The physics of high energy density plasmas generation with intense lasers for energy and for fundamental processes


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The world largest Peta-Watt laser “LFEX”, which can deliver energy up to 10 kJ in a 0.5-20 ps pulse, has been constructed beside the GEKKO XII laser in the Institute of Laser Engineering, Osaka University. The GEKKO-LFEX laser facility enables us to create materials having high-energy-density, which do not exist naturally on the earth and are comparable to energy density of stars. High energy density plasma is a source of safe, secure, environmentally sustainable fusion energy. Direct-drive fast-ignition laser fusion is intensively studied on this facility under the auspices of the FIREX (Fast Ignition Realization EXperiment) project. It was recently demonstrated that ultra-dense fusion fuel compressed by the GEKKO laser is heated efficiently by the LFEX laser with 20% of energy coupling efficiency. The result clarifies that the fast-ignition scheme is an attractive approach for the fusion power plant development, because high gain is achievable relatively small energy laser facility. The advanced schemes have also been investigated to enlarge the coupling efficiency. Fast electrons are scattered and stopped by strong electric field of highly ionized high-Z (i.e. gold) ions, low-Z cone is studied for reducing energy loss of the fast electrons in the cone tip region. Diamond-like carbon cone is fabricated for integrated fast-ignition experiment. Pointed cone tip target is considered not only for extending survival time of the cone tip against the dense fuel core but also for guiding the fast electrons to the fuel core by the self-generated magnetic field. External magnetic field will be applied to compression of the fuel capsule to form a strong magnetic field to guide the fast electrons to the fuel core.

In addition, the facility offers a powerful means to test and validate the astronomical models and computations in the laboratory. As well as demonstrating the ability to recreate extreme astronomical conditions by the facilities, our theoretical interpretation of the laboratory experiment was compared with the generally accepted explanation for astronomical observations. We will present these unique sciences studied on the GEKKO-LFEX laser facility.