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Laser-driven collisionless electrostatic shock generation in a multicomponent-ion plasma

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Shock waves in space, such as in supernova remnants and the bow shock of the earth, are collisionless shocks generated in collisionless plasmas, and the most promising candidate for the sources of cosmic rays. Recently, high-intensity laser-driven electrostatic collisionless shock ion-acceleration is drawing attention [1]. In this scheme, upstream ions of the shock are reflected and accelerated by the shock potential. We have investigated in two-dimensional PIC simulations, the generation of electrostatic collisionless shock and ion acceleration in a multicomponent-ion C_2H_3Cl plasma driven by a high-intensity laser [2, 3, 4]. A relativistic-cutoff electron density ($n_e = a_0 n_c$, $a_0 = 3.35 - 33$ is the normalized laser intensity, and n_c is the cutoff density) is used as an initial plasma. The upstream ions of the shock are accelerated in the laser axis direction by an ambipolar electric field at the rear side of the target. An electrostatic ion-beam two-stream instability is excited due to the difference in the flow velocities between protons and C^{6+} ions [4]. The instability plays an important role in the dissipation/heating and the shock-acceleration of the upstream ions [2]. When the laser intensity is increased, the Mach number of C^{6+} ions, in addition to that of protons, exceeds 1. As a result, shocks are generated for each ion species and both ions are accelerated to different velocities by the two shocks [3]. We also show the results of the high-intensity laser experiments.

References

[1] D. Harberberger, *et al.*, Nature Phys. **8**, 95-99 (2012).
[2] R. Kumar, Y. Sakawa, *et al.*, Phys. Rev. Accel. Beams **22**, 043401 (2019).
[3] R. Kumar, Y. Sakawa, *et al.*, Phys. Rev. E **103**, 043201 (2021).
[4] Y. Sakawa, Y. Ohira, *et al.*, Phys. Rev. E **104**, 055202 (2021).