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Local and global observations of magnetic reconnection in laser produced plasmas

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Magnetic reconnections play essential roles in various space and astrophysical phenomena. In situ observations of space plasmas reveal microscopic plasma processes, although the global structures of the phenomena are hard to obtain. Contrary, astrophysical observations provide the global structures of phenomena, yet the local information is inaccessible. In laboratory, the global structures of plasmas and the local plasma and magnetic field properties are simultaneously obtained under a controlled manner [1]. The simultaneous observations of local and global features of plasmas and particle acceleration are highly challenging in space and astrophysical observations, and thus, the laboratory experiment can be a unique and powerful tool to investigate high energy space/astrophysical phenomena. We have been investigating longstanding open questions in the universe, such as collsionless shocks, plasma jets, magnetic field generation, magnetic field amplification, and the origins of cosmic rays using high-power and ultra-intense lasers [2-12]. Laboratory experiments can be a complemental approach to investigate the magnetic reconnections.

In the triggering process of a magnetic reconnection, the electron dynamics is considered to be essential, however, it has been highly challenging to observe the tiny electron scale microscopic information in the macroscopic magnetic reconnection in the vast universe. By applying a weak magnetic field to the laser-produced plasma, we create the state that only electrons are directly coupled with the magnetic field. The plasma collimation is observed with interferometry only when the magnetic field is appled, furthermore, a plasmoid associated with cusp like features are observed. The plasmoid propagates at the Alfvén velocity defined with electron mass, indicating the magnetic reconnection driven by electron dynamics [13]. We present our recent experimental results showing local electron outflows together with the local magnetic field inversion relevant to magnetic reconnection.

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