Possibility of Planetesimal Formation in Disk Formation Stage

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Planets are formed from planetesimals, so it is important to reveal planetesimal formation processes to elucidate the origin of our solar system and extrasolar planetary systems. It is thought that planetesimals are formed from micrometer-sized grains called "dust", which are present in the protoplanetary disk. They collide each other, coagulate, and grow to form planetesimals. However, there are some obstacles in this process. One of the most serious obstacles is the "radial drift barrier": macroscopic aggregates experience the head wind from the disk gas, lose their angular momentum with respect to the central star, and drift toward the star.
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-size objects inside 10 AU (Okuzumi et al. 2012), though the model did not consider the evolution of the gas disk. It is necessary to take the gas disk evolution into account for the dust coagulation, because when the dust growth starts depends on physical conditions of the disk.
In this study, we consider that both the evolution of the gas disk and the growth of the dust aggregates take place simultaneously. We simulate the viscous evolution of the gas disk starting from the molecular cloud core collapse and simulate the size evolution of icy dust aggregates with their porosities. As a result, we found that when the initial angular velocity of the molecular cloud core is large and the viscosity of the gas disk is small, dust aggregates can grow to planetesimal-size objects via direct collisional growth. In those cases, a large amount of icy dust particles can be supplied outside the snowline before icy aggregates start to drift toward the central star. Our results also suggest that icy planetesimals may be formed within a few hundred thousand years after starting the molecular cloud core collapse.