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高速点火方式のレーザー核融合における自己生成磁場による高速電子集束効果の検証

Fast electron collimation by self-generated magnetic fields in fast-ignition targets

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1. Background / Purpose

Fast ignition (FI) is an approach for inertial confinement fusion, that separates compression of fuel and ignition process by using compression lasers and a heating laser. In the FI scheme, fast electrons, generated by an ultra-intense laser, heat the compressed core and trigger ignition. However, it is indicated that fast electrons usually have large divergence angle (about 100 degrees) and hence laser-to-core energy coupling efficiency can be quite low (about 1%)[1]. In order to improve heating efficiency, the approach using cone-in-shell targets is widely performed[2] but this approach has the difficulty keeping spherical symmetry in the compression process. This study aims to collimate fast electrons and improve heating efficiency while keeping the symmetry by using self-generated magnetic fields at resistivity gradient inside the dense plasma.

2. Method

We performed the verification experiments of the collimation effect of self-generated magnetic fields using the GEKKO-XII (GXII) lasers and LFEX laser at the Institute of Laser Engineering in Osaka University. The targets consist of CH slab, Cu foil and Ni wire, as shown in Fig. 1. In the experiments, three GXII lasers firstly form pre-plasma, especially resistivity gradient between Ni plasma and CH plasma, and the LFEX laser was injected at different times, generating fast electrons. We evaluated the effect of self-generated magnetic fields by measuring photon number of Cu-Kα and Ni-Kα, that emitted from Cu foil and Ni wire, respectively.

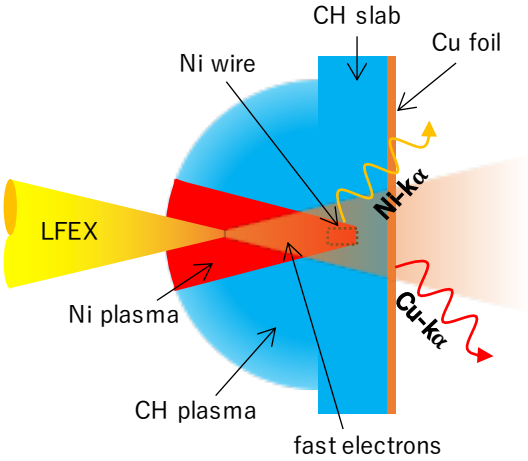

Fig. 1 Schematic of the target and concept of the experiment.

3. Results

We calculated the ratio of Ni-Kα to Cu-Kα from X-ray spectrum results of highly oriented pyrolytic graphite (HOPG) to evaluate collimation of fast electrons. The intensity of Cu-Kα and Ni-Kα corresponds respectively to the number of fast electrons which passed through the whole target and the center of that, and it can be indicated that the higher the ratio is, the more electrons are collimated by self-generated magnetic fields. The ratio varies with time-delay from GXII to LFEX. This result suggests that collimation effect of the magnetic fields becomes more effective as the Ni plasma expands and the magnetic field distribution gets wider. In this presentation, we describe the experiments and discuss about the results.

[1] T. Gong, et al., *Nat. Commun.* **10**, 5614 (2019).
[2] R. Kodama, et al., *Nature* **412**, 798-802 (2001).