Effects of dust size distribution on satellitesimal formation in circumplanetary disks

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Gas planets like Jupiter have an accretion gas disk called circumplanetary disk during its formation process. Although the Galilean satellites are thought to have been formed in this circumplanetary disk, the origin of satellitesimals has not been clarified. In this study, we focus on the possibility of forming satellitesimals from small dust particles in circumplanetary disks.

Shibaike et al. (2017) assumed steady planetary disks and calculated the growth and fall of icy dust particles supplied at a constant rate. As a result, in order for icy dust particles to grow into satellitesimals outside the snow line, the ratio of the dust inflow rate to the gas inflow rate is 1 or more and the strength of turbulence α is 10^{-4} ~ 10^{-2} must be satisfied. However, Shibaike et al. (2017) assumed that the size distribution at each distance from the central planet was sufficiently narrow for simplicity. For this reason, while pointing out the possibility of dust flowing into a wide range of circumplanetary disk and large and small dust particles coexisting, they did not calculate the effects of dust growth and temperature distribution of the circumplanetary disk.

In this study, we aim to obtain the condition for icy dust particles to overcome radial drift barrier by direct collisional growth, and to keep the temperature of the circumplanetary disk below the sublimation temperature of icy dust particles. We consider the spread of both the dust size distribution and the spatial distribution of dust inflow, and perform numerical calculation of dust collisional growth. Furthermore, using the calculation result of the dust size distribution, we recalculate the optical depth and the temperature distribution of the disk.

As a result, we find that it is necessary to satisfy the condition that the ratio of the dust inflow rate to the gas inflow rate is 1 or more and the strength of turbulence α is 10^{-4} or more in order to overcome radial drift. This is in good agreement with the result of Shibaike et al. (2017). On the other hand, when the gas inflow rate is large, the temperature of the disk recalculated also increased, and icy dust particles sublimates throughout the calculation range. This is the first time it became clear by calculating the dust size distribution in this study. From this result, the gas inflow rate should be less than 0.002 Jupiter mass per million years.

Our results suggest that icy satellitesimals formation may occur at the final stage of planet formation. It is a future task to clarify the overall image of satellite formation by further narrowing down the conditions for the formation of satellitesimals in circumplanetary disks and combining it with another approach such as capturing planetesimals.

