

Implications of High Polarization Degree for the Surface State of Ryugu

*Daisuke Kuroda¹, Jooyeon Geem², Hiroshi Akitaya³, Sunho Jin², Jun Takahashi⁴, Koki Takahashi⁵, Hiroyuki Naito⁶, Kana Makino⁷, Tomohiko Sekiguchi⁵, Yoonsoo P. Bach², Jinglyk Seo², Shuji Sato⁸, Hiroshi Sasago⁹, Koji S. Kawabata³, Aoi Kawakami⁴, Miyako Tozuka⁴, Makoto Watanabe¹⁰, Seiko Takagi¹¹, Kiyoshi Kuramoto¹¹, Makoto Yoshikawa¹², Sunao Hasegawa¹², Masateru Ishiguro²

1. Kyoto University, 2. Seoul National University, 3. Hiroshima University, 4. University of Hyogo, 5. Hokkaido University of Education, 6. Nayoro Observatory, 7. Nayoro City University, 8. Nagoya University, 9. Sasago Co.,Ltd., 10. Okayama University of Science, 11. Hokkaido University, 12. Japan Aerospace Exploration Agency

We present the linear polarization measurements of the near-Earth asteroid (162173) Ryugu [1]. The asteroid exploration project "Hayabusa2" has been investigated in detail by the in-situ observations of Ryugu and successfully returned samples from Ryugu in December 2020. However, polarimetry had not been conducted so far.

The polarization degree of asteroids varies with phase angle (Sun-target-observer's angle), and near-Earth asteroids are observable up to the region of their maximum. This study performed polarimetric observations of Ryugu with four ground-based telescopes from September 27 to December 25, 2020, covering a wide-phase angle from 28° to 104°.

We acquired polarimetric data for a total of 24 nights (23 nights in R-band and one night in V-band). The polarization degree of Ryugu reached 53% around the phase angle of 100°, the highest value among all asteroids and comets reported in the previous studies. The polarimetric phase curve of Ryugu is similar to that of (152679) 1998 KU₂ [2]. It is slightly different from (101955) Bennu [3], which is the target of the OSIRIS-REx mission.

This high degree of polarization occurs on the surface layer and is attributed to the scattering properties of the surface material. Scattered light from a low albedo object is qualitatively consistent with a high degree of polarization because the contribution of multiple-scattering light, which reduces the polarization degree, is small [4]. The low light scattering frequency implies that the grain size of the surface layer is large. By analogy with the polarimetric measurements on the pulverized meteorite samples [5, 6], we can infer that there are submillimeter-sized grains on the surface layer of the very low albedo Ryugu [7, 8]. This grain size may also reflect a larger aggregate component, e.g., the cauliflower-like structures on the rock appearances observed by MASCOT [9].

The sample recovered by Hayabusa2 seems to have a very brittle structure. Our polarimetric data will also contribute to reconstructing the surface structure of Ryugu, which has already been lost in the recovered samples.

[1] Kuroda et al., ApJL, submitted; [2] Kuroda et al., 2018, A&A, 611, A31; [3] Cellino et al., 2018, MNRAS, 481, L49; [4] Bohren and Huffman, 1998, Absorption and Scattering of Light by Small Particles, Wiley; [5] Worms et al., 2000, Planet. Space Sci., 48, 493; [6] Hadamcik et al., 2011, JQSRT, 112, 1881; [7] Sugita et al., 2019, Science, 364, 252; [8] Tatsumi et al., 2020, A&A, 639, A83; [9] Jaumann et al., 2019, Science, 365, 817

Keywords: asteroid, polarimetry