SA-I20

1st Asia-Pacific Conference on Plasma Physics, 18-23, 09.2017, Chengdu, China

Laser driven magnetic reconnection experiments in high and low beta plasmas

Jiayong Zhong

Department of Astronomy, Beijing Normal University, China

Magnetic reconnection as a fundamental plasma process in which the opposite directed magnetic-field lines passing plasma undergoes dramatic rearrangement, often happens in the solar plasmas, magnetosphere et al. Laser driven high beta (>4) magnetic reconnection (LDMR) is constructed with self-generated magnetic fields has been experimentally and theoretically studied extensively, where very strong Mega-Gausses magnetic fields are spontaneously generated in high-power laser-plasma interactions, which located on the target surface and produced by Biermann battery effect due to non-parallel temperature and density gradients in expanding plasmas. A well-scaled laboratory reconnection experiment has reproduced the physics of solar flares in a controlled setting, despite orders of magnitude differences in spatial and temporal scales. Relativistic electrons of energy up to MeV with a power law distribution are detected roughly in the direction along the magnetic separatrices that bound the reconnection outflow. We also notice that the electrons that are accelerated in the electromagnetic (EM) field with a guide field could get more energy than those accelerated in an environment without guide field. The numerical experiments performed in the same EM configurations reproduce these results. The experimental results are in line with simulations, and confirm that the energetic electrons are produced in the reconnecting region where the temperature are high and the accelerating process is impulsive.

Magnetic reconnection can be triggered in either high or low beta plasmas, especially in solar atmosphere plasmas, where the resulting β variation with height. We demonstrate a novel plasma device for magnetic reconnection, driven by Gekko XII lasersirradiating a double-turn Helmholtz capacitor-coil target. Optical probing revealed an accumulatedplasma plume near the magnetic reconnection outflow. The background electron density and magneticfield were measured to be approximately 10^{18} cm^{-3} and 60 T by using Nomarski interferometryand the Faraday effect, respectively. In contrast with experiments on magnetic reconnection constructed by the Biermann battery effect, which produced high beta values, our beta value was much lower than one, which greatly extends the parameter regime of laser-driven magnetic reconnection and reveals its potential in astrophysical plasma applications

References

1. J. Y. Zhong et al., **Astrophys. J. Suppl. Ser**. 225，30（2016）

2.J. Y. Zhong et al. , **Nature Physics**, 6(12), 984-987 (2010)

3.X. X. Pei, et al., **Physics of Plasmas** 23, 032125 (2016);

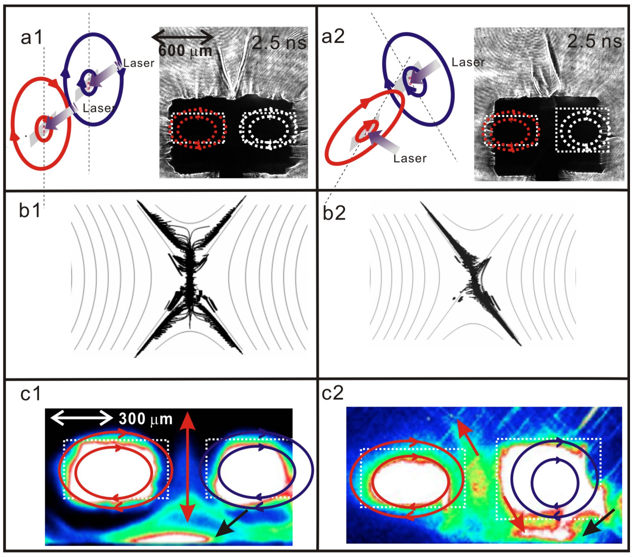

Figure: Two laser bunches produce two plasma bubbles (in left panels) entangled by magnetic fields without (a1) and with (a2) guide field, respectively. Magnetic reconnection taking place in these two configurations yields different results, and both the energetic particles and the reconnection outflow leaves the CS in various ways. First of all, the shadow images (in right panels) show two major trajectories in different orientations that roughly track the motions of energetic electrons (a1) in the first case, and that energetic electrons are seen to leave the CS roughly in the same direction in the second case (a2). (b1)-(b2), Results from theoretical calculations for particle accelerations that almost duplicate the results given in (a1) and (a2), respectively. It is clear that accelerated electrons leave the CS along two separatrices at the same side of the x-axis if no guide field is included (b1, comparing with a1); and electrons leave the CS along one separatrix at one side of the x-axis as guide field is included (b2, comparing with a2). In addition to the energetic electrons, the associated reconnection outflow is also observed by the pinhole X-ray imaging technique, which provides images obtained forward of the Al foil targets (c1 and c2, refer also to Figure 2). These images display the patterns of the reconnection outflows as well we consequences of the interaction between the outflow and the Cu target below. Magnetic field lines are illustrated based on the flux surface of the plasma bubbles as shown in panels (a1) and (a2).