遠心法を用いた隕石粉の付着力測定
Measurements of adhesive force of meteorite powders using centrifugal method

*長足 友哉[1]、中村 昭子[1]
*Yuuya Nagaashi[1], Akiko Nakamura[1]

1. 神戸大学
1. Kobe University

Introduction: Layer of fine particles in the laboratory shows fluffy structure owing to interparticle force (e.g., Kiuchi and Nakamura, 2014). On small bodies, interparticle forces are thought to be dominant compared to gravitational force for small particles. Fast rotators spin in excess of what gravity alone could hold together were shown to be explained by cohesive force between constituent particles (Sánchez & Scheeres, 2016). Measurements of cohesive force between micron-size spherical silica particles using an atomic force microscope cantilever (Heim et al., 1999) showed that the results agree with predictions of the JKR model (Johnson et al., 1971). On the other hand, measurements of cohesive force between 50 or 100 μm glass beads and a glass plate using centrifugal method showed that the results are by several orders of magnitude smaller than predictions of the JKR theory (Nagaashi et al., 2018). In addition, it was also shown that ~ 70 μm irregularly-shaped silica and alumina grains have the range of adhesive force similar to the glass beads, indicating that the adhesive force of the spherical and the irregular particles used in the measurement is dependent not on the macroscopic shape but on the microscopic surface roughness. However, it is not clear whether the adhesive force of the particles that actually form the asteroids is similar to those of silica grains. Measurements of adhesive force of meteorite powders will bring important knowledge of adhesive force of the asteroid-forming particles for understanding physical processes occurring on asteroids.

Experimental method: In this study, we used centrifugal method as in our previous study (Nagaashi et al., 2018) in order to measure cohesive or adhesive force between a particle and a plate. This method can directly measure the cohesive or adhesive force of many particles at the same time, which enables us to statistically analyze the results. Additionally, it can also deal with irregularly shaped particles. The measurements were conducted for carbonaceous chondrite (CV3: Allende, CM2: Murchison), ordinary chondrite (LL3.5: NWA 539, LL5: NWA 1794, LL6: NWA 542), and Eucrite (Millbillillie) powders of median diameter ~ 50 μm. We discretely increased the centrifugal acceleration from 10g to 5000g (g: the Earth's gravitational acceleration) and took optical microscope images of the same location of the plate before and after applying centrifugal force at each centrifugal acceleration. We determined the range of centrifugal acceleration within which the particle separated from the plate based on the microscope images and estimated the cohesive or adhesive force between the particle and the plate. More detail description of the procedure is described in Nagaashi et al. (2018).

Results: As compared with the JKR adhesion force $F_{ad} = 3\pi\gamma R$ (γ: surface energy, R: reduced radius of particle) for a spherical particle of silica composition, we calculated the effective surface energy of particles which reproduces the measurement value, and compared the results of each type of meteorite powders. Similar to the previous results described in the above (Nagaashi et al., 2018), the measurements of meteorite powders showed a wide range of adhesive force distributions over several orders of magnitude for all measured meteorite types. In addition, we found that the effective surface energy of

Allende and Murchison meteorite particles were several times smaller than those for the particles of the other meteorite types. There is no difference in the axial ratio of each type of meteorite powders, and therefore this is likely due to differences in material composition or micro-topography of the particles.