Numerical Simulation of Dust Aggregate Collisions: Current Understandings and Future Perspectives

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Numerical simulation of dust aggregate collisions is a powerful tool to investigate the dust growth process as well as experimental studies. We summarise our findings based on the numerical simulation and discuss future perspectives on a study of aggregate collisions.

In protoplanetary disks, dust aggregates consisting of submicron particles grow through their mutual collisions. In the early growth stage, dust aggregates collide with each other at extremely low velocities (< 1 mm/s) due to strong coupling with disk gas. Because of such low-velocity collisions, the growing dust aggregates are thought to have a fluffy structure similar to ballistic cluster-cluster aggregation (BCCA) clusters with a fractal dimension of $\lesssim 2$. Such BCCA-like aggregates would be compressed with increasing collision energy and may end up with disruption at high-velocity collisions. We have been performing direct N-body simulations of collisions between fluffy aggregates that consist of up to several tens of thousands of ice or SiO_2 particles with a radius of 0.1 μm.

As a result, we find that aggregates formed through collisions between BCCA clusters have a fractal dimension ~ 2.5, smaller than the limit value 3. Another surprising result is that fluffy ice aggregates are feasible to grow at collisions with velocities up to several tens of m/s without significant disruption. These results support a scenario that very fluffy planetesimals are formed through collisions of dust aggregates in protoplanetary disks.

Several points still remain inconsistent between numerical simulations and experimental studies, such as whether or not bouncing occurs at dust aggregate collisions. We will point out unsolved problems for aggregate collisions and show a direction of future studies.

Keywords: dust aggregate; planetesimal formation; N-body simulation