Relativistic expansion of magnetic arcades and particle acceleration

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When the footpoints of magnetic arcades are twisted due to the shear motion, magnetic loops expand in vertical direction, and magnetic reconnection takes place inside the loops (Mikic et. al 1988). This model has been studied to explain solar flares. We applied this model to a relativistic plasma and compact objects, and carried out numerical simulations by using relativistic MHD code and PIC code.

The expansions of magnetic loops take place when magnetic loops connecting the central star and accretion disk are twisted by the different rotational velocity between the star and the disk. Kato et al. (2004) showed that magnetic tower is formed and expands in the vertical direction. We simulated this model by replacing the rotational motion of the footpoints by shear motion similar to that given by Mikic et al. (1988). We simulated the evolution of the arcades by using relativistic MHD code and confirmed that magnetic reconnection takes place in the expanding arcades. We also carried out 2.5-dimensional simulation starting from the same initial condition as the MHD model except that the simulation region (about 100 Larmor radius) is much smaller. At the footpoints of magnetic arcades, electric fields are induced by the shear motions. This electric fields might accelerate particles to high energy parallel to magnetic field lines like as a Pulsar model. However particles cannot be accelerated because they drag surrounding plasma and electric field energy is distributed to many particles. Moreover, the electric fields are screened out by surrounding plasma. On the other hand, shear motions at the footpoints also induce magnetic fields, thus the magnetic loops expand in vertical direction while magnetic energy is accumulated. By this expansion, we found that anti-parallel magnetic field lines are formed. We'd like to show how much magnetic energy and how much fractions of potential energy at the footpoints are converted to particle energy.