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From magnetoconvection to coronal heating: magnetohydrodynamic modeling

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The energy source for coronal heating and solar wind acceleration is the convective motion in the solar photosphere. The mechanisms of coronal heating and solar wind acceleration are closely related. Understanding the coronal heating and solar wind accleration is not only one of the most important problem in solar physics, but also the basis of space weather study because it is the origin of the quasi-steady space environment in the Sun-Earth system.

The kinetic energy of photospheric convection is transported via magnetic field into the upper atomoshere, where the energy is dissipated, heating the corona and accelerating the solar wind. On the other hand, the magnetic field also affects the convective motion through Lorentz force. For example, the strong magnetic field in sunspot umbra suppress the convective motion. This is probably the reason that the corona just above the umbra is dark in X-ray, indicating weak coronal heating in spite of the strong magnetic field. The aim of this work is to study the interaction of convection of magnetic field and resultant generation, transportation and dissipation of magnetic

energy in the solar atmosphere using self-consisten magnetohydrodynamic simulations.

The computational domain includes the upper convection zone, photosphere, chromosphere and corona. Radiative cooling in the photoshere is approximated by Newton cooling, which drives quasi-steady convection in the convection zone.

We impose a vertical and uniform magnetic field in the initial condition. We change the strengh of the imposed magnetic field and calcurate the upward Poynting flux as a measure of coronal heating rate.

We found that, when the magnetic field is weak, its feedback to convection is negligible, and hence the Poynting flux increase monotonically with the magnetic field strength. However, the magnetic field supresses the convection in the

strong magnetic field cases, and conseqently the Poynting flux decreases with increasing magnetic field strength in this regime. Therefore, the Poyinting flux has maximum at intermidiate strength of the magnetic field. The value of magnetic field which gives the maximum Poyinting flux depends on the other parameters such as Rayleigh number of the convection zone. Hence we need further parameter survey for quantitative discussion. However, our simulations qualitatively reproduced the relation between the magnetic field strength and the coronal heating rate indicatead by observations.

We also found many dynamic phenomena in the photospere and chromosphere in the simulation results, such as transient emergence of horizontal magnetic field, magnetic reconnection in the chromosphere, and resultant jets and high-frequency Alfven waves. We will discuss the relation of these dynamics found in the simulations and recent observations from Solar Optical Telescope on board Hinode.