A multi-MeV Alpha Particle Source via Proton-Boron fusion driven by a 10-GW Tabletop Laser

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Nuclear fusion between protons and boron-11 nuclei has undergone a revival of interest thanks to the rapid progress in pulsed laser technology. Potential applications of such reaction range from controlled nuclear fusion to radiobiology and cancer therapy. A laser-driven fusion approach consists in the interaction of high-power, high-intensity pulses with H- and B-rich targets. We report on a pioneering experiment exploiting proton-boron fusion in CH/BN targets to obtain high-energy alpha particle beams (up to 5 MeV) using a compact approach and a tabletop laser system with a peak power of ~10 GW, which can operate at high-repetition rate (up to 1 kHz). The secondary resonance in the cross section of proton-boron fusion (~150 keV in the center-of-mass frame) is exploited for the first time using a laser-based approach. The generated alpha particles are characterized in terms of energy, flux, and angular distribution using solid-state nuclear-track detectors, demonstrating a flux of ~10^5 particles per second at 10 Hz, and ~10^6 per second at 1 kHz. Numerical hydrodynamic and particle-in-cell simulations support our experimental findings. Potential impact of our approach on future spread of ultra-compact, multi-MeV alpha particle sources driven by moderate intensity (10^16-10^17 W/cm2) laser pulses is anticipated.