NEW UNDERSTANDING OF COLLISIONLESS RECONNECTION IN ASTROPHYSICAL AND SPACE PLASMAS

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Collisionless reconnection is a fundamental process occurring in a variety of settings including astrophysics, solar, planetary magnetosphere and laboratory plasmas. Despite its importance as an energy conversion mechanism, many important issues remain not completely understood. One important question is the mechanism to achieve fast reconnection. This problem appeared solved with the advent of the much publicized Hall-mediated reconnection theory. According to this theory, the Hall term plays a central role in localizing the diffusion layer, leading to a steady-state fast reconnection configuration. If correct, alternative explanations would be required for the observed fast reconnection in pair plasmas (mi = me) where the Hall term is absent (when Te=Ti). Here we report on our recent work which has brought into question the Hall-mediated reconnection picture. Several elements of our new picture of reconnection has been recently been observed in the Earths magnetosphere. We show that there is a continuity of physics as a function of mass ratio (mi/me) of the plasma. We also report on our recent 3D simulations using the largest full particle simulations to date. Although the 2D results remain qualitatively valid in 3D, there are significant differences in the details of reconnection. These differences are due to interaction of reconnection with other current sheet instabilities as well as more general changes in topology admitted in 3D. The relevance of these new findings to understanding reconnection in different settings will be discussed.