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Particle Energisation in Collapsing Magnetic Traps

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Investigating the motion of charged particles in time- and space-dependent electromagnetic fields is central to many areas of space and astrophysical plasmas. Here we present results of studying the energy changes of particle orbits that are trapped in inhomogeneous magnetic fields with rapidly shortening field lines. These so-called collapsing magnetic trap (CMT) models can be useful for explaining the acceleration of particles below the reconnection region in a solar flare. For both 2D and 3D CMT models (e.g. Giuliani et al. 2005; Grady & Neukirch, 2009), betatron acceleration was considered to be the dominant energisation mechanism. We present new results that have been obtained using an improved version of the 3D CMT model by Grady and Neukirch (2009). Our investigations show that a sizeable portion of particle orbits can gain a significant amount of energy that is not explained by the betatron effect. The other mechanism at play appears to be Fermi acceleration at loop tops, where the particle passes through the region of field that is collapsing the most rapidly.

We show that the particles that experience this effect the most have initial positions that are related to specific regions of the magnetic field model and it is these particle orbits whose energy gains are not adequately explained by betatron acceleration alone. In fact, some particle orbits seem to gain energy almost entirely as a result of this Fermi acceleration. One can also show that for suitable initial conditions the same effect can be seen in the 2D CMT model given by Giuliani et al. (2005). This updated understanding of the systems at play for particle acceleration in a CMT can, for example, inform any changes made to future CMT models by accounting for the large number of particles that see energy gains due to Fermi acceleration.

Giuliani, P. et al., ApJ 635, 636

Grady, K. & Neukirch, T., A&A 508, 1461