[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

2021年6月4日(金) 15:30 ~ 16:50 | Ch.02 Zoom会場02

[P-PS01] Outer Solar System Exploration Today, and Tomorrow

コンビーナ:木村 淳(大阪大学)、M. Kunio Sayanagi(Hampton University)、土屋 史紀(東北大学大学院理学研究科惑星プラズマ・大気研究センター)、Cindy Young(NASA Langley Research Center)、座長:笠羽 康正(東北大学 惑星プラズマ・大気研究センター)、Steven Douglas Vance(NASA Jet Propulsion Laboratory, California Institute of Technology)

The giant planets provide many keys to understanding planetary processes. They play an important role in shaping our solar system, and the physical and chemical processes they harbor also provide a unique opportunity to study the phenomena relevant for studying Earth and other planets, including exoplanetary systems. In this session, we discuss a wide range of topics encompassing the giant planets and their moons, including their origins, interiors, atmospheres, compositions, surface features, and electromagnetic fields. To advocate for current and future outer planets exploration (Juno, New Horizons, JUICE, Europa Clipper, Dragonfly and beyond), we also call for discussions on future missions to explore giant planet systems, including how to develop better international cooperation. Discussion in this latter category will include progress in developing a solar sail mission concept for observing the Jupiter system and its Trojan asteroids.

15:30 ~ 15:50

[PPS01-06] Observations of tenuous atmospheres at Jupiter's icy Galilean moons: HST and future missions

★Invited Papers

*Lorenz Roth[1] (1.KTH Royal Institute of Technology, Space and Plasma Physics, Stockholm, Sweden)

15:50 ~ 16:05

[PPS01-07] Future observations of Juvian system with LAPYUTA (Life-environmentology, Astronomy, and PlanetarY Ultraviolet Telescope Assembly)

*土屋 史紀[1]、村上 豪[2]、古賀 亮一[3]、鍵谷 将人[1]、木村 智樹[1]、吉岡 和夫[4]、山崎 敦[2]、堺 正太朗[1]、木村 淳[5]、垰 千尋[6] (1.東北大学、2.宇宙科学研究所、3.名古屋大学、4.東京大学、5.大阪大学、6.情報通信研究機構)

16:05 ~ 16:20

[PPS01-08] Characterization of Cl-bearing salts on Europa's surface based on telescope observations and laboratory experiments

*丹 秀也[1]、関根 康人[1]、葛原 昌幸[2]、黒川 宏之[1]、オレ クリスティーナ[3,4]、クルイクシャンク デイル[4] (1.東京工業大学地球生命研究所、2.アストロバイオロジーセンター、3.SETI研究所、4.エイムズ研究センター)

16:20 ~ 16:35

[PPS01-09] Europa's structural conditions for the existence of subsurface ocean and the absence of metallic core-driven magnetic field

*木村 淳[1] (1.大阪大学)

16:35 ~ 16:50

[PPS01-10] The Influence of Salinity and Shape on Magnetic Induction in Ocean Moons

*Steven Douglas Vance[1]、Marshall J Styczinski[2]、Corey J Cochrane[1]、Krista M Soderlund[3]、Natalia Gómez-Pérez[4]、Tom A Nordheim[1]、Carol Paty[5]、Bruce G Bills[1] (1.NASA Jet Propulsion Laboratory, California Institute of Technology, Pasadena、2.Department of Physics, University of Washington, Seattle、3.Institute for Geophysics, John A. and Katherine G. Jackson School of Geosciences, University of Texas at Austin、4.British Geological Survey, Edinburgh、5.Department of Earth Sciences, University of Oregon, Eugene)

Observations of tenuous atmospheres at Jupiter’s icy Galilean moons: HST and future missions

*Lorenz Roth[1]

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In this presentation, the UV observations by the Hubble Space Telescope (HST) of the tenuous atmospheres of Jupiter’s large icy moons are reviewed. We discuss the previous detections of O2 at Europa and Ganymede through auroral emissions and at Callisto through photo-electron emissions. In addition, we show new results from the HST data that reveal the presence of sublimated H2O atmospheres in the sub-solar region in addition to O2. HST also discovered atomic hydrogen coronae at all three moons and measured localized H and O atomic emissions at Europa, interpreted as first evidence for the existence of plumes. At the end, we give an overview on future measurements of the icy moon atmospheres by ESAs JUpiter Icy Moon Explorer (JUICE) and NASAs Europa Clipper mission, with focus on the UVS instruments.

Keywords: Jupiter, Galilean moons, satellite atmospheres, Hubble Space Telescope, Jupiter moon missions

Future observations of Juvian system with LAPYUTA (Life-environmentology, Astronomy, and PlanetarY Ultraviolet Telescope Assembly)

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*Fuminori Tsuchiya[1], Go Murakami[2], Ryoichi Koga[3], Masato Kagitani[1], Tomoki Kimura[1], Kazuo Yoshioka[4], Atsushi Yamazaki[2], Shotaro Sakai[1], Jun Kimura[5], Chihiro Tao[6]

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Ultraviolet observation technique is one of the most powerful tools to cover wide science fields, from planetary science to astronomy. Here we propose a UV space telescope, LAPYUTA (Life-environmentology, Astronomy, and PlanetarY Ultraviolet Telescope Assembly), as a Japanese-leading mission, by using both many heritages of UV instruments for planetary science (e.g., Hisaki) and space telescope techniques for astronomy. We will accomplish the following four goals: (1) dynamics of our solar system planets and moons as the most quantifiable archetypes of extraterrestrial habitable environments in the universe, (2) transit spectroscopy of exoplanetary atmosphere, especially hydrogen and oxygen exosphere, to observe on-going atmospheric escaping predicted to occur on Earth-like exoplanets in the habitable zone of low temperature star system, (3) the unique UV map of the gaseous large-scale structures (LSSs) to test the structure formation scenario of the Λcold dark matter (CDM) model and to unveil galaxy growth and feedback processes in the LSSs, and (4) the time-domain survey for transient sky in the UV wavelength to witness the first moments of high-energy events such as compact-object mergers and supernovae with a great synergy of the growing facilities of multi-messenger astronomy including gravitational-wave observatories.
Pre-phase A study of the LAPYUTA mission have just started in 2021. In this presentation, we focus on science targets of the Jovian system and show overview of this mission.

キーワード：氷衛星、紫外線宇宙望遠鏡
Keywords: Icy mooms, UV space telescope

Characterization of Cl-bearing salts on Europa’s surface based on telescope observations and laboratory experiments

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Europa has been found to possess an interior ocean beneath the icy crust. Europa’s surface has been recently observed in the wavelength range 1.5–2.5 μm with large ground-based telescopes, Keck and VLT (Fischer et al., 2015; Ligier et al. 2016). Those observed reflectance spectra suggest that Cl-bearing salts exist on Europa’s geologically active chaos terrains, and those salts reflect the chemical composition of the interior ocean (e.g., Zolotov & Kargel, 2009; Tan et al., 2021). Moreover, the abundance and grain size of Cl-bearing salts would provide constraints on the formation mechanism of chaos terrains. However, those physicochemical properties of Cl-bearing salts on the surface are not well constrained due to the limitation in existing observation wavelengths and the lack of laboratory experiments.
Here, we report the results of our observations for Europa’s surface in the wavelength range 1.0–1.8 μm using the Subaru telescope/IRCS and adaptive optics AO188 with high spectral resolution and high signal-to-noise ratios. Our observed spectra show no significant absorption features at ~1.2 μm due to hydrated salts (e.g., $NaCl{\cdot}2H_2O$, $MgCl_2{\cdot}nH_2O$, $Mg(ClO_3)_2{\cdot}6H_2O$, $Mg(ClO_4)_2{\cdot}6H_2O$), suggesting that surface salts would be likely anhydrous sodium chloride (NaCl).
On Europa’s surface, the spectrum of NaCl would be changed due to irradiation by high-energy particles (e.g., Hand et al., 2015). We also performed irradiation experiments on NaCl by 10-keV electrons to obtain the optical constants of irradiated NaCl in near-infrared wavelengths. To constrain grain size and abundance of irradiated NaCl on Europa’s surface, we performed spectral model fitting of the observational data using the obtained optical constants (Hapke, 1981; 1993; 2002). Through our results of the spectral fitting, the non-irradiated NaCl cannot reproduce dark reflectance well in wavelength of 1.1–1.3 μm. On the other hand, irradiated NaCl greatly improves the spectral fitting because irradiated NaCl has a red slope in the relevant wavelength range. The best fit of the observations suggests that the abundance and grain size of irradiated NaCl are 40–50% and > a few μm, respectively.
The high abundance and large grain size of NaCl on Europa can be explained by the formation of chaos terrains through slow freezing of subsurface brine reservoirs within the icy crust, and subsequent eruptions of slurry brines containing NaCl particles to the surface.

キーワード：エウロパ、望遠鏡観測、スペクトルモデリング
Keywords: Europa, Telescope Observations, Spectral modeling

Europa’s structural conditions for the existence of subsurface ocean and the absence of metallic core-driven magnetic field

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Measurements of the magnetic field environment by the Galileo spacecraft during flyby of Europa detected an inductive magnetic signal generated by the response of Europa's interior conductors to temporal variations in Jovian magnetic field. On the other hand, no magnetic field originated from the dynamo motion in the metallic core. These measurements strongly suggest that a global subsurface ocean with electrolytes exists beneath the solid ice shell and that convective motion is not occurring in the metallic core.

The interior of Europa, which has a surface radius of 1565 km, is expected to be divided into metallic core, rocky mantle, and water layers based on the moment of inertia factor estimated from gravity field measurements (0.346 ±0.005 normalized by Europa’s radius and mass). Specifically, the thickness of the outermost water layer is 120-170 km, and the radius of the metallic core is 0.11-0.43 Europa’s radius. Within this possible range for the internal structure and uncertainty of material properties (especially the ice properties), no systematic investigation of Europa's internal evolution has been done that can explain the current state of the subsurface ocean and the absence of a core dynamo metal field.

Here, we perform a numerical simulation of the long-term thermal evolution of the Europa’s interior, and investigate the temporal changes of the ocean thickness and the temperature and heat flow of the metallic core. With various structures, e.g., metallic core density and radius, and thickness of water layer, and with various ice viscosity and tidal heating rate, we find the reasonable parameter ranges which are consistent with estimate of the ice shell thickness and the absence of convection in the metallic core. Current ice shell (ocean) thickness mainly controlled by the melting point viscosity of the ice and the tidal heating rate, and it does not depend on the difference in the thickness of the entire water layer. The thermal history of the metallic core is controlled by the entire thickness of the water layer and the metallic core density (thus the metallic core radius and the mass of the rocky mantle), and is not affected by difference of the ice shell (ocean) thickness. For the metallic core, there is no solution that satisfies both the melting and cooling conditions. Assuming Fe-FeS alloy core, the core could be molten without convection if the core composition is near the eutectic, or not molten (and no convection) if the composition is near the Fe or FeS end-member.

キーワード：進化、内部構造、宇宙生命論
Keywords: evolution, interior, astrobiology

The Influence of Salinity and Shape on Magnetic Induction in Ocean Moons

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The magnetic fields induced within the oceans of icy moons can be used to characterize the properties of the oceans. To date, only the Galileo spacecraft has measured induced fields from extraterrestrial oceans—in Europa and possibly Ganymede and Callisto—and in those cases only weak constraints were placed on the thickness and salinity of the oceans. For Jupiter's large icy moons, and for the inner 3 large icy moons of Uranus, we will describe an exploration of the parameter space of ocean thickness and composition, and corresponding induction response at multiple periods of the externally imposed fields.

To date, the modeled induction responses have been limited to nested concentric conducting shells and have neglected motional induction. We will describe recent work examining effects due to deviations from spherical symmetry and secondary magnetic fields induced by fluid flows within the oceans.

Results from this work will be important for exploration of Jupiter's moons by the Europa Clipper and JUICE missions, and by a future mission exploring the moons of Uranus.

Keywords: Europa, Ocean Worlds, Magnetic Induction

