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LFEX-Laser: A Multi-Kilojoule, Multi-Petawatt Heating Laser for Fast Ignition

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A new heating laser for fast ignition, called the LFEX-Laser, has been demonstrated with all four beams. The obtained total pulse energy was 2 kJ for a 1 ps pulse duration. The peak power of 2 PW is the highest of all kilojoule lasers in the world and was achieved with a high intensity contrast ratio of 1 × 10ˆ10.
To increase the pulse energy to the kilojoule class in a short pulse of 1–2 ps, chirped-pulse amplification (CPA) was adopted. Recently, all four beams of this new LFEX-Laser were completed and high-power shots at kilojoule energies with a 1 ps pulse duration were demonstrated. In addition, a new pulse cleaner improved the pulse intensity contrast of the main pulse to suppress the pre-plasma, which significantly reduces the heating efficiency in fast ignition.
One of the key technologies enabling the realization of a kilojoule CPA system is the essential optics for CPA in a large enough size. In particular, the world's largest dielectric grating (92 cm × 42 cm, 1740 grooves/mm) used in the pulse compressor has recently been developed through the collaboration of Okamoto Optics Works, Jovin Yvon, and Osaka University. Using the pulse compressor with the gratings, the typical pulse duration as short as about 1 ps was successfully obtained for all beams. The total pulse energy was 2 kJ, which corresponds to 2 PW. Deformable mirrors were used in the main amplifier to improve the focusing of the beams by compensating for wavefront distortions. About 70% of the pulse energy can be concentrated into a spot with a diameter of 5Fλ, where F is the F-number of the lens and λ is the laser wavelength of 1.053 μm.
Another key technology is our new pulse cleaner. Generally, amplified optical parametric fluorescence (AOPF) before the main pulse, which produces pre-plasmas, can be removed effectively with a saturable absorber (SA, Cr4+:YAG). In CPA, however, AOPF temporally overlaps with the chirped main pulse and is significant because the non-phase-locked AOPF is not compressed by the pulse compressor, making it difficult to remove it with an SA. Our new pulse cleaner combines the SA with the 4-f optical layout, to remove the AOPF. By using two pulse cleaners in the front end, a high contrast ratio of 1 × 10ˆ10, compared to 2 × 10ˆ7 without the cleaners, was obtained.

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