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Local measurements of electron-scale magnetic reconnection in laser-produced plasmas

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Magnetic reconnection, where the magnetic energy is converted to the kinetic and thermal energy of plasmas, is found in various space, astrophysical, and laboratory plasmas. It is believed that the onset of magnetic reconnection is triggered by microscopic electron dynamics, yet it is challenging to observe electron-scale structures experimentally because they require high spatial and temporal resolutions. We performed experiments picking up electron-scale structures of magnetic reconnection using the controllability of laser-produced plasmas [1-5]; we control the plasma flow speed and magnetic field strength so that the electron scale is measurable, i.e., the electron gyroradius is smaller but the ion gyroradius is greater than the system size. Local measurements using collective Thomson scattering and magnetic induction probe show the electron Alfvénic outflows that is not accompanied with ion outflows, and plasmoid and whistler waves generated by electron-scale dynamics, respectively [3]. These illustrate that magnetic reconnection releases upstream magnetic energy to the kinetic energy of electron outflow at a spatial and temporal scales less than the ion gyromotion.

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