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Force-free magnetic island coalescence instability and Shear flow effects

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Magnetic reconnection (MR) is responsible for some of the most energetic/eruptive events observed in space and laboratory plasmas, for example solar flares, coronal mass ejections, magnetospheric aurora formation, saw-tooth crash in tokamaks, etc. during which the global magnetic energy is converted to kinetic energy, thermal energy and non-thermal particle acceleration [1]. The micro-scale current sheets (CSs) are the main site of MR and hence, it is a multi-scale phenomenon. Different plasma parameters around the CS controls the MR in many ways, for example, the plasma collisionality affects the CS dimension, the anti-parallel magnetic field profiles control the reconnection rate [2], shear flows controls the plasma upstream and downstream flow and CS orientation [2,3,5] etc.

Recently, using a visco-resistive incompressible MHD model [2], the effect of in-plane shear flow on 2D magnetic island coalescence and associated reconnection parameters have been investigated, both qualitatively [2] and quantitatively [3]. A new scaling law of reconnection rate with shear flow amplitude, different from that of Harris current sheet setup [5] has been reported. Moreover, the shear flow generated MHD-Kelvin-Helmholtz-instability modes are found to be suppressed by the coalescence instability. In the present work, we investigate the coalescence instability using a 2.5D force-free magnetic island equilibrium. A comparison of reconnection dynamics 2D, regular, non-force-free and a 2.5D force-free magnetic island equilibrium will be discussed. Further, the effect of shear flows on both type of initial profiles, a comparison with the incompressible results in the presence of a shear flow will be presented.

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