APR18-2018-030052

Abstract for an Invited Paper
for the APR18 Meeting of
the American Physical Society

APS Medal for Excellence in Physics Talk: Magnetic dissipation and field-line topology

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It is widely believed that the dissipation of magnetic fields in stars and galaxies is a major cause of so much suprathermal gas, as in solar and stellar flares, coronae, winds, and X-ray filaments. However, this magnetic dissipation hypothesis can be correct only if the magnetic stresses are effective in pushing the magnetic field and suprathermal gas to form local current sheets and rapid magnetic reconnection, We consider here what initial nonequilibrium field line topologies are conducive to the general development of current sheets. Using an idealized model of the field line topology, we consider the equilibrium of the magnetic stresses, described by . We show that almost all field line topologies relax to a final equilibrium solution containing current sheets, i.e. surfaces of tangential discontinuity, while the topological set of continuous solutions is of measure zero by comparison. That is to say, almost all interwoven field line topologies, expected in the magnetic loops extending out from the convecting photosphere of the Sun, contain internal current sheets and rapid reconnection as a direct consequence of their internal topology. So dissipation of magnetic field occurs by rapid reconnection throughout, and is inescapable in the relaxation to equilibrium for almost all magnetic field line topologies. The overall dissipation rate depends on the strength of the interweaving of course.