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[구 SS-12] Near-Infrared Photopolarimetry of Large Main Belt Asteroid - (4) Vesta

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The polarization degree as a function of phase angle (the Sun-target-observer's angle), so-called the polarimetric phase curves (PPC), have provided priceless information on asteroids' albedos since B. Lyot (1929). Succeeding experimental works in 1970s have confirmed the Umow law: There is a universal and strong correlation between the albedo and the PPC slope (slope of the tangential line at the zero of the PPC at phase angle ~ 20 degrees). Experiments in 1990s (ref [1]), on the other hand, have demonstrated that the negative branch of PPC is dependent on the size parameter (X ~ π * particle-size / wavelength), especially when X <~ 5. The change in particle size changed the minimum polarization degree, location of the minimum, and the width of the negative branch (called the inversion angle).

From polarimetry[2] and spectroscopy[3], large asteroids are expected to be covered with fine (<~ 10 μm size) particles due to the gravity. The size parameters are X ~ 30 at the optical wavelength (λ ~ 0.5 μm) and X ~ 10 in near-infrared (J, H, Ks bands; λ ~ 1.2-2.2 μm), if the representative particle size of 5 μm is considered. Accordingly, the near-infrared polarimetry has a great potential to validate the idea in ref[1].

We conducted near-infrared photopolarimetry of the large asteroid (4) Vesta using the Nishiharima Infrared Camera (NIC) at Nishi-Harima Astronomical Observatory (NHAO). NIC allows simultaneous polarimetric measurements in J, H, and Ks bands, and thus the change of PPC is obtained for three different size parameters. As a result, we found a signature of the change in the negative branch in the PPC of asteroid (4) Vesta. We will introduce our observation and the results and give an interpretation of the regolith on Vesta.

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[구 SS-13] Polarimetry of (162173) Ryugu at the Bohyunsan Optical Astronomy Observatory using the 1.8-m Telescope with TRIPOL

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The Hayabusa 2 mission target asteroid (162173) Ryugu is a near-Earth, carbonaceous (C-type) asteroid. Before the arrival, this asteroid is expected to be covered with mm- to cm- sized grains through the thermal infrared observations [1]. These grains are widely understood to be formed by past impacts with other celestial bodies and fractures induced by thermal fatigue [2]. However, the close-up images by the MASCOT lander showed lumpy boulders but no abundant fine grains [3]. Morota et al. suggested that there would be submillimeter particles on the top of these boulders but not resolved by Hayabusa 2's onboard instruments [4].

Hence, we conducted polarimetry of Ryugu to investigate microscopic grain sizes on its surface. Polarimetry is a powerful tool to estimate physical properties such as albedo and grain size. Especially, it is known that the maximum polarization degree (Pmax) and the geometric albedo (pV) show an empirical relationship depending on surface grain sizes [5]. We observed Ryugu from UT 2020 November 30 to December 10 at large phase angles (ranging from 78.5 to 89.7 degrees) to derive Pmax. We modified TRIPOL (Triple Range Imager and POLarimeter, [6]) to attach to the 1.8-m telescope at the Bohyunsan Optical Astronomy Observatory (BOAO). With this instrument, we observed the asteroid and determined linear polarization degrees at the Rc-band filter. We obtained sufficient data sets from 7 nights at this observatory to determine the Pmax value, and collaborated with other observatories in Japan (i.e., Hokkaido University, Higashi-Hiroshima, and Nishi-Harima) to acquire linear polarization degrees of the asteroid from

total 24 nights observations with large phase angle coverage (From 28 to 104 degrees). The observational results have been published in Kuroda et al. (2021) [7]. We thus found the dominance of submillimeter particles on the surface of Ryugu from the comparison with other meteorite samples from the campaign observation.

In this presentation, we report our activity to modify the TRIPOL for the 1.8-m telescope and the polarimetric performance. We also examine the rotational variability of the polarization degree using the TRIPOL data.

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[구 SS-14] Study of Hydrated Asteroids via Polarimetry: Correlation between Polarimetric Properties and the Degree of Aqueous Alteration of Hydrated asteroids (편광을 통한 수화한 소행성 연구)

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Hydrated asteroids get widespread attention for the evolution of water in the Solar System, especially thanks to the recent successes of the Hayabusa2 and OSIRIS-REx space missions. The target asteroids of these missions are believed to be fragments that have experienced aqueous alteration in their parent bodies [3]. Although hydrated asteroids have been studied well via spectroscopy, focusing on the 0.7 um or the 2.7 um absorption bands [2, 3, 4], polarimetric properties of these asteroids have rarely been investigated.

In this study, we conducted a polarimetric observation of 18 C-complex main-belt asteroids with the 1.6-m Pirka telescope at the Nayoro Observatory of Hokkaido University, Japan. We used a polarimetric imaging mode of the Multi-Spectral Imager (MSI) with the standard Rc-band filter (the central wavelength at 0.64 um) [5]. As a result, we found that all of these hydrated asteroids indicate deep negative branches of their polarimetric profiles. Accordingly, the hydrated asteroids have the polarization minima (Pmin), whose values are significantly lower than any other taxonomic types of asteroids (including C-group asteroids). Because Pmin depends on albedo, particle size, and porosity of the surface materials [1], we suspect that hydrated asteroids are distinctive from other asteroids in terms of these physical properties. In this presentation, we introduce our polarimetric observation and findings. We discuss why hydrated asteroids indicate such low Pmin values, comparing Pmin with spectral features at 0.7 um and 2.7 um based on the observation results.

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[구 SS-15] Isotopic Compositions of Ruthenium Predicted from Stellar Evolution Using the NuGrid Project

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Presolar silicon carbide (SiC) grains form around in the envelopes of asymptotic giant branch (AGB) stars by satisfying C/O>1 which is an optimal condition for SiC grains to condense in the stellar outflows. Ruthenium (Ru) isotopes are locked into the SiC grains during the condensation of SiC grains. We investigate the isotopic compositions of Ru in the stellar winds by using the NuGrid data, which are obtained by nucleosynthesis calculations during the stellar evolution. We compare the isotopic compositions of Ru obtained from the NuGrid data with measurements and the predictions obtained from different codes. Our results present a piece of evidence that SiC grains in the presolar system came from low-mass and low-metallicity AGB stars, also confirming that they were not from massive stars. We also suggest a new scenario in which the total stellar yields are also considered because SiC grains can condense during the collapse of molecular clouds.