THE STATUS OF FAST IGNITION REALIZATION EXPERIMENT (FIREX) AND PROSPECT TO INERTIAL FUSION ENERGY

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Fast ignition has high potential to ignite a fusion fuel with only about one tenth of laser energy necessary for the central ignition. One of the most advanced fast ignition programs is the Fast Ignition Realization Experiment (FIREX) [1]. The goal of its first phase is to demonstrate ignition temperature of 5 keV, followed by the second phase to demonstrate ignition-and-burn. As for the heating laser, a high-energy peta-Watt laser called LFEX (Laser for Fusion EXperiment) was fully commissioned in the end of 2014. It consists of a 4-beam and 4-path Nd:glass amplifier system with a 40-cm square aperture in each beam. The design goal of LFEX is to deliver 10-kJ energy in 10-ps width at 1-μm wavelength. The focusing optics is an off-axis parabola mirror with f/10 speed in each beam.

Relativistic fast electrons as the energy carrier, however, are either too energetic to couple with the compressed fuel, or unfavorably diverge at high laser intensities necessary for significant heating [2]. The difficulty of too high-energy electrons was overcome by suppressing the pre-pulse level below ten trillionth of the main pulse via quenching AOPF (amplified optical parametric fluorescence) [3] and introducing a plasma mirror.

The difficulty of the divergence has been overcome by kilo-Tesla magnetic field collimating fast electrons towards a compressed fuel. Such super-strong field has been created with a capacitor-coil target driven by a high power laser [4], and subsequent collimation has been demonstrated, suggesting that one can achieve ignition temperature at the laser energy available in FIREX.

Given the ignition temperature demonstration at the FIREX-I, we anticipate a next step toward inertial fusion energy: a laser fusion experimental reactor that demonstrates electrical power generation. Technology development includes high-efficiency high rep-rate lasers; target injection, and fusion chamber-and-blanket. Among these, high-rep lasers, the most critical element, have been demonstrated by using three technology breakthroughs: split disks for efficient cooling, laser diodes for optical pumping and cooled ceramic crystals for laser materials. These technologies would be converged into a laser fusion experimental reactor.

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