

[E] 口頭発表 | セッション記号 P (宇宙惑星科学) : P-PS 惑星科学

■ 2019年5月29日(水) 10:45 ~ 12:15 | 会場 A01 東京ベイ幕張ホール

[P-PS03] Solar System Small Bodies: A New Frontier Arising Hayabusa 2, OSIRIS-REx and Other Projects

コンピーナ:石黒 正晃(ソウル大学物理天文学科)、中本 泰史(東京工業大学)、安部 正真(宇宙航空研究開発機構宇宙科学研究所)、Olivier S Barnouin(Johns Hopkins University Applied Physics Laboratory)、座長:Masateru Ishiguro(Seoul National University)

2018年6月、小惑星探査機「はやぶさ2」が約3年半の航海を経て、目的地リュウグウに到着した。また、別の小惑星探査機「OSIRIS-REx」も探査天体Bennuに間もなく到着しようとしている。これらの探査によって、太陽系小天体研究は、今まさに新しい局面を迎えようとしている。本セッションは、2012年から開催されてきたもので、これまでに実験、観測、探査、理論、さらにサンプル分析の観点から太陽系小天体の研究に関して議論を行ってきた。特に今回は、はやぶさ2とOSIRIS-RExの初期成果を中心に太陽系小天体に関する最新研究を持ち寄り、今後の展望を議論することを目的とする。はやぶさ2、OSIRIS-REx以外の研究成果発表も歓迎する。

10:45 ~ 11:00

[PPS03-25] Overview and current status of DESTINY⁺ mission

★Invited Papers

*荒井 朋子¹、小林 正規¹、石橋 高¹、吉田 二美¹、木村 宏¹、平井 隆之¹、洪 鵬¹、山田 学¹、千秋 博紀¹、和田 浩二¹、スラマラルフ²、クルーガー ハラルド³、渡部 潤一⁴、伊藤 孝士⁴、石黒 正晃⁵、中村 智樹⁶、藪田 ひかる⁷、橋 省吾⁸、三河内 岳⁸、阿部 新助⁹、大塚 勝仁¹⁰、浦川 聖太郎¹¹、中村メッセンジャー 圭子¹²、小松 睦美¹³、亀田 真吾¹⁴、鍵谷 将人⁶、平田 成¹⁵、出村 裕英¹⁵、佐々木 晶¹⁶、廣井 隆弘¹⁷、小松 吾郎¹⁸、金田 英宏¹⁹、稲守 孝哉¹⁹、岡本 尚也²⁰、柳沢 俊史²⁰、吉川 真²⁰、矢野 創²⁰、岡田 達明²⁰、岩田 隆浩²⁰、大坪 貴文²⁰、川勝 康弘²⁰、豊田 裕之²⁰、西山 和孝²⁰、高島 健²⁰ (1.千葉工業大学惑星探査研究センター、2.シュツットガルト大学、3.マックスプランク研究所、4.国立天文台、5.ソウル大学、6.東北大学、7.広島大学、8.東京大学、9.日本大学、10.東京流星観測網、11.日本スペースガード協会、12.NASA、13.総合研究院大学、14.立教大学、15.会津大学、16.大阪大学、17.ブラウン大学、18.ダヌンツィオ大学、19.名古屋大学、20.宇宙航空研究開発機構)

11:00 ~ 11:15

[PPS03-26] Observational campaign of (3200) Phaethon and (155140) 2005UD in 2017-2018

*吉田 二美¹、Arai Tomoko¹、Ishibashi Ko¹、Hong Peng¹、Ishimaru Ryo¹、International observation collaborators DESTINY+ (1.Planetary Exploration Research Center, Chiba Institute of Technology)

11:15 ~ 11:30

[PPS03-27] Rotationally-resolved spectroscopic observations of Phaethon - 2005 UD, and their fragments detected by lunar impact flashes.

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11:30 ~ 11:45

[PPS03-28] Thermal Radiation Pressure Force on Regolith Particles of Atmosphereless Bodies

*Yoonsoo P. Bach¹、Masateru Ishiguro¹ (1.Department of Physics and Astronomy, Seoul National University)

11:45 ~ 12:00

[PPS03-29] A kilometre-sized Kuiper belt object revealed by OASES stellar occultation observations

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12:00 ~ 12:15

[PPS03-30] AKARI/IRC near-infrared asteroid spectroscopic survey: AcuA-spec

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Overview and current status of DESTINY⁺ mission

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DESTINY⁺ (Demonstration and Experiment of Space Technology for INterplanetary voYage, Phaethon flyby and dUst Science) was selected in 2017 as a mission for JAXA/ISAS small-class program. It is a joint mission of technology demonstration and scientific observation. It will test high performance electric propelled vehicle technology and high-speed flyby of asteroid (3200) Phaethon and possibly asteroid 2005UD, which a break-up body from Phaethon as an extended mission. Engineering challenges include an up-close encounter at a distance of 500 km from Phaethon with radio-optical hybrid navigation guidance and control, and autonomous imaging based on optical information for target tracking during a high-speed flyby of 33km/sec. The science goal is to understand the nature and origin of cosmic dust brought onto the Earth, in the context of exogenous contribution of carbon and organics for possible prebiotic seeds of the terrestrial life. Phaethon is a parent body of Geminid meteor shower, and thus a known source to periodically provide dust to the Earth, via the dust stream. The science objectives are two folded: (1) in-situ analyses of velocity, arrival direction, mass and chemical composition of interplanetary and interstellar dust particles around 1 au, the dust trail, and nearby Phaethon, and (2) flyby imaging of Phaethon to study its geology, for understanding dust ejection mechanism of active asteroid and the surface compositional variation. High-spatial-resolution images of less than 5 meter per pixel are obtained with Telescopic camera (TCAP), and VIS-NIR spectral images of less than 100 meter per pixel are taken with multiband camera (MCAP). Mass, speed, arrival direction and chemical composition for each dust particle are analyzed with dust analyzer (DDA). Here, we present an overview and the current status of DESTINY⁺ mission.

キーワード：デスティニープラス、フェートン、フライバイ、ふたご座流星群、惑星間塵
Keywords: DESTINY+, Phaethon, Flyby, Geminid meteor shower, IDP

Observational campaign of (3200) Phaethon and (155140) 2005UD in 2017-2018

Observational campaign of (3200) Phaethon and (155140) 2005UD in 2017-2018

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(3200) Phaethon is the flyby target and (155140) 2005UD is a second flyby candidate of the DESTINY+ mission. Each asteroid approached to the Earth and became bright in 2017-2018. We utilize this opportunity and organized an observation campaign for both asteroids with international collaborators. The following people participated to the observational campaign : F. Yoshida, R. Ishimaru, K. Ishibashi, P. Hong, T. Arai (PERC/ChiTech), R. Okazaki, T. Sekiguchi, H. Naito, M. Imai, T. Ono (Hokkaido University of Education), S. Urakawa (Japan Spaceguard Association, Bisei Spaceguard Center), Y. Shinnaka (Kyoto Sanyo Univ.), T. Tanigawa (Sumoto high school), T. Yanagisawa, H. Kurosaki (JAXA), S. Abe, R. Kato (Nihon Univ.), N. Natira, T. Nishiumi (Univ. of Tokyo), M. Ishiguro (Seoul National University), M.-J. Kim, Y.-J. Choi, H.-K. Moon (KASI), D.-H. Kim, H.-J. Lee, S.-M. Lee (Chungbuk National University), Zhong-Yi Lin (Institute of Astronomy, National Central University), Xiaobin Wang (Yunnan Observatories, CAS), A. Serebryanskiy, M. Krugov, I. Reva (Fesenkov Astrophysical Institute), O. Burkxonov, E. Kamoliddin (UBAI), A. Peyrot, J-P. Teng (Les Makes Observatory), Y. Krugly (Institute of Astronomy of V.N. Karazin Kharkiv National University), I. M. Volkov (SAI MSU, INASAN), I. V. Nikolenko, S. I. Barabanov (INASAN), M. Kaplan, O. Erece (Akdeniz university), A. Sonka, S. Anghel (Astronomical Institute of Romanian Academy, Bucharest University), M. Birlan, F. Vachier, J. Berthier (Observatoire de Paris, IMCCE, CNRS), A. Klotz (CNRS-OMP-IRAP), P. Thierry (Auragne Observatory), O. Ivanova, M. Husarik (Astronomical Institute of the Slovak Academy of Sciences), E. Kuznetsov, D. Glamazda, G. Kaiser, E. Koren, V. Krushinsky, A. Popov, A. Shagabutdinov, Y. Vibe (Ural Federal University), M. Lazzarin, V. Petropoulou, I. Bertini, F. La Forgia (University of Padova), E. Palomba, E. D'aversa, A. Migliorini (INAF-IAPS), J. Vaubaillon (Observatoire de Paris), T. G. Wilson (University College London, Isaac Newton Group), O. Vaduvescu (Isaac Newton Group, Instituto de Astrofísica de Canarias), M. Popescu, Julia de Leon (Instituto de Astrofísica de Canarias), V. Lorenzi (Fundación Galileo Galilei - INAF, Instituto de Astrofísica de Canarias), M. Granvik (University of Helsinki / Luleå University of Technology), A. Penttilä (University of Helsinki), K. O. Muinonen (University of Helsinki / National Land Survey of Finland), T. Kareta, V. Reddy, D. S. Laretta, B. Sharkey, C. Hergenrother (LPL, University of Arizona), J. A. Sanchez (PSI), T. Linder (Astronomical Research Institute), O. Kuhn, A. Conrad (Large Binocular Telescope Observatory), N. Moskovitz (Lowell Observatory), J. Masiero, A. Mainzer, L. Benner, M. Brozovic, S. Naidu, J. Giorgini (NASA JPL), E.L. Wright, D. Jewitt (UCLA), P. Taylor, E. Rivera-Valentin, S. Bhiravarasu, B. Aponte-Hernandez (Lunar and Planetary Institute), S. Marshall, F. Venditti, A. Virkki, L. Zambrano-Marin (Arecibo Observatory & University of Central Florida), C. R. Sanchez-Vahamonde (University of Western Ontario) (in the order from east to west in Fig.1).

Most of results obtained from the campaign were presented in IDP2019, which was held at Tokyo Skytree Town Campus of CIT, Japan, on February 12-14, 2019 (Fig. 2). So far, for both asteroids, rotation period,

average colors, absolute magnitudes, spectra ($0.4\text{--}2.5\ \mu\text{m}$) were obtained by photometry and spectroscopy during this observation campaign. Radar observation were done for Phaethon, and polarimetric observations were done for both asteroids. As preliminary results, the following properties were reported. Rotation periods: 5.2 hr (or 7.85 hr) for 2005UD, 3.6hr for Phaethon. Average colors : $B-V=0.71$, $V-R=0.37$, $V-I=0.32$ for 2005UD, $B-V=0.73$, $V-R=0.36$ for Phaethon. Absolute magnitude is 17.25 mag for 2005UD. No significant variation of rotationally resolved VIS-NIR spectra were seen for both asteroids. However, a slight variation of visual spectra of Phaethon taken in 2017 was reported. Both asteroids are in C-complex. Interestingly, in the NIR spectra, both asteroids show totally different spectra each other: concave-up and blue for Phaethon, linear and red for 2005UD. The results from polarimetric observation show both asteroids are very similar. As for Phaethon, rotational variation in polarization was reported. Lightcurve observations revealed Phethon has top shape. Radar observation estimated the Phaethon's diameter is about 6km, and revealed no coma, no satellite. Possible craters ($D>1\text{km}$ below 30 deg latitude, $D=1.5\text{km}$ near equator), 600m wide dark spot (likely a flattened region) were discovered.

キーワード : Asteroids, (3200) Phaethon, (155140) 2005UD

Keywords: Asteroids, (3200) Phaethon, (155140) 2005UD

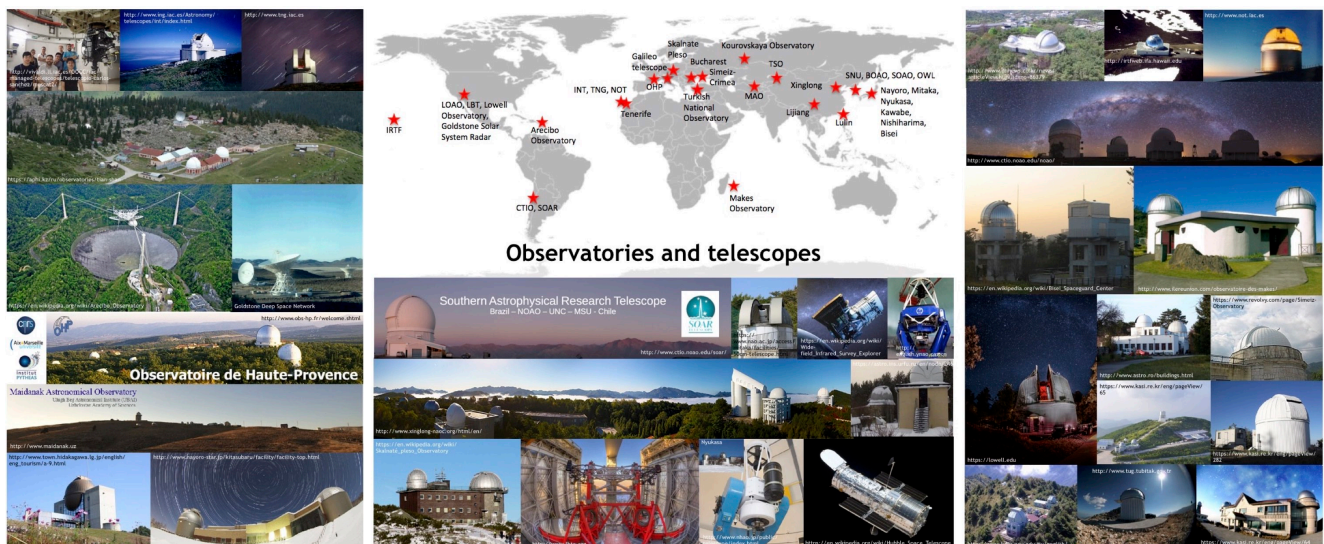


Fig1. Observatories and telescopes participating to the observation campaign of Phaethon and 2005UD in 2017 and 2018.

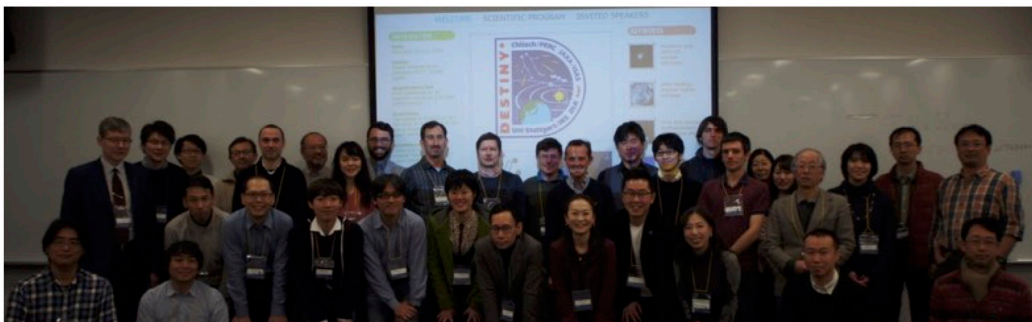


Fig2. IDP2019 held at Tokyo Skytree Town Campus of CIT, Chiba, Japan, on February 12–14, 2019.

Rotationally-resolved spectroscopic observations of Phaethon - 2005 UD, and their fragments detected by lunar impact flashes.

Rotationally-resolved spectroscopic observations of Phaethon - 2005 UD, and their fragments detected by lunar impact flashes.

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3200 Phaethon is an Apollo type near-Earth asteroid (NEA) categorized as a B-type asteroid which has been associated with the most intense meteor shower, Geminids. Cometary activity of Phaethon has been observed during its perihelion passage, ~ 0.140 AU, that motivates us to do direct exploration by the spacecraft, DESTINY+. It is also suggested that (155140) 2005 UD is a break-up pair of Phaethon because of dynamically similarity and same B-type spectrum type which is only $\sim 5\%$ in NEA population. We examined the spectral properties of this asteroid pair to find the surface heterogeneity. Rotationally-resolved spectroscopic observations of Phaethon were carried out using 1.0-m telescopes at Lulin/Taiwan, and Kawabe/Wakayama, observatories in 2007 and 2017 apparitions, respectively. While Rotationally-resolved spectroscopic observation of 2005 UD was performed by using 4.1-m SOAR telescope at Cerro Tololo, Chili in 2018. It is presumably revealed that the surface heterogeneity, C-type like red slope surface area, of Phaethon was clearly seen from 2017 data, while no-existing surface heterogeneity was observed for 2005 UD.

When a meteoroid impacts the moon at several 10s of km/s, a brilliant flash at the point of impact can be observed as a flash in visible and near-infrared light. Lunar impact monitoring has a great advantage to detect large meteoroids in the mass range between 10s of grams and few kilograms corresponding to centimeters and tens of centimeters, which is as a bridge between visual meteors and small asteroids. We observed lunar impact flashes during Geminids maximum in 2018. 11 events were simultaneously detected from 2 locations at Nihon university and UEC, suggesting existence of relatively large fragments, several cm to several tens of cm in diameter, in the Geminid meteor stream.

In order to understand the Phaethon-Geminid stream Complex (PGC), ground-based telescopic observations of Geminids meteoroids and its parent splitting-bodies will be presented.

キーワード：小惑星、彗星、流星、月面衝突閃光

Keywords: Asteroids, Comets, Meteoroids, Lunar impact flash

Thermal Radiation Pressure Force on Regolith Particles of Atmosphereless Bodies

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It is suggested that thermal fracture near the perihelion is a possible mechanism to produce the dust trail of the near-Earth asteroid, (3200) Phaethon (Jewitt and Li, 2013, ApJ 771, L36). For this scenario to be true, generated dust particles should have been ejected from the surface before its next apparition to show the detectable activities (Li and Jewitt, 2013, ApJ, 145, 154). It is, however, not well understood how these particles were escalated from the regolith against the asteroid's gravity. In this study, we hypothesize that the thermal radiation pressure around the perihelion passage would exert substantial force on dust grains to be lifted up and contributes the dust tail formation with further help of solar radiation pressure. As a result, we find that roughly ~ 1 -10 micron size dust grains can be ejected from Phaethon by the mechanism, while a detailed model of gravitational field is required for accurate range of the particle sizes. Our idea is not necessarily limited to Phaethon case, but is applicable to any atmosphereless bodies. We will explain how the thermal radiation pressure is effective at different distances from the sun.

Keywords: asteroids, regolith, thermal radiation

A kilometre-sized Kuiper belt object revealed by OASES stellar occultation observations

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We will report the first detection of a single stellar occultation event candidate by a kilometer-sized (radius= 1-10 km) Kuiper belt object (KBO). Since the kilometer-sized KBOs are too faint to be detected directly, the monitoring of stellar occultation events is one possible way to discover them. With the aim of detecting the stellar occultation events, we launched an optical observation project named Organized Autotelescopes for Serendipitous Event Survey (OASES). We installed two low-cost OASES observation systems in different positions on the rooftop of the Miyako open-air school on Miyako Island, Miyakojima-shi, Okinawa Prefecture, Japan, and monitored up to 2000 stars simultaneously with a sampling cadence of 15.4Hz. In the 60-hour dataset obtained with the two-year OASES observations, we discovered one occultation candidate event by a KBO with a radius of approximately 1.3 km. Our present detection yields a surface number density of KBOs with radii exceeding 1.2 km is approximately $6 \times 10^5 \text{ deg}^{-2}$. This surface number density favors a theoretical size distribution model with an excess signature at a radius of 1–2 km. The present results suggest that planetesimals before their runaway growth phase grew into kilometer-sized objects in the primordial outer Solar System and remain as one of the major populations in the present-day Kuiper belt.

キーワード：太陽系外縁天体、カイパーベルト、可視望遠鏡による地上観測

Keywords: trans-Neptunian objects, Kuiper belt, ground based observations by optical telescopes

AKARI/IRC near-infrared asteroid spectroscopic survey: AcuA-spec AKARI/IRC near-infrared asteroid spectroscopic survey: AcuA-spec

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Water is found in various forms in our solar system and is one of the most important ingredients in the origin of life. It provides evidence for the evolution of the solar system, especially its thermal history. Hydrated minerals are formed in environments where anhydrous rock and liquid water exist together, resulting from aqueous alteration. Because hydrated minerals are stable even above the sublimation temperature of water ice, they become an important reservoir to trace the water present in the history of the solar system unless they were reset by a temperature change after formation. Asteroids are considered to record the initial conditions of our solar nebula of 4.6 Ga ago. To explore the existence of water in the present solar system, it is indispensable to investigate the presence of hydrated minerals and water ice on various types of asteroids. Hydrated minerals and water ice exhibit diagnostic absorption features in the so-called 3 micron band (approximately 2.5-3.5 micron wavelength range). Many spectroscopic surveys have been conducted in the 3 micron band using ground-based observatories, which are severely affected by telluric absorption at around 2.8 micron. Space-borne observations, free from the effect, therefore, offer an excellent opportunity to study and identify the mineral species in asteroids.

The Infrared Camera (IRC) on board the AKARI satellite has a unique spectroscopic capability covering 2.5-5 microns continuously with a spectral resolution of $R \sim 100$, which provides valuable data thanks to its high sensitivity and unique wavelength coverage. We conducted a spectroscopic survey of asteroids in the 3 micron band using IRC. In the warm mission period of AKARI, 147 pointed observations were performed for 66 asteroids in the grism mode in 2.5-5 microns. According to our observations, it is found that most C-complex asteroids, especially all Ch-, Cgh-, B-, and Cb-type asteroids, have obvious absorption features in the reflectance spectra at around 2.75 micron, which is attributed to OH-stretch in hydrated minerals. The peak wavelength of the 2.7 micron band feature is concentrated at around 2.75 micron: in particular, there is a correlation between the peak wavelength and the band depth among 13 C-complex asteroids. This trend can be understood in terms of the process where hydrated minerals are being heated up and gradually losing water, that is, the dehydration process.

In this talk, we present the spectroscopic survey of asteroids with AKARI for detecting the 2.7 micron absorption features and discuss scenarios for the formation and evolution of C-complex asteroids.

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