Collisionless Electrostatic Shock Acceleration of Proton using High Intensity Laser LFEX

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Laser-driven ion acceleration (LDIA) has a potential to take the place of current particle accelerators [1]. The electric field generated by the laser-plasma interaction is much larger than the conventional one. This means that this accelerating gradient can reduce the size of future accelerators by more than an order of magnitude. In the past decades, various LDIA mechanisms have been proposed. For Collisionless Electrostatic Shock Acceleration (CSA), which is one of the most feasible ion acceleration methods, when an electrostatic collisionless shock propagates with a shock velocity v_{sh} much larger than the velocity v_0 of ions in the upstream of the shock, the shock pushes ions forward up to about $2v_{sh}$. The resultant quasi-monoenergetic ions are very important in terms of medical and engineering applications [2].

We conduct CSA experiment with a beam of LFEX (wave length 1053 nm, pulse-width 1.5 ps, laser intensity 10^{19} W/cm^2, normalized laser intensity $a_0 \approx 3$) at Institute of Laser Engineering, Osaka University in Japan. In this experiment, at first, we irradiate Gekko XII laser (1053 nm,1.3 ns,10^{12} W/cm^2) to a CH thin target with 0.7 μm in thickness and create a near-critical density plasma (10^{21} cm^{-3}). After a few ns delay (from 0.2 ns to 1.5 ns), we irradiate LFEX to the rear-side of the ionized surface and observe accelerated ions using Radio Chromic Film (RCF) and CR-39. We also get electron's spectrum using two electron spectrometers.

We compare the electron temperature in two cases, with and without the ionization laser, and find out that the electron temperature with the ionization laser is twice as high as the case without it. It is more likely that this is caused by the laser-plasma interaction. We estimate that the maximum ion energy in the shots is about 6 MeV from RCF when the delay is the shortest. We also confirm the accelerated ions with the energy more than 2.2 MeV from CR-39 in the same shot. From these results, we conclude that CSA occurred when the plasma has an optimum density and profile depending on the delay between the main and ionization lasers. We would like to present these experimental results together with simulation ones.

References

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