STELLAR X-RAY EMISSION AND SPONTANEOUS DISCONTINUITIES IN MAGNETIC FIELDS

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There is the curious fact that the X-ray corona of the Sun appears to be heated by the dissipation of the magnetic energy in a plasma so hot ($1 - 5 \times 10^6$ K) that there is very little resistivity. The X-ray corona would seem to be an unlikely place to find dissipation of magnetic field.

Note then that the photospheric footpoints of the re-entrant magnetic fields of the X-ray active regions are continually shuffled about by the photospheric convection, so that the field lines are randomly interlaced. This reduces the characteristic transverse scale of variation, of course, but not enough to accomplish significant resistive dissipation of the associated electric currents. It appears that the dissipation is accomplished through the remarkable properties of the magnetic equilibrium equation, taking the form $\nabla \times \boldsymbol{B} = \alpha \boldsymbol{B}$ in the simplest case of uniform plasma pressure. This equation has two families of complex characteristics and one family of real characteristic, viz. the field lines. In the presence of an interlaced field line topology an intrinsic part of the equilibrium field is the existence of surfaces of tangential discontinuity, i.e. current sheets lying along the field lines. In the relaxation to equilibrium the stresses in the magnetic field push the field gradients to concentrate into individual surfaces of discontinuity, thereby providing resistive dissipation of the magnetic free energy no matter how small the resistivity. We suggest that this effect is responsible for heating the X-ray corona of the Sun, and, by inference, the X-ray coronas of other late main sequence stars.