§24. Magnetic Reconnection Coupled with Heat Conduction

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Heat conduction plays an important role in energetic phenomena which takes place in the solar corona and in the astrophysical hot plasmas (e.g., X-ray plasma in the cluster of galaxies or in the Galactic ridge) because heat conductivity increases with increasing temperature. In the magnetic reconnection model of flares [1], the thermal energy released by reconnection in the corona is transported to the dense cool plasmas in the chromosphere. Since the corona is highly magnetized, heat conductivity is anisotropic depending on the field direction [2]. In order to study this effect, we developed an MHD code which includes anisotropic heat conduction [3]. Using this code, we performed a two-dimensional simulation of the magnetic reconnection.

The initial condition of the simulation is the antiparallel magnetic field with magnetohydrostatic plasma. The magnetic reconnection starts due to the resistivity in a local region of the current sheet [4]. We studied the effect of heat conduction in this model. We solve the two-dimensional, nonlinear, time-dependent, resistive, compressible MHD equations. For heat loss/gain, Ohmic heating and heat conduction is taken into account.

Figure 1 shows the results. In the case *without* heat conduction, a clear “V” shape structure is emanating from the neutral point at the origin. It is a pair of slow-mode MHD shocks theoretically predicted by Petschek [5] in his fast-reconnection model. On the other hand, in the case *with* heat conduction, the distribution of temperature traces the the magnetic field lines from the neutral point. This is the result of the heat conduction along the field line. It is also seen that the outflow from the neutral point is collimated in the narrower channel inside the high temperature structure. A careful study shows that the edges of this channel are isothermal shocks. The thermal energy transported

along the field lines by heat conduction is produced by the shock heating at these isothermal shocks. In summary, the effect of the heat conduction is to dissociate the adiabatic slow-mode MHD shocks emanated from the neutral point into conduction fronts and isothermal shocks [6].

Fig. 1. Two-dimensional distributions of the results for the case *without* heat conduction [upper panel] and that for the case *with* heat conduction [lower panel]. Temperature (gray scale), magnetic field lines (solid lines), and velocity vectors (arrows) are displayed. The levels of gray scale are shown to the left. The unit of velocity vectors is shown at the right top of the figure, whose size is $V = 5.0$ in unit of the sound velocity outside the current sheet. The unit of length is the initial thickness of the current sheet.

References

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