Collisional Growth and Internal Density Evolution of Icy Dust Aggregate in Disk Formation Stage

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Planetesimals are building blocks of planets so it is important to investigate when and where planetesimals form in protoplanetary disks. However, there are some obstacles to form planetesimals from dust by collisional growth. One of the most serious barrier is the radial drift of macroscopic dust aggregates toward the central star due to the gas drag. On the other hand, it is suggested that highly porous dust aggregates break through the radial drift barrier. In the minimum mass solar nebula model, highly porous icy dust aggregates can grow to planetesimal-sized objects by direct collisional growth inside the disk (Okuzumi et al. 2012, Kataoka et al. 2013). However in these studies, it is not considered when the collisional growth begins in protoplanetary disks. If there is no process that suppresses collisional growth of icy dust aggregates, collisional growth may begin from the protoplanetary disk formation stage.
To investigate how the disk evolution in disk formation stage affects the collisional growth and internal density evolution of porous icy dust aggregates, we have calculated the evolution of radial size distribution of icy dust aggregates using the disk model including mass accretion from molecular cloud core developed by Nakamoto & Nakagawa (1994) and Hueso & Guillot (2005).
As a result, we find that icy aggregates cannot become highly porous as previous studies (Okuzumi et al. 2012, Kataoka et al. 2013), and they suffer the radial drift without growth to planetesimal-sized object. Because the small dust particles from molecular cloud core contribute the growth of aggregates in earlier phase of their growth, the aggregates cannot have many voids until they become large size that collisional compression works effectively. This result suggests that a process that suppresses collisional growth of icy dust aggregates in early stage of protoplanetary disks is present and the age of planetesimals would not be very young.

