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Ion acceleration from laser driven collisionless shockwaves in optically shaped gas targets

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We report on recent experiments using the high power CO_2 laser (λ ~ 10 μm , a0 ~ 1) at the Accelerator Test Facility, Brookhaven National Laboratory to generate ~MeV protons and helium ions, which are accelerated by collisionless shockwave acceleration in overcritical gas targets. We have developed new techniques of shaping gas jet targets with optically induced hydrodynamic shocks, allowing us to tailor density profiles to optimise ion generation. Sufficiently steep gradients resulted in quasi-monoenergetic proton beams with a single laser pulse, in contrast to previous work relying on pulse trains. The laser plasma interaction also generates energetic electrons, which propagate into the target with beam to background ratio up to ~0.1. We have observed transverse filamentation in this region, which is reproduced by PIC modelling. These simulations also elucidate the key role of the laser-generated electrons in heating the plasma to create the conditions required for collisionless shockwave formation and subsequent ion generation.

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