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Laser-driven Ion Acceleration on LFEX for Fast Ignition: State of the Art and Applications

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Fusion fast ignition assisted by laser-driven ion beams requires 10 kJ energy deposition onto the fuel core having ˜500 g/cmˆ3 densities. Assuming 100 kJ as a technically manageable energy of the driving laser, the first milestone can be found on 10% conversion efficiency from the laser energy into ions having kinetic energies of 10-30 MeV/u.

In this paper, we experimentally investigate the ion acceleration mechanism using kilojoule picosecond laser LFEX. When we expand the pulse duration (FWHM) of the laser from 1.5 ps to 3 ps at the fixed laser intensity of 2.3×10ˆ18 Wcmˆ-2, the electron temperature measured by Electron Spectrometer (ESM) is drastically enhanced up to 1.2 MeV, which clearly exceeds the ponderomotive potential around 0.2 MeV for the laser intensity used in this measurement. At the duration of 6 ps, the electron temperature turns to decrease, indicating that an optimum duration can be found around 3 ps. In addition, the proton energy, analyzed simultaneously with the electron temperature, reaches 29 MeV at 3 ps and saturates around 30 MeV at 6 ps.

We also show that the energy conversion efficiency into the protons drastically grows from 0.2% to 5% when the laser duration is expanded from 1.5 to 6 ps. This fact is advantageous for the ion-driven fast ignition by ions from the viewpoint of the energy deposition onto the core plasma.

The efficient ion generation is attributed to the hot electrons anomalously heated by the laser beyond a typical scaling. The electron temperature enhanced via the anomalous mechanism is well reproduced by a Particle-in-Cell simulation. In the presentation, we will show that the enhanced proton energy is explained by newly introducing the anomalous heating effect into the conventional plasma expansion model.

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