はやぶさ２レーザ高度計による小惑星周辺ダスト検出の試み
Detection of levitation dust around the asteroid by Hayabusa-2 LIDAR

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The micron-size particles are continuously produced at the surface of airless bodies like the Moon and asteroids by innumerable micro impacts and thermal stress related to large temperature difference between daytime and nighttime. Previous asteroid missions have revealed smooth appearance of topography on 951 Gaspra, 243 Ida, and 433 Eros suggesting that these asteroids are covered with particles smaller than resolution of camera images. Particularly, the exploration of Eros by NEAR Shoemaker has revealed as smooth surface as a liquid water at the base of craters whose diameter is between 20 and 300 m. This "pond" is consistent with stagnant dusts of diameter smaller than 50 microns. Based on this observation, dust levitation hypothesis was proposed. According to this hypothesis, a photoelectric effect of solar UV positively charges both dust and the surface. Then a balance between electric repulsion and gravity causes 0.5-microns dusts to oscillate vertically over the surface of Eros long period of time. When a dust has a horizontal velocity, it transfers laterally until it reaches to a shadow of topography where electrostatic field is weaker than surroundings. Thus topographic depression such as a crater becomes a sink of levitating dusts.

LIDAR is one of four remote-sensing instruments onboard Hayabusa-2, and is used to measure altitudes of the spacecraft from a surface of the asteroid, 1999 JU3, for not only secure navigation but also scientific investigation of a C-type asteroid. Hayabusa-2 LIDAR has been improved from that onboard Hayabusa which explored and returned samples from asteroid 25143 Itokawa. A new function called dust count mode is implemented to Hayabusa-2 LIDAR to observe spatial distribution of dust number density in 8 levels with resolution of 20 m in bore sight direction. LIDAR can hardly observe lateral distribution of dusts, but distinguish a weak reflection of thin dust cloud from that of the surface. To plan an operation of the dust count mode observation is difficult because the number density of asteroid dust is not known at all. Instead, we evaluate the lower bound of number density that is geologically important for morphology of asteroid surface. For a given number density of dusts and under an assumption that a characteristic time of levitation is the rotation period of 1999 JU3, the rate of embayment of craters is calculated. If this rate of embayment is greater than that of crater production, we need to take into account a modification process for the study of crater morphology and crater counts of 1999 JU3. This lower bound is calculated to be 10^6 m^{-3} for a cloud of dusts whose radius is larger than a few microns. Then we set this value as a target of the dust count mode observation.

A detectability of dust count mode is dependent on sensitivity of Hayabusa-2 LIDAR and an altitude of the spacecraft. We calculate a reflection from dusts using Mie scattering model assuming that a diameter of dust particle is constant and is larger than the wavelength of laser, that is, 1064 nm. A characteristic distance between dusts is also assumed to be sufficiently larger than the wavelength so that interaction between dust particles is negligible. Using a lidar equation, we calculate a peak power of backscattering light from a dust cloud for various sets of the distance, the number density, and the dust radius. The peak power of reflection is generally stronger than noise level of the detector. The reflection from dust cloud is so weak that the targeted number density of 10^6 m^{-3} is hardly higher than the detection limit. Even at the lowest altitude, the reflection from a dust cloud of 10-microns radius for 10^6-m^{-3} number density is equivalent to the detection limit. If the dust radius is 5 microns, number density more than 10^7 m^{-3} is necessary to be detected. Therefore we plan to start the dust count operation from the HP and attempt to conduct as much operations as possible at low altitude.