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Particle acceleration in solar flares: merging magnetic islands in forced reconnection

Max Potter, Philippa Browning, and Mykola Gordovskyy
Jodrell Bank Centre for Astrophysics, University of Manchester, Manchester, United Kingdom
(max.potter@manchester.ac.uk)

There are many proposed mechanisms for particle acceleration in flares, but no single model is able to fully reproduce the range of observed spectra and fluxes from solar flares. It is therefore likely that there are multiple acceleration mechanisms operating as part of a multi-stage process.

Forced magnetic reconnection requires an external process as a trigger and thus operates as part of a chain of perturbative processes in the plasma. Furthermore, many studies of particle acceleration deal with steady reconnection, yet this is unlike the conditions in flares, which are transient event. Forced reconnection has three stages: perturbation to the equilibrium, initial reconnection to form a chain of magnetic islands, and finally the islands begin to coalesce and form 'monster' islands. Previous studies of magnetic energy release and particle acceleration in flares have considered only the first two stages, but we now incorporate also coalescence. This study is also concerned with the relationship between the nature of the perturbation and the dynamics and energetics of the MHD fields. As such, the effects of sinusoid, multiple sinusoid and localised (Gaussian) perturbations of varying amplitude are considered, thereby building towards more realistic models.

To this end, we utilise 2D MHD simulations of forced magnetic reconnection using Lare2d with anomalous resistivity, and a long, periodic simulation domain which allows islands to move and coalesce. Test particles are introduced using a guiding centre approximation code, allowing us to predict the energy spectra of non-thermal ions and electrons, as well as the spatial distributions and evolution on non-thermal particle populations in time-evolving fields.