Dust Growth in Protoplanetary Disks and Reexamination of the Particle Interaction Model

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In protoplanetary disks, fluffy dust aggregates are formed as a result of their collisional growth. Our recent numerical simulations of dust aggregate collisions have shown that dust aggregates are surprisingly sticky. For example, dust aggregates made of sub-micron icy monomer particles can stick to each other even at high-speed collisions with v ~ several tens m/sec. This sticky property of dust aggregates is very helpful for their growth and/or planetesimal formation in protoplanetary disks. However, collisional outcomes in the numerical simulations would be dependent on the particle interaction model used in the simulations.

In this study, we reexamine the previous particle interaction model to construct a better interaction model and a more accurate numerical simulation of dust aggregate collisions.

For the reexamination, we perform molecular dynamics simulations describing a collision between monomer particles. In these MD simulations, each spherical solid particle consists of a large number of molecules ($N \sim 10^5$-10^8). Our MD simulations show that collisions between monomer particles always cause stronger energy dissipation than the predictions by the previous interaction model. Using the results of a large number of MD simulation runs with various particle sizes and collision speeds, we construct a better particle interaction model, by including an additional energy dissipation term in it. The additional energy dissipation in the particle interaction model is expected to make the dust aggregates more sticky.

Next, by implementing the new particle interaction model to the simulation code, we perform numerical simulation of dust aggregate collisions to see how the additional energy dissipation enhances the stickiness of dust aggregates. All these results will be reported in detail in my presentation.