Effect of Laser Chirp on Proton Acceleration in Thin Foil Targets

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Ion acceleration in the interaction of high intensity ultra-short laser pulses with thin foil target has been extensively studied since last one decade. The interest in this field is mainly because the laser produced ion beams promise a great potential for many applications such as cancer therapy, proton driven fast ignition, isochoric heating, particle radiography etc. Most of the experimental results on ion acceleration at currently achieveable laser intensities are primarily explained by the Target Normal Sheath Acceleration (TNSA) mechanism wherein the high intensity laser pulse produces forward propagating fast electrons, which traverse through the foil and leave it, thereby forming a sheath layer on the target - vacuum interface, which is strong enough to ionize and accelerate the atoms present on the foil rear surface. There are a number of experimental and theoretical reports which address the effect of various laser and target parameters on ion acceleration like laser pulse energy, intensity, pulse duration, laser pulse contrast, target thickness, density, structure etc. In this paper, we present a study on the effect of laser pulse duration and chirp on the proton emission from thin metal foils of different thicknesses, using 45 fs, 7 TW laser pulses.

We have observed that the ion emission does not only depend on the laser pulse duration but also on the sign of the laser chirp. The accelerated ion beam was primarily characterized using a Thomson parabola ion spectrograph equipped with a micro-channel plate and a 16 bit CCD camera. The spectrograph was placed along on the rear side of the foil, normal to the foil surface. The spatial profile and the divergence of the ion beam were measured using radiochromic films and CR-39 sheets (as track detector). The ion spectrum was recorded at various laser pulse durations, starting from 45 fs to 765 fs. The measurements were performed with both, positively and negatively chirped laser pulses. We observe that the proton emission spectrum is quite different for the negatively and positively chirped laser pulses, at same laser pulse duration. In the case of negatively chirped laser pulse, the maximum proton energy either stays constant or increases slightly up to 200-300 fs, and decreases monotonically thereafter. Whereas, for the positively chirped laser pulses, there is distinctly different trend in the proton energy spectrum. The maximum proton energy suddenly decreases even with a small increase in the positive chirp.

The observed results may provide some further insight into the acceleration mechanism. The experimental details, the results, and our current understanding on the same, will be presented.