PPS21-P18 Room:Convention Hall Time:May 22 17:15-18:30

Planetary migration in accretion disks and formation of Earth-sized planets

YAMADA, Kou[1*], Satoshi Inaba[2]

[1]Center for Protoplanetary Science, Kobe University, [2]School of International Liberal Studies, Waseda University

Protoplanets form in a disk surrounding a young star. A low-mass protoplanet interacts with a gas disk gravitationally, which leads to a decrease in its semi-major axis. This is called the Type I migration of a planet. It is believed that the Type I migration is one of the most important physical processes in planetary formation. It is caused by the torques acting on a protoplanet by a disk. Recently, it was shown that a protoplanet is possibly trapped in a disk. Hasegawa & Pudritz(2011, MNRAS) comprehensively examined various mechanisms to halt the planet migration in a disk. They showed that a protoplanet might be trapped at the ice line, inside of which all the ice is evaporated and solid particles are composed of rocks and metals. The different opacity laws are used inside and outside of the ice line, resulting in a steep and shallow temperature distributions in the inner and outer regions, respectively. The large corotation torque acting on a protoplanet due to the steep temperature distribution suppresses the negative Lindblad torque in an inner region. On the other hand, the corotation torque on a protoplanet is too weak to cancel the negative Lindblad torque in an outer region. A protoplanet inside and outside of the ice line moves toward the ice line and is expected to accumulate at the ice line. However, it was shown that density waves can be altered by a thermal structure of a disk (e.g., Yamada & Inaba, 2011, MNRAS). It is not clear if protoplanets accumulate at the ice line even when we include dissipation processes in a disk. We make global two-dimensional hydrodynamic simulations and systematically examine the total torque acting on a protoplanet by an optically thick accretion disk, taking dissipation processes in a disk into account.

We study the type I migration of a protoplanet in disks with various opacities. We find that the total torque acting on a protoplanet by a disk strongly depends on opacity of the disk. We adopt a realistic opacity model and find that the sign of the total torque could change around the ice line of a disk. It is found that the total torque becomes zero in the region inside of the ice line if the timescale for the viscosity is nearly equivalent to the turnover time in the horseshoe orbit. This means that the accretion rate of the disk needs to be smaller than 2×10^{-8} solar mass/yr for the protoplanet to move outward in the optically thick accretion disk. Furthermore, using the N-body simulations, we investigate whether the accumulation of protoplanets around the ice line can accelerate further growth of protoplanets or not.

Keywords: planetary system, planetary migration, terrestrial planet, type I migration, density wave