Thermal instabilty of irradiation-dominated protoplanetary disks

Sei-ichiro Watanabe[1]

[1] Earth and Planetary Sci., Nagoya Univ.

The protoplanetary disks are mainly heated by radiation from the central star, which is absorbed by dust in the surface layer first, then reemitted to the interior of the disk. Since the surface irradiation of a certain radius of the disk is sensitive to the disk structure within the radius, the possibility of an unstable feedback is present. Using an approximation that the ratio of the surface height to the density scale height is constant, D'Alessio et al. (1999) treated this problem semi-analytically and concluded that disk are stable to perturbations in vertically isothermal disks. But validity of the approximation was not clear.

We have performed quasi-static calculations of thermal evolution of irradiated disks, using the direct integration of optical depths to determine the optical surface and total emitting area-filling factor of superheated grains. We find that thermal waves are spontaneously excited and propagate inward within a few times of thermal timescale in the region from 100AU to 1AU when viscous heating is weak. Peak mid-plane temperature of the wave is more than twice compare to that of circumference. These waves induce a significant change in spectral energy distribution of the disk.