Observation of 1064 nm normal albedo around equator of the Ryugu using the Hayabusa2 LIDAR

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In June 2018, the Japanese asteroid explore Hayabusa2 has arrived to C-type asteroid 162173 Ryugu after three and half years journey. The Hayabusa2 has the laser altimeter (light detection and ranging: LIDAR) for navigation of the spacecraft and scientific uses. The main purpose of the LIDAR is to measure the distance between the spacecraft and the asteroid using time delay between the transmission and reception of the laser. In addition, the Hayabusa2 LIDAR has the function of measuring the intensities of a transmitted laser pulse and received laser pulse reflected from the asteroid surface. In this study, we have derived the normal albedo of the Ryugu at the laser wavelength of 1064 nm using the intensity data. The observation of normal albedo using the LIDAR has never been performed on C-type asteroid. Our observation will provide first knowledge of normal albedo variation at 1064 nm on C-type asteroid.

Usually, the Hayabusa2 spacecraft stands at home position (altitude of 20 km) and the intensity and ranging data are obtained with 1/32 Hz. As special operation, the spacecraft moves to latitudinal and longitudinal direction or descend to low altitude. Then, the LIDAR data are sampled at 1Hz. For analysis of normal albedo, we have selected the data obtained in altitude lower than 7 km. The size of the footprint become smaller with descent of the spacecraft, and mapping resolution is higher. Then, less size of footprint is effective to reduce effect of the surface terrain on the LIDAR return pulse. We have applied the data obtained at July 20, August 1, 6, 7, September 11, 20, 21, October 2, 3, 4, 15, 24, 31 and November 1, 2018 for normal albedo analysis. In these days, the spacecraft has been operated at low altitude, for example, rehearsal of touchdown for sample sampling has been performed in October 15 and 24. From the selected data, we have derived the normal albedo around equator of the Ryugu in range of about 10 degrees in latitude. The total data number is 37,5151.

For calculation of normal albedo, we applied some reflectance models; they are the Lambert, the Lommel-Seeliger and the Oren-Nayar models. The intensity of the reflected pulse calculated by the Oren-Nayar model depends on the applied value of roughness () in degree. We have applied 9 Oren-Nayar model changing the roughness from 10 to 90 degrees with interval of 10 degrees. On a footprint, 11 types of normal albedo have calculated for 11 reflectance models, respectively.

Firstly, we have found that the derived values of the 1064 nm normal albedo are different for each model. The lowest albedo is derived for the Lommel-Seeliger model, and the highest albedo is derived for the

Oren-Nayar model with roughness of 90 degrees. Secondary, it has been found that values of normal albedo depend on the incident angle of the laser pulse for some reflectance models. Especially, the normal albedo using the Lambert model are evidently higher with increase in incident angle at many areas around the equator. This is impossible phenomena for real material as rocks, and this means the Lambert model is inappropriate to represent reflectance of a lot of areas on the Ryugu. Therefore, we have investigated relation between the normal albedo and incident angle in each grid with resolution of 5 5 degrees. In the investigation, slope of normal albedo for incident angle were derived for 11 reflectance models in each grid, and the model which have the smallest slope would be appropriate in the area. From the results, we found that the Lommel-Seeliger model is dominant around equator of the Ryugu. When we apply the Lommel-Seeliger model, the average of normal albedo in the equator area is 0.042, and the deviation is 9.0 %. It corresponds to typical albedo of C-type asteroid (0.03-0.06) observed by ground telescope. In this presentation, we will also discuss regionality of the normal albedo on Ryugu and relation with surface terrain.

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