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Impact of eccentricity damping on the migration of a giant planet

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Recently, the gravitational instability (GI) model has been revisited as the formation of giant planet and brown dwarf because of the detection of long-period giant planets with small eccentricity (e.g. Marois et al. 2010). With GI, giant planet is formed by the fragment of a gravitationally unstable disk which has a few to tens of Jupiter mass and large semi-major axis above 50AU. We have investigated the migration of a giant planet initially in wide orbit considering eccentricity damping and gravitational turbulence directly integrating the equation of motion numerically. Firstly, we have examined the effect of eccentricity damping. When there is a relative velocity between planet and surrounding disk gas, which means planet has the eccentric orbit, gravitational interaction which is known as “Dynamical Friction” arises between them. As a consequence, eccentricity damps to e = 0. We found that for planet with wide orbit, during eccentricity damping, we can assume the conservation of angular momentum, even if the torque is always exerted on the planet. In other words, semi-major axis and eccentricity almost decrease due to energy dissipation. If planets have large eccentricity, planet can migrate faster than Type I migration due to eccentricity damping. In addition, we have investigated the effect of gravitational turbulence. For the random forces due to disk turbulence, we used the semi-analytical formula developed by Laughlin et al.(2004) and modified by Ogihara et al.(2007) with slight modification. As a result, we found that gravitational turbulence cannot excite planet’s eccentricity to $e \gg H/r$. Therefore, it can be said that gravitational turbulence is not important to the migration of a giant planet.

Keywords: giant planet, migration, disk-planet interation