Effect of “fibrous materials” on dust agglomeration

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The current model planetesimal-formation process is based on the collisional growth of tiny monomers whose typical size is (sub) micrometers. However, it is not very easy to form planetesimals only by simple mutual collisions of dust aggregates. Particularly, a highly porous structure should be kept during the collisional growth to prevent fragmentation. In this study, therefore, we consider the effect of the shape of monomers to efficiency form the porous disk aggregation. Specifically, we consider the effect of fibrous monomers.

When we look around us, we realize that dust on the floor and corners in the room can grow to a visible (macroscopic) size keeping a highly porous structure. By careful inspection of the formed dust, one can confirm that hair and fiber debris play a crucial role to sustain the porous structure.

Based on this simple observation, we consider similar phenomena might govern the planetesimal formation as well. If there were fibrous materials as monomers constructing dust aggregates, the entanglement of the fibrous materials would help the dust- aggregate growth also in space.

However, it is not very easy to mimic realistic planetesimal conditions in laboratory experiments. Thus, in this study, we focus on the effect of fibrous materials on the aggregate-growth process by performing a simple laboratory experiment under the atmospheric pressure condition. Specifically, we prepared a set of thin silk threads as starting materials. The length of the threads was varied from 1.6 cm to 15 cm. Then, the threads were sucked by a vacuum cleaner. By this simple procedure, we succeeded to form porous dust aggregates formed by fibers.

As a result, we found that there were two types of aggregate structures depending on the length of the threads. Furthermore, the mass of formed aggregates logarithmically grows as a function of the length of threads. By the image analysis of the formed aggregates, we revealed that the aggregates have a highly porous structure whose fractal dimension is less than 2.

By considering the elasticity of the fibers, we can qualitatively explain the logarithmic relation between aggregate mass and thread length. However, the experimental conditions are far from the actual planetesimal-formation conditions. Moreover, the flow produced by the vacuum cleaner was not controlled in this experiment. Measurement and/or control of the experimental conditions are necessary to discuss actual planetesimal formation. In this study, we only revealed that the fibrous materials indeed enhanced the growth of dust aggregates in the laboratory conditions.

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