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Studies of Magnetic Reconnection in Colliding Laser-Produced Plasmas

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Novel images of magnetic fields and measurements of electron and ion temperatures have been obtained in the magnetic reconnection region of high-β, laser-produced plasmas. Experiments using laser-irradiated foils produce expanding, hemispherical plasma plumes carrying MG Biermann-battery magnetic fields, which can be driven to interact and reconnect. Thomson-scattering measurements of electron and ion temperatures in the interaction region of two colliding, magnetized plasmas show no thermal enhancement due to reconnection, as expected for $\beta \sim 8$ plasmas. Two different proton radiography techniques used to image the magnetic field structures show deformation, pileup, and annihilation of magnetic flux. High-resolution images reveal unambiguously reconnection-induced jets emerging from the interaction region and show instabilities in the expanding plasma plumes and supersonic, hydrodynamic jets due to the plasma collision. Quantitative magnetic flux data show that reconnection in experiments with asymmetry in the scale size, density, temperature, and plasma flow across the reconnection region occurs less efficiently than in similar, symmetric experiments. This result is attributed to disruption of the Hall mechanism mediating collisionless reconnection. The collision of plasmas carrying parallel magnetic fields has also been probed, illustrating the deformation of magnetic field structures in high-energy-density plasmas in the absence of reconnection. These experiments are particularly relevant to high-β reconnection environments, such as the magnetopause. This work was performed in collaboration with C. Li, F. Séguin, A. Zylstra, H. Rinderknecht, H. Sio, J. Frenje, and R. Petrasso (MIT), I. Igumenshchev, V. Glebov, C. Stoeckl, and D. Froula (LLE), J. Ross and R. Town (LLNL), W. Fox (UNH), and A. Nikroo (GA), and was supported in part by the NLUF, FSC/UR, U.S. DOE, LLNL, and LLE.