

Development of an instrument for measuring cohesive force of extraterrestrial organic matter using impact accelerations

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In protoplanetary disks, dust grains are thought to grow to larger bodies through collisional sticking until they reach a size where gravity is effective, however, silicate dust is thought to be poorly sticky, and thus fragmentation, bouncing, and radial drift are thought to become obstacles to growth. However, interplanetary dust particles collected in the stratosphere have been found to be covered with organic matter (Flynn et al., 2013), and organic-mantled grains may be more sticky than bare silicate grains (Homma et al., 2019). On the other hand, a formose-type reaction is one of the synthetic reactions of meteorite and cometary organic matter (Cody et al., 2011; Furukawa et al., 2021), however, the sticking property of the synthetic organic matter is unknown. We therefore conceived cohesive force measurements of the synthetic organic matter at a low temperature and evacuation condition. The following techniques have been used to measure the cohesive forces of dust grains: the use of an atomic force microscope cantilever to directly measure the force required to pull contacting particles apart (Heim et al., 1999); the estimation of the interparticle force based on tensile strength measurements of particle aggregates (Steinpilz et al., 2019); and the use of centrifugal accelerations to directly measure the force required to pull particles away from a slide (centrifugal method: Nagaashi et al., 2018; 2021; Nagaashi & Nakamura, in press). However, for each method, the points that it is not easy to measure irregularly shaped particles and to obtain data sufficient for statistical discussion, that the relationship between tensile strength and cohesive force is not clear, and that it is not easy to control a measurement environment due to a long time required for measurements are problematic, respectively. Therefore, in order to realize a statistical cohesive force measurement that can easily control a measurement environment, we adopt a method using instantaneous impact acceleration (impact separation method: Otsuka et al., 1983), instead of centrifugal acceleration, although the principle is similar to the centrifugal method.

The measurement mechanism in this study is to measure the cohesive force of particles inside a mini-vacuum chamber based on the impact acceleration generated when the chamber is accelerated by a compression spring and then impacts with a plate. The acceleration is measured by an acceleration sensor attached to the chamber, and the magnitude of the acceleration is adjusted by changing the material of the plate and the compression length of the spring. The mechanism to measure the impact acceleration generated by the compression spring has been completed, and the magnitude of the acceleration is currently being adjusted. In the presentation, more detailed measurement mechanisms and concepts for mini-vacuum chambers and low-temperature measurements will be given.

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