JeongAhn[1], Hongu Yang[1], Seul-Min Baek[1], Hee-Jae Lee[1], Masateru Ishiguro[3]
[1]*Korea Astronomy and Space Science Institute*
[2]*University of Science and Technology*
[3]*Department of Physics and Astronomy, Seoul National University*

99942 Apophis is an Sq-type Aten group Near-Earth Asteroid (NEA) with an estimated size of 370 m. It will approach the Earth to come within the geostationary orbit during the upcoming encounter on April 13, 2029 to offer a unique chance to study its 1) global properties, 2) surface arrangements, and 3) their detectable changes expected to happen, in sub-meter scale. What measurable scientific goals for the asteroid in this "once a millennium" event could transform our knowledge of planetary science and defense?

The Apophis rendezvous mission aims to understand the characteristics of the small solar system body's nature. It also prepares for potential threats from natural objects by measuring in-situ surface, shape, rotation, and orbit changes expected to occur when the target asteroid passes close to the Earth in 2029. We will present an overview of the mission scheduled to be launched from late 2026 to early 2027 and introduce scientific objectives.

[구 SS-10] Apophis Rendezvous Mission: II. Payloads and Operation Scenario

Minsup Jeong[1], Young-Jun Choi[1,2], Hong-Kyu Moon[1], Myung-Jin Kim[1], Jin Choi[1], Bongkon Moon[1], Youngmin JeongAhn[1], Hee-Jae Lee[1], Seul-Min Baek[1], Hongu Yang[1], Masateru Ishiguro[3]
[1]*Korea Astronomy and Space Science Institute,* [2]*University of Science and Technology,* [3]*Seoul National University*

We plan to visit the Apophis, a Potentially Hazardous Asteroid (PHA). Apophis will have an extremely close encounter with the Earth on April, 2029. At the closest position, Apophis approaches 0.1 lunar distances from the Earth. The science goals are 1) mapping the surface of the asteroid before and after the encounter, 2) measuring surface roughness before and after the encounter, and 3) measuring interplanetary space environments such as magnetic field and dust particles. For the science goal, we are planning to employ five instruments for this mission, which are Polarimetric Asteroid Camera (PolACam), Asteroid Terrain Mapping Camera (MapCam), Laser Altimeter, Dust Particle Detector (DPDetector), Magnetometer (Mag). In this presentation, we plan to give a talk on the instruments.한기로 나누어 보면, 흑점의 관측 빈도는 두 기간에서 비슷하지만, 오로라는 냉한기에 집중적으로 관측된다. 특이하게도, 크기가 큰 흑점의 경우는 냉한기보다 온난기에서 관측 빈도가 세 배 이상 높다. 또한, 흑점과 관련된 오로라의 강도를 분석해보면 크기가 큰 흑점은 작은 흑점보다 2~3배 이상 지구영향성이 높다는 것을 알 수 있다.

[구 SS-11] Rotational instability as a source of asteroidal dust near Earth

Hangbin Jo, Masateru Ishiguro
Seoul National University (서울대학교)

As implied by the zodiacal light and spacecraft impact measurements, the space between large bodies in our Solar System is filled with interplanetary dust particles (IDPs). IDPs give us deeper insight into the composition and evolution of the Solar System, as well as being a crucial reference for extrasolar research. IDPs can be interpreted as bearers of carbon and organic materials, and thus, their interaction with Earth can be considered as important factors for the birth of terrestrial life.

One of the key routes of IDPs entering Earth is via meteoroid streams (Love and Brownlee 1993).

The Geminid meteoroid stream is a notable example. Together with its source asteroid (3200) Phaethon, the Phaethon-Geminid stream complex (PGC) (Whipple 1983; Gustafson 1989) can potentially provide information on the properties and evolution of IDPs in near-Earth space. DESTINY+* is a JAXA/ISAS spacecraft planned to launch in 2024 to explore the physical and chemical features of near-Earth IDPs and uncover the dust ejection mechanism of active near-Earth asteroids, especially Phaethon (Arai et al. 2018).

Previous studies on the dust ejection mechanism of Phaethon have various degrees of success in explaining the ejection of submillimeter particles and try to recreate the dust replenishment rate of the Geminid stream. However, none of them are satisfactory for explaining the observed Geminid stream, especially for larger particles of a millimeter and centimeter scales. Inspired by the discovery of rotational mass shedding in the Main Belt region (Jewitt et al., 2014), we investigate a dust ejection scenario by rotational instability on Phaethon. Using the N-body integrator MERCURY6 (Chambers 1999; modified by Jeong 2014), we performed a long-term integration of dust particles of various sizes ejected at ~1 m/s. Through this process, we discuss the implications Phaethon's rotation may have on its ejection, the formation and evolution of IDP by this mechanism, and contribute to the DESTINY+ mission.

* Demonstration and Experiment of Space Technology for Interplanetary voYage Phaethon

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

Yoonsoo P. Bach[1], Masateru Ishiguro[1], Jun Takahashi[2], Hiroyuki Naito[3], Jungmi Kwon[4], Daisuke Kuroda[5]
[1]Seoul National University, [2]Nishi-Harima Astronomical Observatory, Center for Astronomy, University of Hyogo, [3]Nayoro Obeservatory [4]The University of Tokyo [5]Okayama Observatory, Kyoto University

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 ($X \sim \pi$ * 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 ($\lambda \sim 0.5$ μm) and X ~ 10 in near-infrared (J, H, Ks bands; $\lambda \sim 1.2$-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

Sunho Jin[1], Masateru Ishiguro[1], Daisuke Kuroda[2], Jooyeon Geem[1], Yoonsoo P. Bach[1], Jinguk Seo[1], Hiroshi Sasago[3], and Shuji Sato[4]
[1]Seoul National University, [2]Kyoto University, [3]Sasago Co. Ltd., [4]Nagoya University

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