EXCITATION OF ION WEIBEL INSTABILITY AND COLLISIONLESS SHOCK GENERATION USING LARGE-SCALE LASER SYSTEMS

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Collisionless shock, in which coulomb mean-free-path is longer than the shock-front thickness, is often observed in space and astrophysical plasmas. It is believed that collisionless shocks are sources of high-energy particles or cosmic rays. In such collisionless plasmas, wave-particle interactions and collective effects play an essential role in the shock formation. However, there are significant uncertainties in the physics of particle acceleration by collisionless shocks. In addition to local observations of spaces plasmas by spacecraft and global emission measurements of astrophysical plasmas, a laboratory experiments can be an alternative approach to study the formation of collisionless shocks.

In this paper, a collisionless Weibel-instability mediated shock (Weibel shock) in a self-generated magnetic field is investigated using large-scale laser systems. It is predicted in two-dimensional particle-in-cell simulation that the generation of the Weibel shock requires to use hundreds of kJ high-power laser system. On OMEGA laser experiments with CH double-plane target, plasma parameters of counter-streaming flows are measured by collective Thomson scattering, and Weibel filaments are observed by D-3He fusion produced proton radiography[1]. On the National Ignition Facility, with CD double-plane target, DD neutrons and strong x-ray emission from the hot plasmas in the middle of the two planes are observed after the laser turned off. These results indicate that neutrons are produced in a shock.

[1] C. M. Huntington et al, Nature Physics 11, 173 (2015).