DIRECT HEATING OF COMPRESSED CORE BY ULTRA-INTENSE LASER

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In the fast ignition scheme of inertial confinement fusion (ICF), the energy coupling efficiency from heating laser to the high density core plasma is important to reduce the heating laser energy required for the ignition. In order to increase its coupling efficiency, we have proposed the direct core heating by the ultra-intense laser. In this approach, first, the target shell is imploded to the high density by compression lasers. Then, the compressed core is directly irradiated by the ultra-intense laser, in which energetic ions and electrons are generated by the interaction between the ultra-intense laser and implosion plasmas, and both fast electrons and fast ions are able to simultaneously heat the high density core efficiently.

When the compressed core is heated by both fast electrons and fast ions simultaneously, fast electrons can heat the entire core due to its relatively longer mean free path. On the contrary, fast ions have a relatively shorter mean free path in the core. Although the conversion efficiency from the laser to the fast ions is limited to the order of several %, the fast ions can locally heat the compressed core, and contribute to formation of the hot spot.

We demonstrated the direct heating of the compressed core by LFEX laser in Osaka University. We obtained DD beam-fusion neutrons with the yield of 5×10^8 n/4π sr. Observation of the beam-fusion neutrons verified that the ions directly collide with the core plasma. While the hot electrons heat the whole core volume, the energetic ions deposit their energies locally in core, forming hot spot. We simultaneously observed thermal neutrons with the yield of 6×10^7 n/4π sr. Our numerical analysis explains the shell implosion dynamics and the transport of energetic particles, including the beam fusion and thermal fusion initiated by fast deuterons and carbon ions, in which the 2 g/cm^3 density core is heated from 0.8 keV to 1.8 keV.

Since the core density is limited to relatively low density in the current experiment, the neutron yield remains relatively low. In the future work, we expect to achieve the higher core density, and subsequently the hot electrons could contribute more to the core heating via drag heating. As well as the hot electrons, the ion contribution to fast ignition is significant in igniting the core and realizing high-gain fusion. We will present our experimental results and numerical analysis, and discuss our future target design with the more compressed core.

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