Japan Geoscience Union Meeting 2010
(May 23-28 2010 at Makuhari, Chiba, Japan)

PPS006-02 Room: 304 Time: May 28 09:15-09:30

Thermodynamical Structure of Protoplanetary Disks

Shigenobu Hirose[1*], Neal Turner[2]

[1]JAMSTEC, [2]JPL/Caltech

The thermodynamics of protoplanetary disks is relevant for understanding the origin and formation of planetary systems because it determines chemical and physical evolutions of dust and gas and also it affects the gravitational interactions between planets and gas in the disks. However, the thermodynamics is quite complicated: the heating arises from the dissipation of magnetohydrodynamic (MHD) turbulence driven by magnetorotational instability due to differential rotation of the disk and the cooling comes from infrared radiation losses. Also the gas near the disk photosphere for visible lights is heated by stellar irradiation. In these heating and cooling processes, the dust grains play vital roles because they determine the opacities in both the infrared and visible radiative transfers and also determine the electrical resistivity that controls the MHD turbulence. In this paper, the thermodynamical structure of protoplanetary disks around low-mass stars is firstly studied using three-dimensional radiation MHD simulations. Local patches of the disk are modeled using the shearing box approximation with vertical gravity. For simplicity, the dust and gas are well mixed and have the same temperature. The frequency-integrated radiation field is evolved using the flux-limited diffusion approximation, adopting thermally averaged opacities. The results indicate the heating is more concentrated in the disk atmosphere than in the classical model. The single-point heating rate in the atmosphere fluctuates by orders of magnitude over time intervals comparable to the orbital period due to magnetic reconnection and shocks, while the patch of disk overall sustains dynamical and thermodynamical equilibrium over many cooling times. Also how the thermodynamical structure depends on the resistivity, dust depletion, stellar irradiation, and surface density of the disk will be discussed.

Keywords: protoplanetary disk, MHD turbulence, radiative transfer, thermodynamics, dust, MHD simulation