PHOTOELECTRIC DUST LEVITATION ON EROS AND ITOKAWA. H. Senshu[1], M. Kobayashi[1], K. Wada[1], N. Namiki[1], N. Hirata[2], H. Miyamoto[2], and T. Matsui[1]. [1]Planetary Exploration Research Center, Chiba Institute of Technology (senshu@perc.it-chiba.ac.jp), [2]The University Museum, The University of Tokyo.

Introduction: Dust grains may exist on and around asteroids. Hayabusa mission revealed that sub-km-sized S-type asteroid Itokawa is covered with boulders and cobbles [1,2] but finer dust grains [2,3]. However dust grains smaller than 200 μm are found from sample catchers despite Hayabusa failed to fire projectiles for use in sample collection. The mechanism how dust grains had come into dust catchers is not decided yet [3,4], photoelectric dust levitation [5,6] is one of the most plausible mechanisms. Thus, in this study, we simulate vertical motion of dust grains launched from Itokawa by applying a theoretical model, proposed by Colwell et al. [6] for dust motion on Eros and Moon, to the case for Itokawa.

Numerical Model: An airless asteroid with resistive surface is charged up by a balance between photoelectric effect due to solar EUV and implantation of solar wind electrons, resulting an upward electric field above the surface. At the same time a dust grain above the surface is also charged up as a result of balance between photoelectric effect, implantation of solar wind electrons, and also implantation of photoelectric electrons from the surface of the asteroid. Thus the motion of a dust grain launched with a velocity can be solved as a result of balance between gravity and electric force.

It is to be noted that the charge of asteroidal surface is independent on solar distance since both power of solar EUV and solar wind decreases by inverse square of solar distance. On the other hand the strength of electric field above the surface is dependent on the solar distance since the density of electron above the surface is decided by only the photoelectric effect. The balance of gravity and electric force is highly dependent on the size of the grain since the former is body force while latter is surface force. Thus parameters affecting the motion of a grain above an asteroid are: solar distance, gravity of the asteroid, size of the grain, and initial velocity of the grain.

In this study, we solve the vertical motion of a dust with a wide variety of radius on Eros and Itokawa at perihelion, aphelion, and mean of them, respectively. Initial velocity of grains is not given straightforward. Thus in this study the initial velocity is varied as a free parameter. Initial velocity is to be directly analyzed by future missions (see Kobayashi et al., this conference).

Numerical Results: Fig. 1 shows the vertical motion of dust with a radius from 0.1 to 1.0 μm launched from the surface of Eros with a velocity from 0.5 to 3 m/s (same as the situation of [6]). In this case a dust grain with a radius of 0.5 μm levitates at an altitude as high as 600 m when the launch velocity is lower than 3 m/s. This is because the electric repulsion from the surface, which works effectively only near the surface, pushes up the dust again. On the other hand, when the launch velocity is 3 m/s, 5 μm-sized grain achieves 1200 m altitude but finally plunges into the surface. This is because the dust comes down so fast that the electric repulsion cannot push it back.

When 1.0 μm-sized dust is launched from the surface of Eros, the dust follows a nearly parabolic flight path. This means that electric force does not work effectively in this case.

When a dust grain is as small as 0.1 μm, the fate of the grain is divided into two extreme cases. One is immediate falling down to the surface and another is escaping from the gravity. When the grain remains lower than about 4 m, the implantation of photoelectric electrons from the surface charges up the dust negatively, resulting a strong drag force from the surface which is positively charged. On the other hand, if the dust overreaches the height successfully, the dust is charged up positively by photoelectric effect due to solar EUV. A strong repulsion force from the surface accelerates the dust grain to the escape velocity.

Fig. 2 shows numerical results similar to Fig. 1 but for the case of Itokawa. In this case, because of small gravity of Itokawa, electric force effectively affects the motion of a dust grain. For example, 8 μm-sized dust grain escapes from the gravity with a help of electric repulsion from the surface when the launch velocity is higher than 6 cm/s, otherwise immediately plunges into the surface. Such a result is corresponding to the 0.1 μm-sized dust case for Eros. A 12 μm sized dust seems following a nearly parabolic flight path but the path shape changes with solar distance, suggesting the electric force is still effective.

When a 10 μm-sized dust is launched from Itokawa's surface, its achieved altitude is higher than the case with dust size of both 8 and 12 μm, which is corresponding to the 0.5 μm-sized dust case for Eros. If the dust is launched with a velocity of about 5 cm/s at aphelion (solar distance is 1.70 AU), it levitates for a long time. However such a libration solution is achieved only under a fine-tuned parameter set.

Discussion and Conclusion: In this study we numerically simulate the vertical motion of dust grains. According to our results, dust would not levitate for a long time above Itokawa, unlike Eros. However, 10 μm is still the size of dust which achieves higher altitude than both larger and smaller grains. This model might be validated if the size distribution of small grains is analyzed in the near future.

References: [1] Saito, J. et al. (2006) Science, 312, 1341. [2] Noguchi, T. et al. (2010) Icarus, 206, 319. [3] Miyamoto, H. et al. (2007) Science, 316, 1011. [4] Yano, H. et al. (2006) Science, 312, 1350. [5] Lee, P. (1996), Icarus, 124, 181. [6] Colwell, J. E. et al. (2005) Icarus, 175, 159.

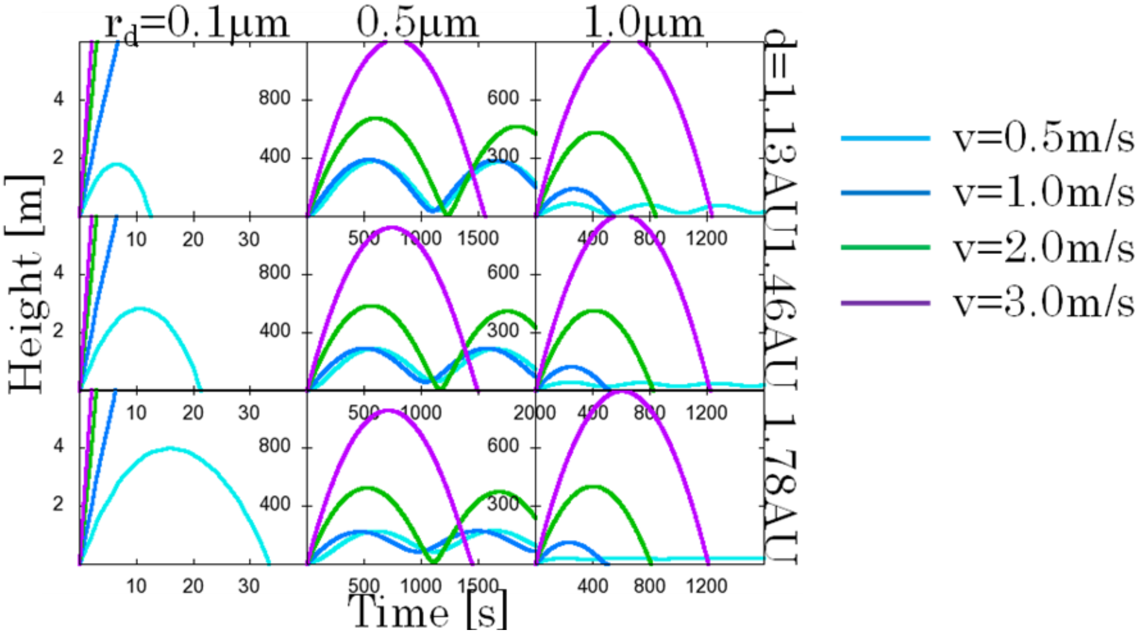

Fig. 1: Vertical motion of dust launched from surface of Eros.

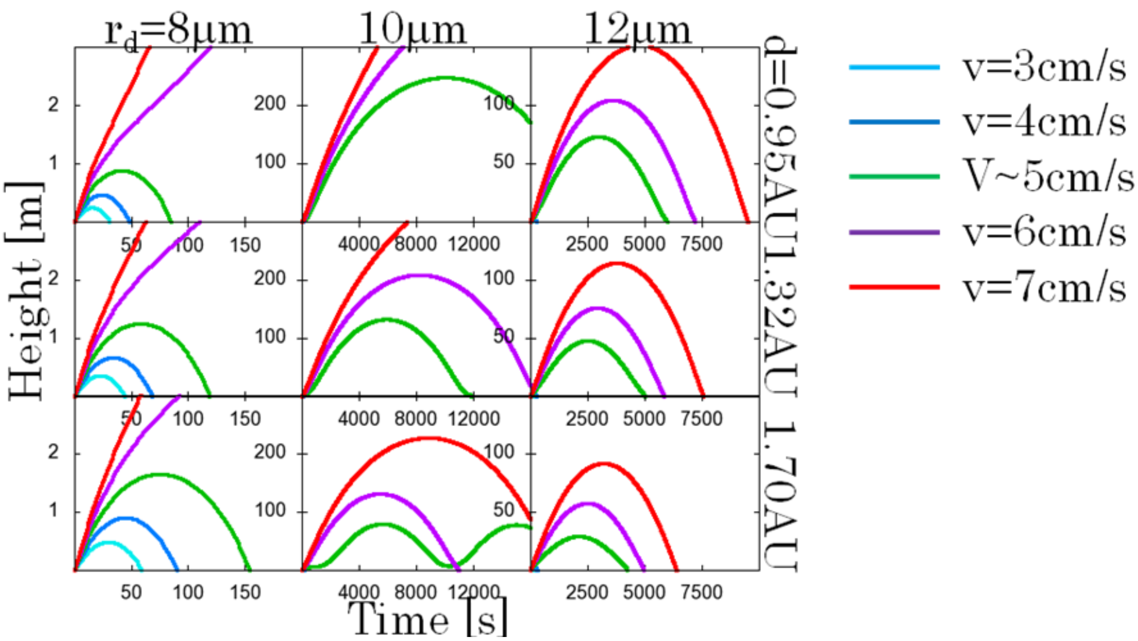

Fig. 2: Vertical motion of dust launched from surface of Itokawa.