Enhancement of Proton Acceleration by Optimizing Laser Pulse

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The achievable proton energy using present laser facilities is still limited due to the large inertia of the proton and the unsatisfied optical quality of the laser. There are ways to use specially designed targets and better focusing and contrast of the laser to improve the laser driven proton acceleration. Here we report two new methods to enhance proton acceleration by optimizing the laser pulse. First, considering the inevitable pre-pulse which burns a foil into a low-density plasma, we propose to employ a laser pulse of two peaks with different intensities. Similar to the case for inertial confinement fusion, the two peak laser pulse can drive two sequent shocks to produce high plasma density to support high energy proton acceleration with the scheme of collisionless shock. Second, we propose to accelerate proton with a plasma wake driven by a light spring (LS) pulse which has a helical structure in its intensity profile. Compared to normal Gaussian pulse, much laser energy can be saved due to the helical structure in its intensity profile. In this way, simulation shows that 10GeV Proton can be obtained with a 5PW Light Spring Pulse.