Numerical Simulation of Dust Aggregate Collisions: Compression and Disruption of 3D Aggregates

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We study collisions between dust aggregates to construct a model of their structural evolution in protoplanetary disks. We carry out three-dimensional simulations of aggregate collisions and examine their compression and disruption processes following our previous two-dimensional simulations [1]. We take clusters of ballistic cluster-cluster aggregation (BCCA) formed by a hit-and-stick process as initial structures and study their head-on collisions with the use of realistic binding forces. Our numerical results indicate that the energy criteria for compression and disruption of BCCA clusters are consistent with previous two-dimensional simulations [1,2]. For aggregate compression at a collision, we succeed in obtaining a scaling law that the gyration radius of the resultant aggregate is proportional to $E_{\rm imp}^{-0.10}$, where $E_{\rm imp}$ is the impact energy. The compressed aggregates have a fractal structure with $d_{\rm c} \simeq 2.5$, suggesting that 3D dust aggregates remain a relatively fluffy structure even if they are compressed to a maximum extent by collisions. Furthermore, we derive an "equation of state" of aggregates which reproduces the scaling law for compression. The equation of state is useful to describe the density evolution of dust aggregates during their growth.

Keywords: dust; planetesimal formation; aggregate; impact

References

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