MHD avalanches in magnetized solar plasma: proliferation and heating in coronal arcades

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MHD avalanches involve small, narrowly localized instabilities spreading across neighbouring areas in a magnetized plasma. Cumulatively, many small events release vast amounts of stored energy. Solar coronal loops, composed of many fine flux tubes, can readily host these, and are easily modelled as straight cylindrical flux tubes between two parallel planes: one unstable flux tube causes instability to proliferate, via magnetic reconnection, through its neighbours, resulting in an ongoing chain of like events. True coronal loops, however, are visibly curved between footpoints on the same solar surface. With 3D MHD simulations, we verify the viability of MHD avalanches in the realistic, curved geometry of an arcade. MHD avalanches thus amplify instability in strong, astrophysical magnetic fields and disturb wide regions of plasma. Contrasting with the behaviour of straight cylindrical models, a modified ideal MHD kink mode occurs more readily and preferentially upwards in the present curved geometry. Instability spreads over a region far wider than the original flux tubes, and wider their footpoints. Sustained heating is produced in a series of ‘nanoflares’, collectively contributing substantially to coronal heating. Overwhelmingly, viscous heating dominates, generated in shocks and jets produced by individual small events. Reconnection is not the greatest contributor to heating, but rather facilitates those processes that are. Localized and impulsive, heating shows no strong spatial preference, except a modest bias away from footpoints, towards the apex. Effects of physically realistic plasma parameters, and the implications for thermodynamic models, with energetic transport, are discussed.