Laser-Driven Particle Acceleration and Its Applications Using SULF-10 PW Laser

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The peak intensity of multi-petawatt lasers on target has reached beyond $10^(21)W/cm^2$, bringing new opportunities for the development of laser particle acceleration. Currently, the Shanghai Ultra-Intense Ultrafast Laser Facility, SULF Laser, is operating normally, with its 10-petawatt laser experimental platform providing on-target peak powers of several petawatts. This report mainly introduces the progress in high-energy ion acceleration based on the SULF 10-petawatt laser. By using novel target materials such as micro-nano structures, the cutoff energy of protons has been effectively increased, reaching over 70 MeV, with acceleration efficiency nearly tripled. Comparisons between experiments and simulations reveal that the high-charge electron beam generated by direct laser acceleration in micro-nano structures is the main reason for efficient proton acceleration. Additionally, by interacting 10-petawatt lasers with higher-density gas targets, a mixed acceleration mechanism produced electron beams of several tens of nC at hundreds of MeV. These experimental results provide guidance for further improving the energy and efficiency of particle acceleration, and lay an important foundation for applications in laser nuclear physics, high-energy-density physics, and other fields.