5th Asia-Pacific Conference on Plasma Physics, 26 Sept-1Oct, 2021, Remote e-conference

Generation and dynamics of electron vortex and induced particle acceleration in laser plasma interaction

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Nonlinear structures such as shockwaves and vortices are widely existed in nature and universe. They have also been observed separately in laser plasma interaction. Here, by using multi-dimensional Particle-in-Cell simulations, we study the electron vortex generation and its dynamics in laser plasma interaction [1-2]. Detailed fields structures and electron trajectories show the micro dynamics of the vortex, which explains the drift motion of the vortex. We also find that collisionless electrostatic shockwaves (CESs) can be excited by a moving electron vortex (EV) driven by an ultra-short intense laser interacting with an underdense plasma with downramp density profile. Two CESs are observed on both sides of the passing route of the EV. The left side CES is induced by a high density electron layer which originates from the front of the EV and is compressed and accelerated during the EV motion. The right side CES is induced by supersonic ions accelerated by the EV directly. Ion acceleration along the directions perpendicular to the vortex propagation by such CESs are observed. The energy evolution of the EV has been investigated. Our study reveals the transformation of the nonlinear structures and provides new forms of laser energy dissipation in plasma.

References

[1] D.N. Yue, M. Chen, P.F. Geng, et al., Phys. Plasmas, 28, 042303 (2021)

[2] D.N. Yue, M. Chen, P.F. Geng, et al., Plasma Phys. Control. Fusion, 63, 075009 (2021)

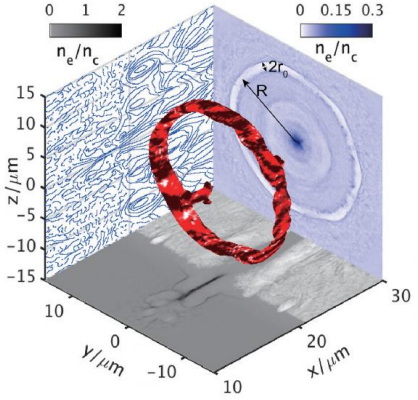

Fig. 1. The magnetic ring stricture of a vortex generated in the down-ramp range of a plasma.

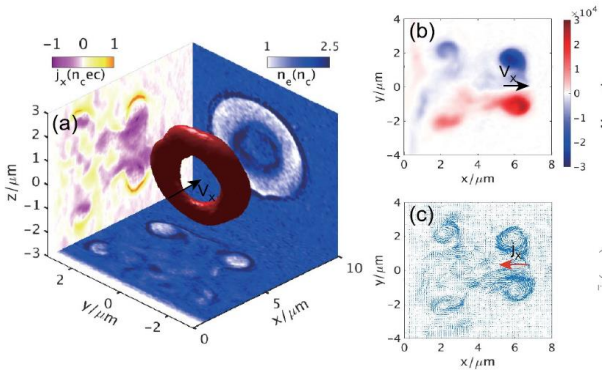

Fig. 2. (a) The magnetic ring stricture of a vortex generated in the up-ramp range of a plasma. Distributions of the moving magnetic fields (b) and currents (c).