMA[1,2] based on diode-pumped-solid-state laser technology that is scalable to future Inertial Fusion Energy (IFE) reactor. So far, we have demonstrated compact fast ignition experiments [3,4], and laser engagement into a flying target [5] in couterbeam configuration to realize IFE reactor based on FI scheme with direct laser illumination configuration [6].

The problems of FI so far are (i) the accessibility of an ignition laser pulses into the assembled core in which the driver energy is converted into relativistic electrons produced in the laser-plasma interactions and (ii) the divergence of relativistic electrons those deliver the ignition energy into the assembled core.

We have experimentally demonstrated that a tailored-pulse-assembled core with diameter of 70 μm, originally deuterated polystyrene spherical shell of 500 μm diameter, is flashed by directly counter irradiating 0.8 J/110 fs pulses [7]. The resulting energy coupling efficiency from the heating laser to the core inferred from photon emission is 10±2% [8], which is the higher efficiency than what was obtained recently (up to 7%) by using cone-in-shell target. This result indicates that once the assembled core is squeezed into the target center, the heating laser can access to the core's edges and deposit its energy into the core without the cone guiding with higher coupling.

In this talk, we will present (i) the heating effects in relation to formation of the assembled core, and (ii) expectations of heating mechanism occurred in counterbeam configuration from two-dimensional particle-in-cell simulation; counter flows of relativistic electrons induced a strong, beyond mega-Gauss magnetic filaments through the Weibel instability, those filaments may compensated the divergence of relativistic electrons or improve the energy coupling.

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