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The effect of turbulence on 2D magnetic reconnection

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Magnetic reconnection is a well known plasma process believed to lie at the heart of a variety of phenomena such as sub-storms in the Earth's magnetosphere, solar/stellar and accretion-disk flares, sawteeth activity in fusion devices, etc. During reconnection, the global magnetic field topology changes rapidly, leading to the violent release of magnetic energy. One of the outstanding theoretical challenges in this field is the understanding of the mechanism(s) responsible for such rapid changes.

In single-fluid MHD, it is believed that magnetic reconnection is well described by the Sweet-Parker theory (SP), which, however, is orders of magnitude too slow to explain observations. In many cases of interest, reconnection takes place in plasmas which are fundamentally collisionless, and which cannot, therefore, be described by MHD theory. Indeed, a vast amount of numerical studies suggest that fast reconnection can be obtained when kinetic physics becomes important. However, in many astrophysical situations (e.g., inside stars and accretion disks) the density is so high that the reconnection layer is collisional and resistive MHD should apply. How, then, can reconnection be fast in these environments?

Missing from the SP picture is that most, if not all, environments where reconnection occurs are likely to be turbulent. Theoretical arguments exist [Lazarian & Vishniac, ApJ **517**, 700 (1999)] (LV) suggesting that indeed turbulence can significantly enhance the reconnection rate, but only in 3D. In this talk, we present the results of an extensive, high-resolution, numerical study of the effect of small-scale background turbulence on 2D magnetic reconnection [Loureiro *et al.*, MNRAS **399**, 1 (2009)]. We show that, contrary to theoretical expectations, turbulence has a very significant effect in speeding-up the 2D reconnection process, yielding a reconnection rate whose dependence on resistivity (η) is extremely weak and is even consistent with an η-independent value. We suggest that these results point to a mechanism of turbulent enhancement of the reconnection rate which is alternative to that envisionaged by LV, and which may be related to the instability of the current sheet to the formation of multiple secondary magnetic islands (plasmoids).