**Detectability of levitation dust around the asteroid by Hayabusa-2 LIDAR.** S. Oshigami[1], H. Senshu[2], R. Yamada[1], N. Namiki[1], T. Mizuno[3], and Hayabusa-2 LIDAR science team, [1]RISE Project Office, National Astronomical Observatory of Japan, [2]Planetary Exploration Research Center, Chiba Institute of Technology, [3]Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency.

**Introduction:** 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. The exploration of 433 Eros by NEAR Shoemaker has revealed smooth surface with stagnant dusts of diameter smaller than 50 microns at the base of craters whose diameter is between 20 and 300 m [1]. According to dust levitation hypothesis proposed based on this observation, a photoelectric effect of solar UV positively charges both dust and the surface [2]. Then a balance between electric repulsion and gravity possibly causes dusts to oscillate vertically over the surface of an asteroid for a long period of time. Since a dust transfers laterally until it reaches to a shadow area where electrostatic field is weaker than surroundings when it has a horizontal velocity, 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 [3, 4]. A function called dust count mode is implemented to LIDAR to observe spatial distribution of dust number density in multiple levels with resolution of 20 m in bore sight direction [5]. LIDAR can hardly observe lateral distribution of dusts, but distinguish a weak reflection of thin dust cloud from that of the surface.

**Target number density of dusts:** 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 evaluated the lower bound of dust number density that is geologically important for morphology of asteroid surface.

Under an assumption that a characteristic time of levitation is the rotation period of $1999JU_3$ (7.6 hours [e.g., 6]), crater disappearance rate is calculated [7, 8, 9, 10]. Since Itokawa comparable in size to $1999JU_3$ is deficient in the craters with <10 m in diameter [11], we focused on craters of about 1 to 10 m diameter. If the crater disappearance rate, *Dc* is greater than crater production rate, *Pc*, we need to take into account a modification process for the study of crater morphology and crater counts of $1999JU_3$. The lower bound, that is dust number density at *Pc*=*Dc* is calculated to be $10^6$ $m^{-3}$ for a cloud of dusts whose radius is 1 micron.

**Detectability of the dust count mode:** We calculated a reflection from dusts using Mie scattering model assuming that a diameter of dust is larger than the wavelength of laser, that is, 1064 nm. A characteristic distance between dusts is assumed to be sufficiently larger than the wavelength so that interaction between dust particles is negligible. We also assume that dust clouds float close to the surface (a few 10s meters high) and their thickness is negligible. Using a lidar equation (eq. (1)) [12, 13], we estimated a return peak power, $P_r$, of backscattering light from a dust cloud for various sets of the distance, the dust number density, $N$, and the dust size distribution, $N(a)$ (Tables 1, 2).

$$P_r = P_o T_t T_r \frac{c\Delta t}{2} \frac{\pi D_r^2}{4h^2} \frac{\beta}{4\pi} \quad (1)$$

$$V_r = P_r \times R_{pd} \quad (2)$$

$$\beta = \int_{a_1}^{a_2} S_b(a) \frac{dN(a)}{da} da \quad (3)$$

$$S_b = \frac{\pi}{\kappa^2} \left| \sum_{n=1}^{\infty} (-1)^n (2n+1)(A_n - B_n) \right|^2 \quad (4)$$

**Table 1**. Parameter values relevant to dust count prediction.

| Symbol | Parameter | Unit | Value |
|---|---|---|---|
| $P_r$ | Return power | W | eq. (1) |
| $V_r$ | Output voltage of detector | V | eq. (2) |
| $c$ | Velocity of light in vacuum | m/s | 3.0e+8 |
| $\Delta t$ | Laser pulse width | s | 1e-8 |
| $\kappa$ | Wave number of laser pulse | - | 5.91e+6 |
| $P_o$ | Laser output peak power | W | 1e+6 |
| $h$ | Range | m | 1e+3, 5e+3, 20e+3 |
| $T_t$ | Optical efficiency of laser transmitter | - | 0.894 |
| $T_r$ | Optical efficiency of receiver | - | 0.678 |
| $D_r$ | Effective radius of telescope | m | 0.11 |
| $R_{pd}$ | Detector responsivity | V/W | 5e+5 |

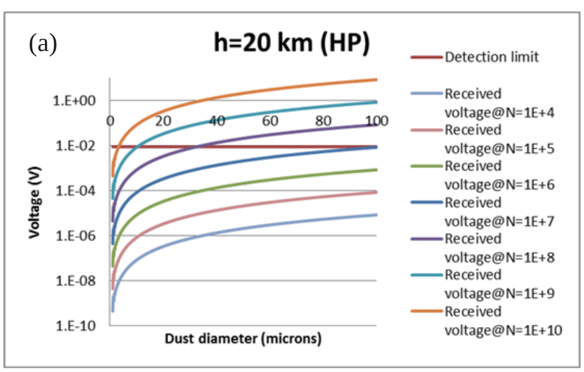
**Table 2**. Assumed values of physical characters for dust particles.

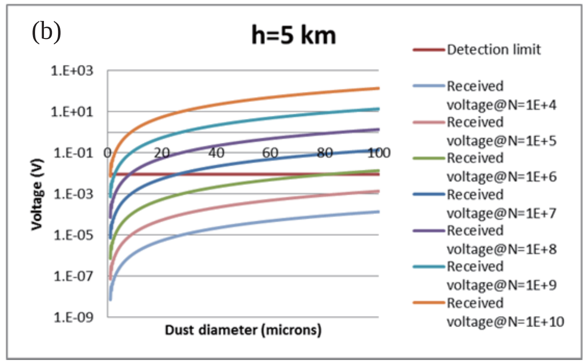
| Symbol | Physical character | Unit | Value |
|---|---|---|---|
| $a$ | Dust radius | m | 5e-7 – 5e-5 |
| $N$ | Dust number density | $m^{-3}$ | 1e+4 – 1e+10 |
| $\beta$ | Volume backscatter coefficient | $m^{-1}$ | eq. (3) |
| $S_b$ | Mie backscatter cross-section | $m^2$ | eq. (4) |

Mie scattering coefficients ($A_n$, $B_n$ in eq. 3) depend on a complex dielectric constant. We assumed that the complex dielectric constant of dust particles are same as typical value of soot or dirty silicate cosmic dust analogs in visual, that is, 2.40+2.38i [14].

**Results and discussion:** We show the expected peak output voltages of detector resulted from receiving reflection from dust clouds with homogeneous size distribution in Figure 1. The reflection from dust clouds is so weak that the dust clouds having the targeted number density ($10^6$ $m^{-3}$) are hardly detectable when the spacecraft elevation is 20 km (home position) as shown in Figure 1a. Even at the lowest altitude (1 km), the reflection from a dust cloud of 20-microns radius for $10^6$-$m^{-3}$ number density is equivalent to the detection limit (about 9 mV) (Figure 1c). If the dusts range from 1 to 100 microns in diameter, number density more than $10^9$ $m^{-3}$ is necessary to be detected at home position while $10^6$ $m^{-3}$ at low altitude. Therefore we plan to start the dust count operation from the home position and attempt to conduct as much operations as possible at low altitude.

Some parameter values shown in Table 2 such as pulse width ($\Delta t$) and output peak power ($P_o$) are designed values. Therefore we plan to revise these parameter values based on the data analyses of performance evaluation tests of the LIDAR preflight model in the near future.



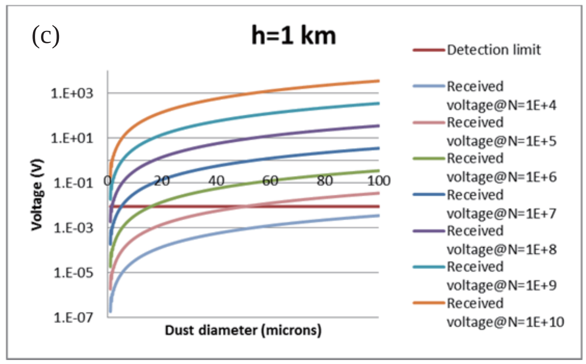




**Figure 1**. Expected peak output voltage of detector versus dust diameter when the flight altitude is (a) 20 km (home position), (b) 5 km, and (c) 1 km. Detection limit (about 9 mV) of the detector is also shown.

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