Asteroids have undergone various processes such as impacts, space weathering, and thermal evolution. Because they expose their surfaces to space without atmosphere, these evolutional processes have been recorded directly on their surfaces. The remote-sensing observations have been conducted to reveal these evolutional histories of the target asteroids. For example, crater and boulder distributions are unambiguous evidence for past nondestructive impacts with other celestial bodies. Multiband and spectroscopic observations have revealed space-weathering history (as well as compositions).

Whereas most physical quantities have been examined intensively using spacecraft and telescopes, only a little has been studied on "the grain size". It is one of the fundamental physical quantities for diagnosing the collisional and thermal history of asteroids. Our group has conducted polarimetric research of asteroids (as well as Moon [1]) to determine the particle size and further investigate the evolutional histories of target asteroids [2],[3]. For example, the existence of regolith on an S-type asteroid, Toutatis, was suggested almost twenty years before space exploration [4]. Moreover, we reported that near-Sun asteroids indicate a signature of submillimeter grains, which could be created by a thermal sintering process by solar radiation [5].

However, it is important to note that in-situ polarimetry has not been reported on the asteroid surface, although the Korean Lunar Exploration Program aims to do polarimetry on the lunar surface [6]. Therefore, it is expected that the polarizer mounted on the Korean Apophis spacecraft can make the first estimate of the grain size and its regional variation over the Apophis surface.

In this presentation, we outline research of S-type asteroid surfaces through remote-sensing observations and consider the role of polarimetry. Based on this review, we consider the purpose, potentiality, and strategy of the polarimetry using the onboard device for the Apophis spacecraft. We will report a possible polarization phase curve of Apophis estimated from ordinary chondrites and past observational data of S-type asteroids, taking account of the space weathering effect. Based on this estimation, we will consider the strategy of how to determine the particle size (and space weathering degree) of the Apophis surface. We will also mention the detectability of dust hovering on the surface.

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[구 RMA-04] Rendezvous Mission to Apophis: IV. Investigation of the internal structure – A lesson from an analogical asteroid Itokawa

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Exploration of asteroids' internal structure is essential for understanding their evolutional history. It also provides a fundamental information about the history of coalescence and collision of the solar system. Among several models of the internal structures, the rubble-pile model, confirmed by the near-Earth asteroid (25143) Itokawa by Hayabusa mission [1], is now widely regarded as the most common to asteroids with size ranging from 200 m to 10 km [2]. On the contrary, monolithic and core-mantle structures are also possible for small asteroids [3]. It is, however, still challenging to look through the interior of a target object using remote-sensing devices. In this presentation, we introduce our ongoing research conducted at Seoul National and propose an idea to infer the internal structure of Apophis using available instruments.

Itokawa's research provides an important benchmark for Apophis exploration because both asteroids have similar size and composition [4][5]. We have conducted research on Itokawa's evolution in terms of collision and space weathering. Space weathering is the surface alteration process caused by solar wind implantation and micrometeorite bombardment [6]. Meanwhile, resurfacing via a collision acts as a counter-process of space weathering by exposing fresh materials under the matured layer and lower the overall degree of space weathering. Therefore, the balance of these two processes determine the space weathering degrees of the asteroid. We focus on the impact evidence on the boulder surface and found that space weathering progresses in only 100-10,000 years and modifies the surface optical properties (Jin & Ishiguro, KAS 2020 Fall Meeting).

It is important to note that the timescale is significantly shorter than the Itokawa's age, suggesting that the asteroid can be totally processed by space weathering. Accordingly, our

result triggers a further discussion about why Itokawa indicates a moderately fresh spectrum (Sq-type denotes less matured than S-type). For example, Itokawa's smooth terrains show a weaker degree of space weathering than other S-type asteroids [7]. We conjecture that the global seismic shaking caused by collisions with >1 mm-sized interplanetary dust particles induces granular convection, which hinders the progression of space weathering [8]. Note that the efficiency of seismic wave propagation is strongly dependent on the internal structure of the asteroid.

Finally, we consider possible approaches to investigate Apophis's internal structure. The first idea is studying the space weathering age, as conducted for Itokawa. If Apophis indicates a younger age, the internal structure would have more voids [9]. In addition, the 2029 close encounter with Earth provides a rare natural opportunity to witness the contrast between before and after the event. If the asteroid exhibits a slight change in shape and space weathering degree, one can determine the physical structure of the internal materials (e.g., rubble-pile monolithic, thick or thin regolith layer, the cohesion of the materials). We will also consider a possible science using a seismometer.

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[구 RMA-05] Rendezvous Mission to Apophis: V. Wide-Angle Camera Science

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The Korean spacecraft for the exploration of Apophis will be equipped with an optical navigation camera with a wide-angle lens. The major purpose of the wide-angle camera is to capture imagery during the rendezvous phase in order to determine the spacecraft's position and the pointing direction relative to the asteroid Apophis. Two potential sciences, however, can be achieved by the wide-angle camera: (1) to measure the high-order gravity terms, and (2) to capture possible ejecting small particles. In this presentation, we will discuss instrument specification and operation scenario required to accomplish the given science objectives.

[구 RMA-06] Rendezvous Mission to Apophis: VI. Observation Campaign during the 2021 Apparition

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On March 6 2021, Apophis made a close approach to the Earth with a minimum distance of 0.11 AU when the apparent magnitude reached up to V~16. This was the most favorable condition to observe this asteroid until its 2029 encounter. The observations during this apparition were extremely important to determine major physical properties, such as size, rotational state, 3D shape model, surface mineral properties. So, we organized the observation campaign during the 2021 apparition. The main goals of our campaign are to refine the spin state and 3D shape model and check the surface composition variations. The campaign involved dozens of countries and included ground-based photometry and spectroscopy, and spacecraft observations. Our timely observation campaign will provide essential data in planning the operation scenario for the space mission. In this presentation, we will report the preliminary result of the Apophis observation campaign during the 2021 apparition.