Monoenergetic High-energy Ion Source via Femtosecond Laser Interacting with a Microtape

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Laser-based ion sources are characterized by unsurpassed acceleration gradient and exceptional beam emittance. They are promising candidates for next-generation accelerators towards a broad range of potential applications [1–3]. However, the laser-accelerated ion beams available currently have limitations in energy spread and peak energy [2–8]. In this talk, I shall report a novel method to achieve monoenergetic proton beams with energy spread at 1% level and peak energy of hundred MeV by irradiating the edge of a microtape with a readily available femtosecond petawatt laser [4]. As the laser sweeps along the tape, it drags out a huge charge (about 100 nC) of collimated electrons and accelerates them to superponderomotive energies. When this dense electron current reaches the rear edge of the tape, it induces a strong electrostatic field. Due to the excessive space charge of electrons, the longitudinal field becomes bunching while the transverse is focusing for protons. Together, this leads to a highly monoenergetic energy spectrum and much higher proton energy as compared to results from typical target normal sheath acceleration and radiation pressure acceleration. Our three-dimensional particle-in-cell simulations demonstrate that a monoenergetic proton beam with peak energy > 100 MeV, energy spread about 1% and particle number $\sim 10^9$ can be stably obtained with a femtosecond laser pulse characterized by intensity $> 10^{20}$ $\mathrm{W/cm^2}$ [4]. The proposed scheme opens a new route for the development of future compact ion sources.

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