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Observation of quasi-monoenergetic Ion acceleration by magnetized collisionless shock in laboratory

Hui-bo Tang[1], Yu-fei, Hao[2], Guang-yue Hu[1]
[1]CAS Key Laboratory of Geospace Environment, University of Science and Technology of China, Hefei, China
[2]Key Laboratory of Planetary Sciences, Purple Mountain Observatory, Chinese Academy of Sciences, Nanjing, China
e-mail (speaker):tanghb@ustc.edu.cn

Collisionless shock has long been considered as an efficient way to produce high energy charged particles in the astrophysical environment, and diffusive shock acceleration is well-known as the underlying physical mechanism to produce these relativistic particles. Before entering the process of diffusive shock acceleration, the particles should suffer a first-stage acceleration from the thermal population. Identifying the exact mechanism of the first-stage acceleration is still a big challenge. Supersonic, super-alfvenic plasma flow produced by high power lasers provides a controlled way to study collisionless shock in laboratory. Several studies have focused on unmagnetized shocks, like electrostatic shocks [1-4] and Weibel-mediated shocks [5-9]. The study of magnetized collisionless shocks remained insufficient so far. Important progress was made in quasi-perpendicular shock geometry by experiments of a laser-driven supersonic plasma is expanding into magnetized ambient plasma [10-15].

Here we produce magnetized collisionless shocks in laser plasma experiment, and observe ion acceleration process. We found that ions can be accelerated to 3-5 times the shock velocity via shock drift acceleration, and exhibit an quasi-monoenergetic distribution. As the magnetic field increases, ions acceleration becomes more pronounced. Our observations provide new insight into particle injection in collisionless shocks and open the way for controlled laboratory studies of the physics underlying cosmic accelerators.

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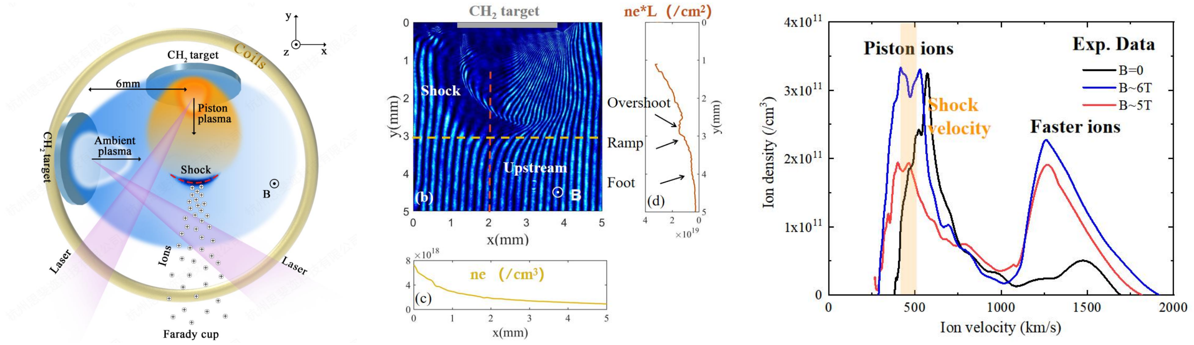

Figure1. Laser-driven magnetized collisionless shock experiments.