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Efficient creation of ultra-high-energy-density states by magnetized fast isochoric laser heating

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Fast isochoric heating, also known as fast ignition [1], of a pre-compressed core, was proposed as an alternative approach to the inertial confinement fusion ignition that avoids the ignition quench caused by the mixing because the hot spark is generated not by the adiabatic compression but by the external energy injection whose time scale is shorter than the hydrodynamic time scale. Relativistic intensity laser pulses efficiently produce relativistic electron beams (REB) via laser-plasma interactions [2]. The REB travels in a plasma from its generation zone to the core. A part of the REB kinetic energy is deposited into the core, and then the heated region becomes the hot spark to trigger the fusion ignition. However, only a small portion of the REB collides with the core because of its large spray angle [3]. Here we have demonstrated enhanced laser-to-core energy coupling with the magnetized fast isochoric heating on the GEKKO-LFEX laser facility at the Institute of Laser Engineering, Osaka University.

We have introduced two novel experimental techniques. A laser-driven capacitor-coil target was introduced to generate kilo-tesla level magnetic field [4]. Application of external magnetic fields to the path of a REB is expected to guide the diverging REB to guide the REB to the core [3]. The guidance of the REB by the laser-produced external magnetic field has already been demonstrated experimentally in an uncompressed-planar geometry [5]. Another technique is the use of a solid ball target containing Cu atoms [6] attached to a gold cone, which is used for visualizing spatial distribution of REB and measuring a laser-to-core coupling from the absolute number of Cu-Kα X-ray photons emitted from Cu atoms [7]. The use of solid ball provides stable core formation [8] and production of a moderate guiding field [9] compared to the conventional shell target.

A strong Cu-Kα emission spot located at 100 μm away from the cone tip was observed. This is the evident feature indicating the guiding of the REB with the externally applied magnetic field in the long transport distance. The maximum coupling of 7.7 +/- 1.2 % was achieved even with a relatively small radial area density core (ρR = 0.08 g/cm^2 along the REB path) [10]. This highest coupling per unit area density leads to a high laser-to-core coupling (>15%) for an ignition scale core (ρR = 0.3 g/cm^2).

The details of the experiments and simulations will be discussed in the talk.

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