Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

PPS21-16 Room:201A Time:May 22 13:45-14:00

Surface Density Distributions of Protoplanetary Disks with Dead Zones of Magneto-Hydrodynamic Turbulence

TAKEUCHI, Taku[1*], OKUZUMI, Satoshi[2], MUTO, Takayuki[1]

[1]Tokyo Institute of Technology, [2]Nagoya Univeristy

We study evolution of the surface density distributions of protoplanetary disks taking into account the effect of turbulent viscosity via magneto-rotational instability. The inner part of a protoplanetary disk is inactive to MHD turbulence because of its low ionization degree. In such a region, called as a dead zone, gas accretion due to turbulent viscosity is suppressed, and consequently the gas from the outer part accumulates, making the surface density of the inner part higher than that of the outer part. At the outer boundary of the dead zone, which locates from a few AU to several tens AU, the surface density of the disk is expected to have a jump. Such surface density structures are expected to be detected by future dust continuum observations of ALMA.

The radial extent of the dead zone is determined by the ion-electron recombination on the dust surfaces, and depends of the total surface area of the dust particles. As the dust particles grow, the dead zone shrinks radially. There is an accretion flow at the surface of the dead zone, and its accretion rate depends on the strength of the vertical magnetic fields. The jump in the surface density depends on the vertical magnetic fields. Because the vertical magnetic fields advect or diffuse with the gas, both the gas density profile and the vertical magnetic fields should be determined self-consistently.

In this study, as a first step, we consider the case where the plasma beta is constant with radius. The ionization degree of the gas is calculated for various values of the dust particle size and the gas accretion rate, and then the extent of the dead zone and the surface density structure of the disk are determined. The ionization degree and accretion rate are calculated using the approximated formulae of Okuzumi (2009, ApJ, 698, 1122) and Okuzumi & Hirose (2011, ApJ, 742, 65), respectively. For the accretion rate of 10^(-8) M_sun / yr, the dust size of 1 micron, and the vertical magnetic fields of 0.1 mG, the surface density jumps 3 times at 20AU, and for stronger magnetic fields, the jump becomes weaker. For larger dust particles, the dead zone shrinks. We also discuss the effect of advection and diffusion of the vertical magnetic fields on the surface density structure of the disks.

Keywords: planet formation, protoplanetary disks, magnetohydrodynamic turbulence