Demonstration of REB Drive Fast Ignition with Assistance of External Magnetic Field in FIREX Project

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Fast ignition (FI) [1] is a high-gain ignition scheme of the inertial confinement fusion, where a compressed dense fuel is heated with relativistic electron beams (REB) produced by high intensity short pulse lasers. The original FI scheme has a critical issue of low energy coupling to the compressed core, mostly due to REB's large divergence and excessive electron energy, making energy deposit of REB in the core inefficient [2]. To improve the energy coupling, delivering REB with guidance of external magnetic field had been proposed [3].

The Fast Ignition Realization Experiments (FIREX) [4], incorporating magnetic field REB guiding, had been being conducted using the Gekko XII (GXII) + LFEX laser at the Institute of Laser Engineering, Osaka University. We have demonstrated an enhancement of compressed plasma core heating by magnetically guided REB produced by picosecond Petawatt LFEX pulse [5] and external kilo-tesla magnetic field generated by a laser-driven capacitor coil [6]. A Cu (II) oleate sphere with a reentrant gold cone was imploded by six GXII laser beams. K-shell x-ray emission lines from the Cu tracers recoded with a flat HOPG crystal spectrometer appeared more significantly with the magnetic assistance.

From the spectral analysis, the electron temperature of ~ 1.7 keV at density of 6 g/cc was inferred. The integrated simulations have been performed for the experiments to study the implosion [7], REB production, REB transport, and core heating. We found the most efficient timing of REB injection is 400 ps earlier than the maximum compression. The details of the experiments and simulations will be discussed in the talk.

References

[1] M. Tabak *et al*., *Phys*. *Plasmas* **1**, 1626 (1994). [2] S. Fujioka *et al*., *Phys*. *Rev E* **91**, 063102 (2015). [3] D. J. Strozzi *et al*., *Phys Plasmas* **19**, 072711 (2012). [4] H. Azechi *et al*., *Plasma Phys*. *Control*. *Fusion* **48**, B267 (2006). [5] N. Miyanaga *et al*, *J*. *Phys*. *IV* **133**, 81 (2006). [6] S. Fujioka *et al*., *Sci*. *Rep*. **3**, 1170 (2013). [7] T. Johzaki *et al*., *Plasma Phys*. *Control Fusion* **59**, 014045 (2017).