Global High-resolution N-body Simulation of Planet Formation: Planetesimal Driven Migration with Type-I Migration

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By means of fully self-consistent N-body simulations, we investigated whether outward Planetesimal Driven Migration (PDM) takes place or not when the self gravity of planetesimals is included. We performed N-body simulations of planetesimal disks with large width (0.7 - 4AU) which ranges over the ice line. The simulations consisted of two stages. The first stage simulations were carried out to see the runaway growth phase using the planetesimals of initially the same mass. The runaway growth took place both at the inner edge of the disk and at the region just outside the ice line. This result was utilized for the initial setup of the second stage simulations in which the runaway bodies just outside the ice line were replaced by the protoplanets with about the isolation mass. In the second stage simulations, the outward migration of the protoplanet was followed by the stopping of the migration due to the increase of the random velocity of the planetesimals. Due to this increase of random velocities, one of the PDM criteria derived in Minton and Levison (2014) was broken. In the current simulations, the effect of the gas disk is not considered. It is likely that the gas disk plays an important role in planetesimal driven migration. Hence, we also carried out N-body simulations of PDM including the gas drag and type-I migration. Type-I migration and gas drag are known as the effects that drag the planeteismals and protoplanets toward the central star. We showed that the random velocity of the planetesimals are subdued by the gas drag and enhances the outward migration. We found that in Minimum Mass Solar Nebula (MMSN), there were a period that outward PDM overcomes the type-I mirgation.

