Fast magnetic reconnection in high-energy-density laser-produced plasmas

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Abstract

Recent experiments have observed magnetic reconnection in high-energy-density, laser-produced plasma bubbles, with reconnection rates observed to be much higher than can be explained by classical theory. This is a novel regime for magnetic reconnection study, characterized by extremely high magnetic fields, high plasma beta and strong, supersonic plasma inflow. We use particle-in-cell simulations (with collision operator) to study reconnection in this regime with geometry and parameters relevant to the experiments. These simulations have identified two key ingredients, simultaneously present for the first time: two-fluid reconnection mediated by collisionless effects (that is, the Hall current and electron pressure tensor), and strong flux pile-up of the inflowing magnetic field. These effects combine to yield reconnection rates independent of the nominal Alfvén speed (based on the magnetic field before interaction), and simply given by the dynamic time L/V, in qualitative agreement with the experiments. We present simulations spanning the parameter ranges of the experiments, including the role of binary collisions. We conclude with a discussion of proposed future laser-driven reconnection experiments.