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The compressive strength of cometary nuclei and their density evolution

Sin-iti Sirono [1], J. Mayo Greenberg [2]

[1] Earth and Planetary Sci., Hokkaido Univ, [2] Astrophysics Laboratory, Leiden Univ.

In order to clarify the outcomes of cometary collisions, the compressive strenth of a grain aggregate consisting the comet nuclei is calculated analytically. The strength has been calculated as 7.5*10^3 dyn cm^-2 at porosity of 0.8, and 1.8*10^3 dyn cm^-2 at porosity of 0.9. Based on the results, It has been found that the compaction proceeds only slightly at impact velocity of 10 cm s^-1. However, when impact velocity is on the order of 100 cm s^-1, significant compaction and deformation of the aggregates are expected.

One of the important physical processes influencing the evolution of the internal structure of comet nuclei is what occurs when they collide. The consequences of collision depends strongly on the nature of the material consisting the nuclei. Although it is widely believed that the basic units of the nuclei are porous grain aggregates consisting from interstellar dust tenth micron sized, there are only a few studies on collisions taking into account such micro-structure of the nuclei. Here we calculate the compressive strength of grain aggregates and discuss the consequence of the cometary collisions.

Since arrangement of grains in an aggregate depends on the history of the aggregate, we cannot determine the arrangement a priori. For calculational ease, we assume that an aggregate consists of distorted chains of identical spherical grains. Based on this assumption, we can calculate the compressive strength of the aggregate in terms of the strength of a chain, which is determined by the method by Kantor and Webman (1984; Phys. Rev. Lett. 52, 1891).

The compressive strength is calculated to be 7.5*10^3 dyn cm^-2 at porosity of 0.8, and 1.8*10^3 dyn cm^-2 at porosity of 0.9. On the other hand, the tensile strength of an aggregate can be calculated as 5.8*10^4 dyn cm^-2 and 2.6*10^4 dyn cm^-2 at porosities of 0.8 and 0.9, respectively. Therefore, the compressive strength is much weaker than the tensile strength, leading to the compaction of colliding nuclei without severe fragmentation. We can estimate the degree of

compaction from the ratio of initial kinetic energy of aggregates to the compressive strength. It has been found that the compaction proceeds only slightly at impact velocity of 10 cm s^-1. However, when impact velocity is on the order of 100 cm s^-1, significant compaction and deformation of the aggregates are expected.