Full particle-in-cell simulation of the interaction between two plasmas for laboratory experiments on the generation of magnetized collisionless shocks with high-power lasers

*Takayuki Umeda[1], Ryo Yamazaki[2], Yutaka Ohira[3]

1. Institute for Space-Earth Environmental Research, Nagoya University, 2. Aoyama Gakuin University, 3. The University of Tokyo

A preliminary numerical experiment is conducted for laboratory experiments on the generation of magnetized collisionless shocks with high-power lasers by using one-dimensional particle-in-cell simulation. The present study deals with the interaction between a moving aluminum plasma and a nitrogen plasma at rest. In the numerical experiment, the nitrogen plasma is unmagnetized or magnetized by a weak external magnetic field. Since the previous study suggested the generation of a spontaneous magnetic field in the piston (aluminum) plasma due to the Biermann battery, the effect of the magnetic field is of interest. Sharp jumps of the electron density and magnetic field are observed around the interface between the two plasmas as long as one of the two plasmas is magnetized, which indicates the formation of tangential electron-magneto-hydro-dynamic discontinuity. When the aluminum plasma is magnetized, strong compression of both the density and the magnetic field takes place in the pure aluminum plasma during the gyration of nitrogen ions in the aluminum plasma region. The formation of a shock downstream is obtained from the shock jump condition. The results suggest that the spontaneous magnetic field in the piston (aluminum) plasma plays an essential role in the formation of a perpendicular collisionless shock.

Keywords: plasma, shock waves, PIC simulation, laboratory astrophysics