§14. Clarification of Magnetohydrodynamics Phenomenon of the Sun and Astronomical Objects

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The study of particle acceleration associated with plasmoid ejection (fractal recconection and particle acceleration). A plasmoid ejection is observed in a solar flare associated with hard X-ray emission. This suggests the relationship of the plasmoid ejection and the particle acceleration. We performed 2.5D resistive MHD simulation of plasmoid ejections and test particle simulation. We analyzed the particle acceleration mechanism during the plasmoid ejection. As a result, it was shown that the particles are efficiently accelerated accompanying with the plasmoid ejection than in the steady reconnection. Particles are accelerated by reconnection electric field in a current sheet and by Fermi mechanism at the fast shocks. We succeeded in reproducing the time variation of hard X-ray spectrum such as "Soft-Hard-Soft" observed in a solar flare.

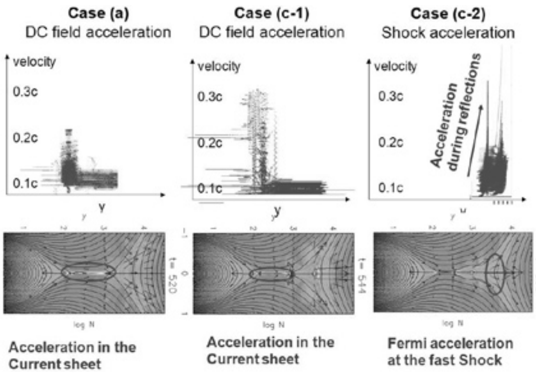

Fig. 1: Snapshot images of a plasmoid ejection in MHD simulation (bottom) and energy change of particles (upper panel).

Magnetohydrodynamics simulations of nonlinear Alfvén wave propagation driven by the solar photosphere. We performed one dimensional magnetohydrodynamc simulation of nonlinear evolution of Alfvén wave which propagates with a flux rope in the solar atmosphere. Alfvén waves driven by photospheric motion are affected by the nonlinear shock dissipation. Spicules are produced by shock waves, and the rest of wave energy reaches to the corona. In this simulation, we drived Alfvén waves by observed velocity fluctuations. As a result, we could reproduce the characteristics of spicules and energy flux necesarry for coronal heating. Futhermore, the atmosphere between photosphere and transition region plays a role of Alfvén wave resonator, contributing for coronal heating.

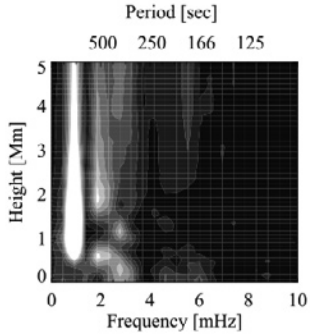

Fig. 2: Power spectrum of toroidal velocity field. It shows the superiority of fundamental mode around 1mHz.

Numerical simulations and self-similar solutions of relativistic expansion of magnetic arcades in magnetars. Giant flares in soft γ-ray repeaters are erupting phenomena of high energy release. Their candidate object is a magnetars($B \sim 10^{15}$). Huge amount of energy release can be explained by magnetic reconnection, in which outflow velocity is expected to be relativistic. The physical dynamics of outflows and their conditions of formation and propagation are essensial for the understanding of flares, though it has not been studied so much. We performed relativistic magnetohydrodynamic simulations and revealed some characteristics. Takahashi et al.[1] (2009) obtained the self-similar solutions for relativistic expansion of magnetic arcades. They have toroidal magnetic fields inside and shock and contact discontinuity in front of themselved. We showed that, as one property of the solutions, the Lorenz factor of the shock wave grows in proportion to the 1/4th power of time. Additionally, we reproduced the self-similar solutions and showed that they are stable solutions. We found that these solutions can be used as a standard problem of relativistic MHD simulation.

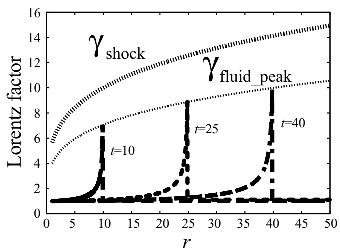

Fig. 3: Lorentz factor of shock wave on the equatorial plane.

1) Takahashi et al., MNRAS, (2009) vol.394 pp.547-568