Density evolution of dust aggregates growing in protoplanetary disks

Toru Suyama[1], Koji Wada[1], and Hidekazu Tanaka[1]
[1]*Institute of Low Temperature Science, Hokkaido University, Sapporo 060-0819 Japan (storu@neko.lowtem.hokudai.ac.jp)*

In protoplanetary disks, planetesimals are thought to be formed through the gravitational instability [1] or simple coalescence [2]. If the gravitational instability occurs, it needs that dust aggregates becomes large aggregates (r~cm) that gas drag force is not efficient. Small dust aggregates have the fluffy structure. However, dust aggregates are compressed as they grow. Thus, large dust aggregates can not keep such fluffy structure. Such compression changes the cross section of dust aggregates and the gas drag force which governs the dust motion. Thus, when and how to compression is important on dust growth.

In this study, we perform the N-body simulation of aggregate collisions. In our simulation, using the aggregates obtained at previous collision, we repeat the calculation s of aggregate collision to examine the structure evolution during aggregate growth. For simplicity, we consider only head-on collisions of icy aggregates.

In our simulation, collisions between dust which have a variety of the mass and the density occur. We examined the density change at such collisions. As a result of numerical simulation, when the impact velocity is lower than a few m/s, the density hardly increases. On the other hand, when the impact velocity is higher than a few tens of m/s, the fragmentation occurs.

We introduce "the pressure" [3] and construct the model which explains our numerical simulations. In this model, the pressure does not depend on the mass and it depends on the density only. This model describes the density change at any collisions. However, it is on the basis of head-on collisions. We will perform the off-set collisions and examine the effect of such collisions.

References

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