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Statistical description of coalescing magnetic islands via magnetic reconnection

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The physical picture of interacting magnetic islands (or flux tubes in 3D) provides a useful paradigm for certain plasma dynamics in a variety of physical environments, such as the solar corona, the heliosheath, and the Earth's magnetosphere. The successive coalescence of magnetic islands via magnetic reconnection leads to robust dissipation of magnetic energy. Meanwhile, the length scale of magnetic fields increases, giving rise to the formation of large-scale structures. We have investigated the system dynamics of a large ensemble of magnetic islands with analytical theory and direct numerical simulations (Zhou *et al.*, 2019, 2020), and through a Boltzmann-type kinetic approach (Zhou *et al.* 2021). This talk will focus on the latter. We derive an island kinetic equation (IKE) to describe the evolution of the island distribution function (in area and in flux of islands) subject to a collisional integral designed to account for the role of reconnection during island mergers. We solve our IKE numerically for three different types of initial distribution that are relevant to space and astrophysical environments: delta-distribution, Gaussian and power-law distribution. The time evolution of several key quantities is found to agree well with our analytical predictions: magnetic energy decays as $\tilde{t}^{-1}$, the number of islands decreases as $\tilde{t}^{-1}$, and the averaged area of islands grows as $\tilde{t}$, where $\tilde{t}$ is the time normalized to the characteristic reconnection time scale of islands. General properties of the distribution function and the magnetic energy spectrum are also discussed. This study provides the statistics of island mergers and is a building block to studying the statistics of particle energisation and solar flares.

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