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Experimental verification of the role of electron pressure in fast magnetic reconnection with a guide field

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Magnetic reconnection enables explosive conversion of magnetic field energy to plasma kinetic energy in space and laboratory plasmas. In many reconnecting plasmas in space, solar, and laboratory plasmas, reconnection proceeds in the presence of a finite guide field (GF) such that the magnetic field lines meet at an angle less than 180, and in magnetic fusion devices the guide field can be the largest component of the field. We report detailed laboratory observations of the structure of reconnection current sheets in a two-fluid plasma regime with a guide magnetic field. We observe and quantitatively analyze the quadrupolar electron pressure variation in the ion-diffusion region, as originally predicted by extended magnetohydrodynamics simulations. The projection of the electron pressure gradient parallel to the magnetic field contributes significantly to balancing the parallel electric field, and the results demonstrate how parallel and perpendicular force balance are coupled in guide field reconnection and confirm basic theoretical models of the importance of electron pressure gradients for obtaining fast magnetic reconnection. I discuss connections to observations of reconnection with finite guide field by spacecraft missions, and implications for two-fluid reconnection in magnetic fusion devices.