Small-Scale Magnetospheric Structure Formation due to Laser-Produced Plasma Jet

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Multi-point irradiation of high-power laser to a thin solid target produces a directional high-Mach plasma jet. The laser-produced plasma jet interacting with external magnetic fields causes various structure formations relevant to space plasma phenomena. We investigate ion-scale structure formations due to the high-Mach plasma jet in uniform magnetic fields by means of fully kinetic particle-in-cell simulation.

In the absence of ambient plasma, spontaneous focusing of plasma jet is observed[1]. This is caused by the positive feedback between field line distortion due to cross-field current density and field-aligned electron flow. The out-of-plane magnetic field characterizes the field line structure indicating two-fluid effect plays a role in the focusing. Condition of plasma flow required for the structure formation is obtained from the dispersion relation of whistler wave as in the two-fluid magnetic reconnection model[2].

In the presence of ambient plasma, the plasma jet propagates while expelling the ambient plasma. As a result, a gradual shock-like structure with whistler waves is generated at the front of the plasma jet. In the moving frame of the jet front, this may correspond to the whistler wake and the bow wave, that are expected in solar wind interaction with an ion-scale magnetized object[3,4]. Various magnetospheric structures associated with slow/fast magnetosonic and whistler waves have been found in accordance with the object size in the numerical simulations[3]. However number of such astronomical object is not so sufficient for observational verification of the ion-scale magnetosphere. We will discuss experimental condition for plasma jet and external magnetic field to demonstrate the small-scale magnetospheres.

[1] T. Moritaka, Y. Kuramitsu, Y-L. Liu, and S-H. Chen, Physics of Plasmas 23, 032110 (2016).
[2] J. F. Drake, M. A. Shay, and M. Swisdak, Physics of Plasmas 15, 042306 (2008).
[3] N. Omidi, X. Blanco-Cano, C. T. Russell, H. Karimabadi and M. Acuna, Journal of Geophysical Research 107, 1487 (2002).
[4] T. Moritaka, Y. Kajimura, H. Usui, M. Matsumoto, T. Matsui, and I. Shinohara, Physics of Plasmas 19, 032111 (2012)