Efficient Ion Acceleration by Colliding Collision-less Shock in NRCD Plasmas

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The laser driven ion acceleration has been widely investigated for their applications to the fast ignition [1], the ion beam cancer therapy, laser driven neutron source [2][3], and so on. It is also interested from the point of cosmic particle acceleration. In the recent experiments with the LFEX laser, it is found that a few tens of MeV ions are efficiently generated and it may be attributed to the pre-ion acceleration in the pre-formed near relativistic critical density (NRCD) plasma and overlap focus of the 4 LFEX beams. In this paper, we discuss the efficient ion acceleration mechanism by analyzing dynamics of “a ripple collision-less shock” shown in Fig.1.

The PIC simulations show that collision-less shock waves are generated in the NRCD pre-plasmas where the piston velocity is faster than the sound velocity. When the laser irradiates the NRCD plasma, strong electromagnetic fluctuations are generated by the two stream instabilities. Those fluctuations scatter relativistic electrons generated by laser plasma interactions. So, the electron energy flow into the bulk of the NRCD plasma is reduced and the up-stream plasma temperature could be kept low. On the other hand, ions accelerated near the critical surface are injected into the NRCD plasma and induce the ion–ion two stream instability to generate collision-less shock waves, as shown in Fig.1. Here, the laser intensity is modulated by the interference of oblique injection of two laser beams. As indicated by circles in Fig.1, the plasma is highly compressed by the colliding shock and plasma jets are formed. By the formation of the jets, the accelerated ion energy and the efficiency are enhanced. This new acceleration mechanism will be discussed in the presentation.

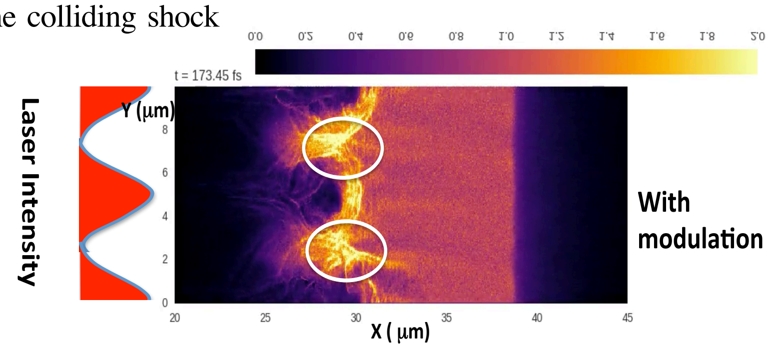

Figure 1: Electron density distribution of rippled shock. Two laser beams of the intensity of 10^{19}W/cm^2 with ±2.5° incident angle are injected into a 10 n_c plasma of *15 μm* thick.

References

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