Efficient acceleration scheme to achieve GeV proton energy by using dual-laser pulses

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The laser-plasma interaction can generate high acceleration fields, which exceeds those of the conventional accelerators by orders of magnitude. Due to this excellent feature of large acceleration gradient with a table-top facility, laser-driven proton acceleration possesses high potential to realize the compact high energy proton sources. Proton beams with energies beyond 100 MeV is necessary for a wide range of applications, including modern cancer therapies [1]. Recently, numerical attempts to produce GeV proton beams also have been made [2-6] for the future experiments such as the generation of high energetic cosmic ray.

We propose an efficient hybrid acceleration scheme to generate relativistic (~GeV) protons with using dual-pulses and solid density (SD) and near critical density (NCD) foils in tandem [7]. The acceleration mechanism is the two-stage acceleration process of radiation pressure acceleration (RPA) and laser wakefield acceleration (LWFA), where the injection of relativistic ions into wakefield is controlled by the parameters of the dual pulses. The energetic protons, which are accelerated by the first laser pulse in the first RPA stage, are injected into the NCD plasma. In the second stage, protons are trapped in front of the second laser pulse and accelerated by the laser induced wakefield. Since the second pulse reaches the NCD plasma through the hole of the SD target made by the first pulse, all amount of second pulse energy is used for the second LWFA, resulting in more efficient acceleration compared to the hybrid RPA-LWFA with a single-pulse, where a large amount of pulse energy is reflected by the SD target, resulting in the reduction of the energy used for the LWFA [5].

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