Multi-band image analysis of Itokawa and optical properties analysis of Hayabusa2/ONC-T

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Hayabusa2 is planned to bring samples from Ryugu back to the earth. Choosing sampling sites on Ryugu is very important. Sampling fresh materials not affected by space weathering very much is important for obtaining information on early evolution of the Solar System, because space weathering may overwrite record from the long past. In order to understand where on small asteroid we can find fresh materials, we analyzed the data taken by AMICA/Hayabusa. In addition, we analyzed optical characteristic, especially the point spread function (PSF), of the multi-band visible camera (ONC-T) of Hayabusa2 in order to carry out the same spectral analysis of space weathering.

Specifically, we analyzed the following two things.

1. Based on the data taken by Hayabusa, we estimated space weathering on the surface of Itokawa and searched for geometric parameters (HAY-A-AMICA-3-AMICAGEOM-V1.0) that exhibit good correlation with space weathering.

2. In preparation of such data analysis using Hayabusa2 data, we investigated PSF characteristics of Hayabusa2/ONC-T.

First, we conducted image correction for Hayabusa images. We calculated the ratio of light intensity of p-band (860nm) image to b-band (430nm) image (P/B). The ratio represents the degree of space weathering because space weathering caused reddening. We investigated the correlation between the ratio and slope and between the ratio and gravity in order to find out physical characteristics of places unaffected by space weathering.

This analysis was carried out on Sagamihara and MUSES-C. Sagamihara and MUSES-C are smooth areas covered by regolith where safe sampling is possible. We found that the P/B of Sagamihara is larger than that of MUSES -C. That is, MUSES -C is fresher than Sagamihara, although the topographic slope of both areas is small. Furthermore, the surface gravity on Sagamihara is larger than that on MUSES-C. Then, we measured P/B ratio along four lines in both Sagamihara and MUSES-C. For each line, correlation coefficient between ratio P/B and slope and between ratio P/B and gravity was calculated. We found the calculation results indicate that correlation coefficient between P/B and topographic slope is low (~ -0.40) and that between ratio P/B and gravity is high (~0.85). This means that the distribution of space weathering correlates more strongly with gravity than topographic slope. This result suggests that areas with weaker surface gravity would retain regolith particles for longer period of time on Itokawa. Thus, in exploration of small bodies, we should carry out sampling where gravity is weak in order to sample fresh substance relatively unaffected by space weathering.

Second, we analyzed the PSF of Hayabusa2/ONC-T. In our analysis, we approximated PSF as summation of Gaussian functions following Ishiguro (2014). We derived PSF by calculating coefficients of Gaussian function. We made unblurred images by applying edge detection to images for calibration. We reproduced the blurred images by convolving estimated unblurred images with PSF. This procedure was repeated with changing coefficients one by one. We obtained optimum coefficients to make residuals smallest.

First, we calculated PSF correction coefficients of Hayabusa and tried to reproduce the PSF calculated by previous work (Ishiguro 2014). Results indicate that the error between our PSF and the PSF by Ishiguro 2014 was 9.8%. Although this difference in coefficients is not very small, both coefficient sets can remove PSF-derived halos around the asteroid disk very well. The intensity of halo residuals turned out to be only 0.2 - 0.8% of the intensity of the light sources. Then we calculated the PSF correction coefficients of ONC-T/Hayabusa2 by the same procedure. Finally, we correct images taken by Hayabusa2 by using the PSF we calculated. The residuals were less than 1% in all bands, indicating that the same-quality of image analysis as Hayabusa will be possible for Hayabusa2.

