In-situ Dust Observation in future asteroidal mission.
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Introduction: Dust particles may exist on the surfaces of or around asteroids. Their existence would reflect the evolution of the surface environment of an asteroid, which is important when interpreting terrestrial observations of asteroids. However, the role of dust particles on small bodies are not critically studied due to limited chances of observations.

The NEAR-Shoemaker spacecraft reveals that the surface of Eros hold enormous amount of dust particles, which appear to fill a crater to form smooth dust ponds [1]. On the other hands, the high resolution images of Itokawa obtained by Hayabusa spacecraft indicate that dust particles are deficient on the surface of the asteroid. However, interestingly, the returned samples of Hayabusa are generally dust particles [2], which raise the question if dust particles actually exist around the asteroid as a cloud, but are optically not detectable because the cloud is extremely thin. If this is the case, small asteroids may typically hold numerous numbers of dust particles as results of evolutional histories of asteroids. However, even so, no terrestrial observations can critically determine the existence of dust due to the above reason.

We are, therefore, planning a direct observation of circumasteroid dust with using the Dust Monitor (DM) instrument, which may be useful even for a flyby mission to an asteroid. In Japan, Hayabusa-2 mission, a successor of Hayabusa mission, is planned to be launched in 2014, aiming at a C-type asteroid, 1999JU3. In this study, we discuss the scientific advantage and the feasibility of the in-situ dust observation considering Hayabusa-2 as a model mission.

Observation targets with dust monitor: Observing the circumasteroid dust with DM has three principal significances. They are explained in detail below.

Levitating dust. Surface of a resistive and airless body is positively charged on the dayside due to photoelectric effect to make an upward electric field. Since a dust grain on the surface is also positively charged, it would levitate from the surface if the electric field became strong enough. Such levitating dust grains around asteroids have not been directory observed so far. We are planning to observe them with DM and obtain their size- and velocity-distributions, which are required to reveal the surface evolution of asteroids.

Impact ejecta. An active impact experiment on the asteroid 1999JU3 is proposed in Hayabusa-2 mission (An impactor of 2 kg will be hit on 1999JU3 at 2 km/s). Detecting ejecta grains from such an impact experiment with DM is challenging but our preliminary study shows that the amount of ejecta is sufficient to be detected with DM and that we are able to obtain meaningful information about the interior and the surface of asteroids: the porosity and the grain size-distribution around the impact site.

Avoidance of debris collision. Hayabusa-2 mission plans to conduct an active impact experiment as described above. It is difficult to precisely predict the size and the ejection velocity of the ejecta. Hence, high risk “debris” as large as one can critically affect the spacecraft still can drift around the asteroid when the spacecraft is approaching the asteroid after the impact. Monitoring dust will be able to reduce such a risk.

Observation methods: For dust observation on and around the asteroid, we suggests direct method and indirect method as follows:

Direct method. There are detection methods for low speed grains (< 1m/s), for example, utilization of momentum transfer and electrostatic induction. Momentum sensor utilizes momentum transfer during collision between the grains and the detector. Time-of-flight (TOF) sensor utilizes electrostatic induction while a charged particle passes through an electrode. The grain size can be inferred from the charge signal assuming the charge state of the incident particle is proportion to the size. Those instruments can be onboard the orbiter of Hayabusa-2 or onboard the lander/rover.

Indirect method. The technique of the aerosol measurement by LIDAR (LIght Detection And Ranging) that must be equipped for ranging between the spacecraft and asteroids for its landing can be applied for observing the drifted dust grains around asteroids.

Summary: As described above, the asteroidal exploration needs dust monitoring device onboard. After the successful asteroidal mission Hayabusa, successive asteroidal missions are planned and studied. Dust monitors for circumasteroid dust should be seriously considered to be onboard upcoming asteroidal missions.

References: [1] Robinson, M. S. et al. Nature 413, 396, 2001. [2] Yano, H. et al. Abst. of 37th LPSC #1596, 2006.