Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

PPS01-01 会場:418 時間:4 月 30 日 14:15-14:35

ソーラー電力セイルによる木星トロヤ群往復探査と深宇宙クルージング観測
The Solar Power Sail for Round Trip Exploration to Jupiter Trojans and Deep Space Cruising Observation

矢野 創[1*] ; 中村 良介[2] ; 松浦 周二[1] ; 関根 康人[3] ; 豊田 岐聡[4] ; 青木 順[4] ; 吉田 二美[5] ; 高遠 徳尚[5] ; 木下 大輔[6] ; 米徳 大輔[7] ; 吉川 真[1] ; 森 治[1] ; 太陽系小天体探査ＷＧＴ .[1] ; ソーラー電力セイルＷＧ .[1]
YANO, Hajime[1*] ; NAKAMURA, Ryosuke[2] ; MATSUURA, Shuji[1] ; SEKINE, Yasuhito[3] ; TOYODA, Michisato[4] ; AOKI, Jun[4] ; YOSHIDA, Fumi[5] ; TAKATO, Naruhisa[5] ; KINOSHITA, Daisuke[6] ; YONETOKU, Daisuke[7] ; YOSHIKAWA, Makoto[1] ; MORI, Osamu[1] ; SOLAR SYSTEM SMALL BODY EXPLORATION WGT, .[1] ; SOLAR POWER SAIL WG, .[1]

[1] 宇宙航空研究開発機構・宇宙科学研究所, [2] 産業技術総合研究所, [3] 東京大学, [4] 大阪大学, [5] 国立天文台, [6] 台湾中央大学, [7] 金沢大学
[1]JAXA/ISAS, [2]AIST, [3]The University of Tokyo, [4]Osaka University, [5]NAOJ, [6]Taiwan Central University, [7]Kanazawa University

Since 2002, the Solar Power Sail WG has been studying a mission design of Japan’s first outer planet region exploration, by demonstrating the solar power sail technology, and it is bound to Jupiter Trojan asteroids, which may hold fundamental clues of the Solar System formation and revolution discussed by two competing hypotheses between the classic model and the planetary migration model. The former suggests that Trojan asteroids are mainly survivors of building blocks of the Jupiter system, while the latter claims that they must be intruders from outer regions after the planetary migration of gas planets settled.

After Jupiter flyby, the spacecraft will reach to a candidate Trojan asteroid, hopefully being larger than a few 10’s of km in size. Both global remote observation and deployment of an autonomous lander will be conducted. On the surface of the Trojan asteroid, sampling will be attempted for in-situ TOF mass spectrometry and passing the sample container to the mothership for a possible sample return option.

Also during the cruising operation, ”dust free” astronomical platform beyond the cocoon of the zodiacal light formed by the main asteroid belt for the benefit of infrared astronomy searching for the first generation light of the Universe, let alone continuous observation of the zodiacal light structure of the Solar System. Extremely long baseline with the observation from the Earth, gamma-ray burst observation can identify their sources.

This presentation discusses major scientific objectives of an exploration mission to Jupiter Trojans for the first time in the history, its mission design and spacecraft system using solar power sail, a hybrid propulsion system of electric propulsion and photon sail, which inherited from the IKAROS deep space solar sail spacecraft, together with major engineering challenges, in-situ observation instruments and operational options including landing and sample return from the surface of a Trojan asteroid.

キーワード: ソーラー電力セイル, 木星トロヤ群小惑星, 深宇宙探査, 深宇宙天文学, 黄道光, サンプルリターン
Keywords: Solar Power Sail, Jupiter Trojans, Deep Space Exploration, Deep Space Astronomy, Zodiacal Light, Sample Return

Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

PPS01-02 会場:418 時間:4 月 30 日 14:35-14:55

EUROPA CLIPPER MISSION CONCEPT OVERVIEW
EUROPA CLIPPER MISSION CONCEPT OVERVIEW

PAPPALARDO Robert[1] ; GOLDSTEIN Barry[1] ; MAGNER Thomas[2] ; PROCKTER Louise[2] ; SENSKE David[1] ; PACZKOWSKI Brian[1] ; COOKE Brian[1] ; Vance Steven[1*] ; PATTERSON G. Wesley[2]
PAPPALARDO, Robert[1] ; GOLDSTEIN, Barry[1] ; MAGNER, Thomas[2] ; PROCKTER, Louise[2] ; SENSKE, David[1] ; PACZKOWSKI, Brian[1] ; COOKE, Brian[1] ; VANCE, Steven[1*] ; PATTERSON, G. wesley[2]

[1]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109, [2]The Johns Hopkins University, Applied Physics Laboratory, Laurel, MD, 20723
[1]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109, [2]The Johns Hopkins University, Applied Physics Laboratory, Laurel, MD, 20723

A NASA-appointed Science Definition Team (SDT) recently considered options for a future strategic mission to Europa, with the stated science goal: Explore Europa to investigate its habitability. The team worked closely with a technical team from the Jet Propulsion Laboratory (JPL) and the Applied Physics Laboratory (APL). Together, the group considered several mission options, which were fully technically developed, then costed and reviewed by technical review boards and planetary science community groups. Study results strongly favored an architecture consisting of a spacecraft in Jupiter orbit, making many close flybys of Europa, and concentrating on remote sensing to explore the moon. The resulting nominal mission design is innovative for its use of gravitational perturbations of the spacecraft trajectory to permit flybys at a wide variety of latitudes and longitudes. The design enables globally distributed regional coverage of the moon's surface, nominally with 45 close flybys at altitudes from 25 to 100 km. We will present the science and reconnaissance goals and objectives, a mission design overview, and the notional spacecraft for this concept, which has become known as the Europa Clipper. The Europa Clipper concept provides a cost-efficient means to explore Europa and investigate its habitability, through understanding the satellite's ice and ocean, composition, and geology. The set of investigations derived from these science objectives traces to a notional payload for science, consisting of: Ice Penetrating Radar (for sounding of ice-water interfaces within and beneath the ice shell), Topographical Imager (for stereo imaging of the surface), ShortWave Infrared Spectrometer (for surface composition), Neutral Mass Spectrometer (for atmospheric composition), Magnetometer and Langmuir Probes (for inferring the satellite's induction field to characterize an ocean), and Gravity Science (to confirm an ocean). Among the many science investigations addressed, Europa Clipper could potentially characterize plumes linked to Europa's internal lakes or ocean. The mission would also include the capability to perform reconnaissance for a future lander, with the Reconnaissance goal: *Characterize safe and scientifically compelling sites for a future lander mission to Europa*. To accomplish these reconnaissance objectives and the investigations that flow from them, principally to address issues of landing site safety, two additional instruments would be included in the notional payload: a Reconnaissance Camera (for high-resolution imaging) and a Thermal Imager (to characterize the surface through its thermal properties). These instruments, in tandem with the notional payload for science, could assess the science value of potential landing sites. This notional payload serves as a proof-of-concept for the Europa Clipper during its formulation stage. The actual payload would be chosen through a NASA Announcement of Opportunity. If NASA were to proceed with the mission, it could be possible to launch early in the coming decade, on an Atlas V or the Space Launch System (SLS).

キーワード: Europa, Icy Worlds, Astrobiology, Europa Clipper, Missions, Planetary Science
Keywords: Europa, Icy Worlds, Astrobiology, Europa Clipper, Missions, Planetary Science

Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

PPS01-03 会場:418 時間:4 月 30 日 14:55-15:10

Investigation of the Galilean Moons with the Ganymede Laser Altimeter (GALA)
Investigation of the Galilean Moons with the Ganymede Laser Altimeter (GALA)

HUSSMANN, Hauke[1*] ; LINGENAUBER, Kay[1] ; MICHAELIS, Harald[1] ; KOBAYASHI, Masanori[2] ; THOMAS, Nicolas[3] ; LARA, Luisa M.[4] ; ARAKI, Hiroshi[5] ; BEHNKE, Thomas[1] ; GWINNER, Klaus[1] ; KIMURA, Jun[6] ; NAMIKI, Nori[2] ; NODA, Hirotomo[5] ; OBERST, Juergen[1] ; ROATSCH, Thomas[1] ; RODRIGO, Rafael[4] ; SASAKI, Sho[7] ; SEIFERLIN, Karsten[3] ; SPOHN, Tilman[1] ; BARNOUIN, Olivier[8] ; BREUER, Doris[1] ; CASOTTO, Stefano[9] ; CASTRO, Jose[4] ; CHOBLET, Gael[10] ; CHRISTENSEN, Ulrich[11] ; FERRAZ-MELLO, Sylvio[12] ; GIESE, Bernd[1] ; KALLENBACH, Reinald[11] ; KURITA, Kei[13] ; LAINEY, Valery[14] ; LICHOPOJ, Alexander[1] ; LOETZKE, Horst-georg[1] ; LUPOVKA, Valery[15] ; MOORE, William B.[16] ; RODRIGUEZ, Adrian[6] ; SANTOVITO, Maria rosaria[17] ; SCHREIBER, Ulrich[18] ; SCHROEDTER, Rolf[1] ; SOHL, Frank[1] ; DEL TOGNO, Simone[1] ; VERMEERSEN, Bert[19] ; WIECZOREK, Mark[20] ; YSEBOODT, Marie[21]
HUSSMANN, Hauke[1*] ; LINGENAUBER, Kay[1] ; MICHAELIS, Harald[1] ; KOBAYASHI, Masanori[2] ; THOMAS, Nicolas[3] ; LARA, Luisa M.[4] ; ARAKI, Hiroshi[5] ; BEHNKE, Thomas[1] ; GWINNER, Klaus[1] ; KIMURA, Jun[6] ; NAMIKI, Nori[2] ; NODA, Hirotomo[5] ; OBERST, Juergen[1] ; ROATSCH, Thomas[1] ; RODRIGO, Rafael[4] ; SASAKI, Sho[7] ; SEIFERLIN, Karsten[3] ; SPOHN, Tilman[1] ; BARNOUIN, Olivier[8] ; BREUER, Doris[1] ; CASOTTO, Stefano[9] ; CASTRO, Jose[4] ; CHOBLET, Gael[10] ; CHRISTENSEN, Ulrich[11] ; FERRAZ-MELLO, Sylvio[12] ; GIESE, Bernd[1] ; KALLENBACH, Reinald[11] ; KURITA, Kei[13] ; LAINEY, Valery[14] ; LICHOPOJ, Alexander[1] ; LOETZKE, Horst-georg[1] ; LUPOVKA, Valery[15] ; MOORE, William B.[16] ; RODRIGUEZ, Adrian[6] ; SANTOVITO, Maria rosaria[17] ; SCHREIBER, Ulrich[18] ; SCHROEDTER, Rolf[1] ; SOHL, Frank[1] ; DEL TOGNO, Simone[1] ; VERMEERSEN, Bert[19] ; WIECZOREK, Mark[20] ; YSEBOODT, Marie[21]

[1]DLR Institute of Planetary Research, Berlin, Germany, [2]Chiba Institute of Technology, Planetary Exploration Research Center, Chiba, Japan, [3]Physics Institute, University of Bern, Switzerland, [4]CSIC, Instituto de Astrofisica de Andalucia, Granada, Spain, [5]National Astronomical Observatory of Japan, Mizusawa, Japan, [6]Earth-Life Science Institute, Tokyo Institute of Technology, Japan, [7]Osaka University, Toyonaka Japan, [8]Space Dept., The Johns Hopkins University Applied Physics Laboratory, Laurel, MD, USA, [9]University of Padua, Dept. of Physics and Astronomy and Center for Space Studies, Padova, Italy, [10]Laboratoire de Planetologie et Geodynamique de Nantes, France, [11]Max Planck Institute for Solar System Research, Katlenburg-Lindau, Germany, [12]Institute of Astronomy, Geophysics and Atmospheric Science, Sao Paulo, Brasil, [13]University of Tokyo, Earthquake Research Institute, Tokyo, [14]IMCCE-Observatoire de Paris, France, [15]Moscow State University of Geodesy and Cartography, (MIIGAiK), Russia, [16]Hampton University, National Institute of Aerospace, USA, [17]CO.RI.S.T.A. Consortium of Research on Advanced Remote Sensing Systems, Napoli, Italy, [18]Technische Universitat Munchen, Fundamentalstation Wettzell, Germany, [19]Astrodynamics & Space Missions, Faculty of Aerospace Engineering, TU Delft, Netherlands, [20]Institut de Physique du Globe de Paris, France, [21]Royal Observatory of Belgium , Brussels, Belgium
[1]DLR Institute of Planetary Research, Berlin, Germany, [2]Chiba Institute of Technology, Planetary Exploration Research Center, Chiba, Japan, [3]Physics Institute, University of Bern, Switzerland, [4]CSIC, Instituto de Astrofisica de Andalucia, Granada, Spain, [5]National Astronomical Observatory of Japan, Mizusawa, Japan, [6]Earth-Life Science Institute, Tokyo Institute of Technology, Japan, [7]Osaka University, Toyonaka Japan, [8]Space Dept., The Johns Hopkins University Applied Physics Laboratory, Laurel, MD, USA, [9]University of Padua, Dept. of Physics and Astronomy and Center for Space Studies, Padova, Italy, [10]Laboratoire de Planetologie et Geodynamique de Nantes, France, [11]Max Planck Institute for Solar System Research, Katlenburg-Lindau, Germany, [12]Institute of Astronomy, Geophysics and Atmospheric Science, Sao Paulo, Brasil, [13]University of Tokyo, Earthquake Research Institute, Tokyo, [14]IMCCE-Observatoire de Paris, France, [15]Moscow State University of Geodesy and Cartography, (MIIGAiK), Russia, [16]Hampton University, National Institute of Aerospace, USA, [17]CO.RI.S.T.A. Consortium of Research on Advanced Remote Sensing Systems, Napoli, Italy, [18]Technische Universitat Munchen, Fundamentalstation Wettzell, Germany, [19]Astrodynamics & Space Missions, Faculty of Aerospace Engineering, TU Delft, Netherlands, [20]Institut de Physique du Globe de Paris, France, [21]Royal Observatory of Belgium , Brussels, Belgium

The icy moons of Jupiter ? Europa, Ganymede, and Callisto ? are believed to contain global subsurface water oceans underneath their icy crusts. The possibility is intriguing that these large liquid water oceans represent ”habitable” environments. Investigation of the latter is a major objective of ESA’s Jupiter Icy Moons Explorer (JUICE) mission. The Ganymede Laser Altimeter (GALA) is one of the instruments focusing on aspects related to the presence and characterization of subsurface water oceans by measuring Ganymede’s tidal deformation. GALA will further contribute (a) to the exploration of the surface morphology and physical properties of Ganymede, Europa and Callisto, (b) to determination of their interior structures from a combination of shape, topography and gravitational field data, and (c) to understanding the satellites formation and evolution especially with respect to subsurface water oceans. GALA will investigate the surface and topography of Ganymede in particular. Topography data is needed to account for the effects of topographic heights on the gravity field and to account for near surface

mass distribution anomalies above the reference figure; to support geological studies, e.g. to identify and characterize tectonic and cryo-volcanic regions on the icy moons and to identify periodic variations of Ganymede's shape due to tides.

Investigations by GALA will furthermore contribute to determine the orientation and rotational state of Ganymede and to study surface characteristics (roughness, slopes, and albedo) on Ganymede, Europa, and Callisto.

The instrument can be operated from ranges smaller than about 1000 to 1300 km (depending on the different albedo values and surface slopes of Europa, Ganymede and Callisto) during flybys and orbital pericenter passages. The main phases for acquiring data at Ganymede are the final circular orbit phases, where continuous operations are possible from altitudes around 500 km and 200 km, respectively.

Here, we will give an overview on the GALA experiment focusing on its scientific goals and performance.

キーワード: Laser altimetry, Satellites of Jupiter, Ganymede, Tides
Keywords: Laser altimetry, Satellites of Jupiter, Ganymede, Tides

Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

PPS01-04 会場:418 時間:4 月 30 日 15:10-15:25

Longevity of an internal ocean in Ganymede
Longevity of an internal ocean in Ganymede

木村 淳 [1*] ; Vance Steven[2] ; Hussmann Hauke[3] ; 栗田 敬 [4]
KIMURA, Jun[1*] ; VANCE, Steven[2] ; HUSSMANN, Hauke[3] ; KURITA, Kei[4]

[1] 東京工業大学地球生命研究所, [2] ジェット推進研究所, [3] ドイツ航空宇宙研究所, [4] 東京大学地震研究所
[1]Earth-Life Science Institute, Tokyo Institute of Technology, [2]Jet Propulsion Laboratory, [3]DLR Institute of Planetary Research, [4]Earthquakle Research Institute, The University of Tokyo

The outer solar system may provide a potential habitat of extra-terrestrial life. Most moons orbiting planets in the outer Solar System, at orbits beyond the snow line, such as Jupiter or Saturn, are covered with water ice and are referred to as ”icy moons”. Galileo’s detection of induced magnetic fields combined with imaged surface characteristics and thermal equilibrium modeling of the moons, support that the Jovian icy moons Europa and Ganymede, and possibly Callisto, may harbor liquid water oceans underneath the icy crusts. The presence of internal oceans in the icy moons means that a deep habitat different from Earth’s biosphere may exist, located beyond the ”habitable zone” of the Sun. Evidence for oceans is not definitive, however, and awaits confirmation measurements. Also, the depth and composition of the oceans remain unclear, as do their variability through time.

Here we focus on Ganymede, the largest moon in the Solar System and the primary target of a new mission to the Jupiter system, the Jupiter Icy Moons Explorer (JUICE), which is planned by the European Space Agency (ESA). The bulk density of Ganymede, 1.936 g/cc, indicates a composition of approximately equal amounts of rocky material and water. Previous measurements of Ganymede’s gravitational field and intrinsic magnetic field by the Galileo orbiter suggest that its interior is completely differentiated into three layers, a convecting metallic core at the center, a rocky mantle surrounding the core, and an outermost water-ice shell. The water-ice layer in total has a thickness of 800-1000 km. A layer of melted, salty water that lies beneath the icy crust would be the best way to explain the signal of magnetic induction.

To investigate the lifetime of an ocean (thickness change through time) assumed to be initially in an entirely liquid state, we performed numerical simulations for the internal thermal evolution using a spherically symmetric model for the convective and conductive heat transfer with radial dependence of viscosity, heat source distribution, and other material properties. Here we take into account the energy due to decay of long-lived radioactive elements and also evaluate the effect of tidal heating. If the ocean were composed of pure water, a primordial ocean would have disappeared (completely solidified) within 1 Gyr even if tidal heating for the current orbital state were included. Consistent with previous predictions , this result indicates that significant tidal heating in the past, or strong antifreeze components (e.g., salts or ammonia),

are needed if the presence of the internal ocean in Ganymede would be confirmed from future JUICE observations. We numerically investigate their effect on the lifetime of the ocean.

Keywords: satellite, evolution, ocean, habitability, ice, Ganymede

Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

PPS01-05 会場:418 時間:4 月 30 日 15:25-15:40

冥王星における衝突盆地の緩和: 内部海存在への示唆
Impact basin relaxation on Pluto: Implications for the presence of a subsurface ocean

鎌田 俊一 [1*] ; Francis Nimmo[2]
KAMATA, Shunichi[1*] ; NIMMO, Francis[2]

[1] 北海道大学理学研究院, [2] カリフォルニア大学サンタクルーズ校
[1]Hokkaido University, [2]UC Santa Cruz

Large-scale topographies, such as impact basins, on solid planetary bodies deform in geologically long timescales. The degree of deformation depends mainly on the viscosity, and the viscosity is strongly controlled by temperature. Consequently, viscous relaxation of large impact basins has been studied to investigate the thermal evolution of terrestrial planets as well as that of icy satellites of giant planets [e.g., 1-4].

Pluto, an icy dwarf planet, is likely to possess large impact basins. In this study, we investigate long-term viscoelastic deformation of impact basins on Pluto which can be compared with forthcoming observational data from New Horizons, the first Pluto explorer.

Although little is known for Pluto, its interior is likely differentiated into a rocky core and an outer H_2O layer [e.g., 5]. The presence of a subsurface ocean, however, is highly uncertain. If the outer (solid) H_2O layer is convective, the radiogenic heat from the rocky core is efficiently transferred to the surface, and temperature of the H_2O layer can be lower than its melting temperature. On the other hand, if the outer H_2O layer is conductive, the heat from the core can melt the H_2O layer. The main controlling factor whether the H_2O layer is convective or conductive is the reference viscosity: the ice viscosity at its melting temperature [6]. In this study, we calculate viscoelastic deformation of impact basins assuming different viscosity profiles and examine the effect of the presence of a subsurface ocean on basin relaxation.

For the initial study, we use two time-independent viscosity profiles; one profile assumes a stiff top shell overlying a thick subsurface ocean, and the other assumes a completely solidified interior. The same viscosity profile in the shell is assumed.

Our results indicate that the instantaneous elastic response largely differ between the viscosity models. However, long-term relaxation does not differ much because it is controlled by the viscosity profile in the shell, which is identical in our calculations. Nevertheless, long-term relaxation strongly depends on the reference viscosity, the main controlling factor whether the shell is convective. Consequently, relaxation state of impact basins can be used to infer the reference viscosity as well as the presence of a subsurface ocean. This result would be applicable to icy satellites of Jupiter and Saturn.

Our next step is to use time-dependent viscosity profiles. To do so, we have modified our relaxation code to take into account the temporal change in the shell thickness. The results will be discussed.

[1] Kamata et al. JGR 118, 398-415, 2013. [2] Mohit and Phillips, GRL, 34, L21204, 2007. [3] Robuchon et al. Icarus 207, 959-971, 2010. [4] Solomon et al. JGR 87, 7763-7771, 1982. [5] McKinnon et al. in Pluto and Charon, pp. 295-343, 1997. [6] Robuchon and Nimmo, Icarus 214, 426-439, 2011.

キーワード: 衝突盆地, 緩和, 冥王星, 粘弾性
Keywords: Impact basin, Relaxation, Pluto, Viscoelasticity

Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

PPS01-06 会場:418 時間:4 月 30 日 15:40-15:55

サブミリ波観測で拓く氷天体の固体惑星科学：惑星形成と宇宙化学
Sub-millimeter observations of icy bodies toward understanding of planetary formation and cosmochemistry

関根 康人 [1*] ; 笠井 康子 [2] ; 佐川 英夫 [2] ; 黒田 剛史 [3] ; 兒玉 賢哉 [1] ; 堀 安範 [4] ; 生駒 大洋 [1] ; 倉本 圭 [5] ; 臼本 尚義 [5]
SEKINE, Yasuhito[1*] ; KASAI, Yasuko[2] ; SAGAWA, Hideo[2] ; KURODA, Takeshi[3] ; KODAMA, Kenya[1] ; HORI, Yasunori[4] ; IKOMA, Masahiro[1] ; KURAMOTO, Kiyoshi[5] ; YURIMOTO, Hisayoshi[5]

[1] 東京大学, [2]NICT, [3] 東北大学, [4] 国立天文台, [5] 北海道大学
[1]University of Tokyo, [2]NICT, [3]Tohoku University, [4]NAOJ, [5]Hokkaido University

The present-day composition of regular icy satellites consists of combinations of initial conditions and subsequent evolution. These icy satellites are considered to have been formed in a circumplanetary disk associated with giant planet formation. Thus, icy satellites that are not geologically active, such as Callisto, would serve as solar system fossils, which may preserve the information of the protoplanetary disk and planetary formation. On the other hand, geologically active satellites, such as Europa and Enceladus, would provide particular geological processes and consequent products of geochemical reaction. Sub-millimeter observations are capable of providing unique isotopic and chemical compositions of gas molecules in atmospheres and plumes of the icy satellites. In this paper, we discuss key observational targets and their importance for planetary formation theory and geo/cosmochemistry, especially focusing on sub-millimeter observations of Galilean satellites by the Jupiter Icy moons Explorer mission, JUICE.

キーワード: サブミリ波観測, 氷衛星, 惑星形成, 宇宙化学
Keywords: sub-millimeter observation, icy satellite, planetary formation, cosmochemistry

Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

PPS01-07 会場:418 時間:4 月 30 日 16:15-16:30

周惑星ガス円盤中で形成する巨大氷衛星の原始大気
Proto-atmospheres on giant icy satellites forming within gaseous circum-planetary disks

三上 峻 [1*] ; 倉本 圭 [1]
MIKAMI, Takashi[1*] ; KURAMOTO, Kiyoshi[1]

[1] 北海道大学理学院宇宙理学専攻
[1]Department of Cosmosciences, Graduate School of Science, Hokkaido University

In spite of the great similarity in size and mean density, the giant icy satellites Ganymede, Callisto, and Titan have very different surface environments. In particular, only Titan holds a thick atmosphere dominated by N_2. Recent data of the Cassini spacecraft indicated that atmospheric N_2 is probably originated from other nitrogen-bearing species like NH_3. However, it still remains an open question when and how N_2 was generated. This is partly because the physical states of giant icy satellites have been poorly understood.

According to a widely-accepted theory of regular satellites formation, the giant icy satellites were formed in subnebulae with low temperature and low pressure taking a long accretion time. Some models assert that their surfaces were kept too cold to induce significant differentiation during accretion. However, these satellites may capture a significant amount of subnebula gas, which possibly forms proto-atmospheres along with gases volatilized from icy components. Such a hybrid-type proto-atmosphere may have significant blanketing effect.

Here, we numerically analyze the structure and effect of a hybrid-type proto-atmosphere. Our model atmosphere is hydrostatically connected with subnebula at the satellite Hill radius. It contains H_2 and He as nebula gas components, H_2O and NH3 as volatilized ice components. The radiative-convective equilibrium structure is solved as a function of surface temperature. The subnebula conditions are given by Canup and Ward (2002), the temperatures are 150 K at Ganymede, 120 K at Callisto, and 50 K at Titan, and the corresponding subnebula pressures are varied over 0.1-10 Pa.

For all the boundary conditions, the proto-atmosphere is opaque due to water vapor, so that the outgoing thermal radiation (OTR) flux at top of the atmosphere is smaller than that of black body radiation without atmosphere when the surface temperature is higher than 273 K. When the surface temperature is lower, the OTR fluxes from the proto-atmospheres of Ganymede and Callisto are close to black-body radiation because these atmospheres have low surface pressure and are optically thin due to large scale height under high background temperature. On the other hand, the proto-atmosphere of Titan has another type of solution with the OTR fluxes significant lower than blackbody radiation under low surface temperature. This is due to the formation of optically thick atmosphere tightly bounded by gravity because of low background temperature.

These results imply that a warm proto-atmosphere near 200 K could be kept on Titan for a long time after the end of accretion. Our stability analysis suggests that the proto-atmospheres of Ganymede and Callisto were lost associated with the dissipation of the Jovian subnebula, but that of Titan survived after the dissipation of the Saturnian subnebula.

In the case, NH_3 vapor pressure would be kept high under the irradiation of the solar UV for a long time. The present atmospheric N_2 of Titan may be generated by photochemical reaction of NH_3 vapor in such a warm proto-atmosphere.

キーワード: 巨大氷衛星, 大気, 周惑星円盤
Keywords: Giant icy satellites, Atmosphere, Circum-planetary disks

Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

PPS01-08 会場:418 時間:4 月 30 日 16:30-16:45

木星と土星における雲形成過程の違い
The difference of cloud formation process between Jupiter and Saturn.

高橋 康人 [1*] ; はしもと じょーじ [2] ; 石渡 正樹 [1] ; 高橋 芳幸 [3] ; 大西 将徳 [3] ; 倉本 圭 [1]
TAKAHASHI, Yasuto[1*] ; HASHIMOTO, George[2] ; ISHIWATARI, Masaki[1] ; TAKAHASHI, Yoshiyuki[3] ; ONISHI, Masanori[3] ; KURAMOTO, Kiyoshi[1]

[1] 北海道大学, [2] 岡山大学, [3] 神戸大学
[1]Hokkaido Univ, [2]Okayama Univ, [3]Kobe Univ

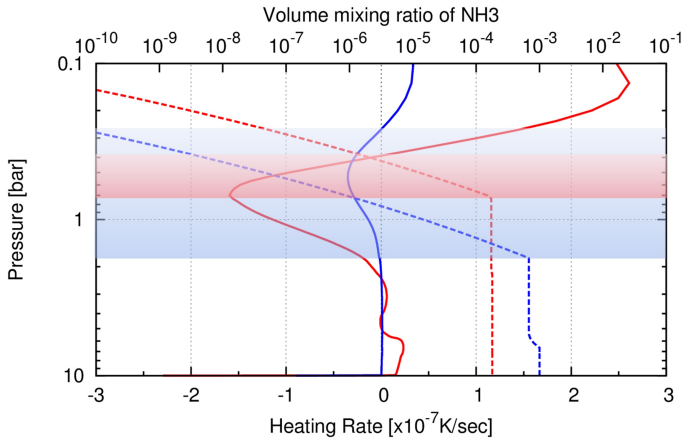
Gas giant planets have hydrogen-rich, thick atmospheres, and their styles of cloud activities are thought to be closely related to the profile of radiative cooling rate in troposphere. For example, Recent studies indicate that it basically controls the intermittency of cumulonimbus clouds. In spite of its significance, however, no systematic estimate has been made for the radiative cooling profiles of gas giant planets.

Recently, we have developed a 1D radiative-convective equilibrium model for such hydrogen-rich atmospheres. The model atmosphere continues to a lower boundary where the optical depth from the top of atmosphere is sufficiently large and the thermal structure follows convective equilibrium. The atmospheric composition and potential temperature of each planet are given from observational constraints. The mixing ratios of H2O, CH4, NH3, H2S, PH3 and NH4SH follow their saturation vapor pressure in the altitudes where their condensation occurs. Collision induced absorption of H2-H2 and H2-He, and line absorption of H2O, CH4, NH3, H2S, PH3 are included while the extinction by condensates is neglected. Under these settings, our model can calculate a reasonable atmospheric vertical structure by the iteration of radiative transfer calculation and convective adjustment.

For the case of Jupiter, the peak of radiative cooling rate is 1.6e-7 K/sec at 0.7 bar level. Also, our model predicts the radiative-convective boundary i.e., tropopause to be located around 0.3-0.4 bar level, where is slightly higher than the uppermost NH3 condensation layer ˜0.5 bar. For the case of Saturn, the peak of radiative cooling rate is 3.5e-8 K/sec at 0.53 bar, and the separation of tropopause and NH3 cloud layer is larger than that of Jupiter. This implies that the Saturnian NH3 cloud formation is essentially confined in the troposphere, whereas the Jovian one is also affected by the stratospheric processes.

Figure description : Radiative heating rate profile (solid lines, bottom x axis, K/sec) and Volume mixing ratio of NH3 profile (dashed lines, top x axis, mole fraction). Y axis is pressure (bar). Shaded area represents between NH3 condensation level and tropopause level. Red means Jovian model, and blue means Saturnian model. Note that these results are calculated with the polytropic temperature profiles for preliminary calculation, not thermal equilibrium profiles.

Keywords: Jupiter, Saturn, Cloud, Radiative transfer, Convection



Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

PPS01-09 会場:418 時間:4 月 30 日 16:45-17:00

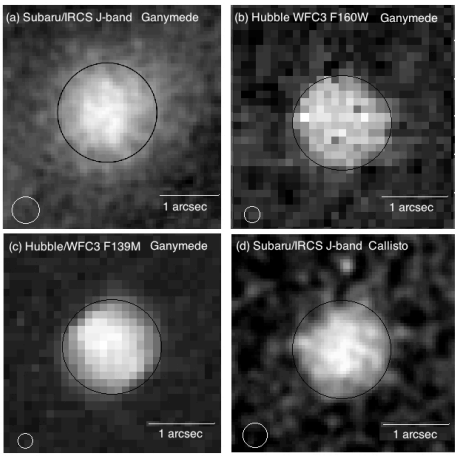
木星の影中におけるガニメデ・カリストの予想外の近赤外線輝度の検出
Near-infrared detections of surprisingly bright Ganymede and Callisto in the Jovian shadow

津村 耕司[1*] ; 有松 亘[2] ; 江上 英一[3] ; 早野 裕[4] ; 本田 親寿[5] ; 木村 淳[6] ; 倉本 圭[7] ; 松浦 周二[1] ; 美濃和 陽典[4] ; 中島 健介[8] ; 中本 泰史[9] ; 白旗 麻衣[1] ; スレース ジェイソン[10] ; 高橋 康人[7] ; 和田 武彦[1]
TSUMURA, Kohji[1*] ; ARIMATSU, Ko[2] ; EGAMI, Eiichi[3] ; HAYANO, Yutakla[4] ; HONDA, Chikatoshi[5] ; KIMURA, Jun[6] ; KURAMOTO, Kiyoshi[7] ; MATSUURA, Shuji[1] ; MINOWA, Yosuke[4] ; NAKAJIMA, Kensuke[8] ; NAKAMOTO, Taishi[9] ; SHIRAHATA, Mai[1] ; SURACE, Jason[10] ; TAKAHASHI, Yasuto[7] ; WADA, Takehiko[1]

[1] 宇宙航空研究開発機構　宇宙科学研究所, [2] 東京大学, [3] アリゾナ大学, [4] 国立天文台　すばる観測所, [5] 会津大学, [6] 東京工業大学　地球生命研究所, [7] 北海道大学, [8] 九州大学, [9] 東京工業大学, [10] カリフォルニア工科大学
[1]Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, [2]University of Tokyo, [3]Arizona University, [4]Subaru Observatory, Natinal Astronomical Observatory of Japan, [5]The University of Aizu, [6]Earth-Life Science Institute, Tokyo Institute of Technology, [7]Hokkaido University, [8]Kyushu University, [9]Tokyo Institute of Technology, [10]California Institute of Technology

The Galilean satellites (Io, Europa, Ganymede, and Callisto) are expected to be dark when eclipsed by the Jovian shadow. However, we have discovered that Ganymede and Callisto are still surprisingly bright at 1.5 μm even when not directly lit by sunlight, based on observations from the Hubble Space Telescope and the Subaru Telescope. Their eclipsed luminosity was one-millionth of their uneclipsed brightness (i.e. $\sim$50 μJy for Ganymede and $\sim$30 μJy for Callisto in eclipse), which is low enough that this phenomenon has been undiscovered until now. In contrast, Europa in eclipse was not detected ($<$5.5 μJy), a potential clue to the origin of the source of luminosity. Likewise, Ganymede was observed at 3.6 μm by the Spitzer Space Telescope but it was not detected either ($<$3.6 μJy), suggesting a significant wavelength dependence. Why are they luminous even when in the Jovian shadow? These facts may be consistent with sunlight scattered by dust in the Jovian upper atmosphere, and if this is the case, observations of Ganymede and Callisto while eclipsed by the Jovian shadow provide us with a new method to investigate Jupiter's atmospheric composition.

キーワード: ガリレオ衛星食, ガニメデ, カリスト, エウロパ, 木星上層大気
Keywords: Galilean satellite eclipse, Ganymede, Callisto, Europa, Jovian upper atmosphere



Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

PPS01-10 会場:418 時間:4 月 30 日 17:00-17:15

木星成層圏における分子による放射強制のシミュレーション
Simulated radiative forcing by molecules in Jupiter's stratosphere

黒田 剛史 [1*] ; Medvedev Alexander[2] ; Hartogh Paul[2]
KURODA, Takeshi[1*] ; MEDVEDEV, Alexander[2] ; HARTOGH, Paul[2]

[1] 東北大・理, [2] マックスプランク太陽系研究所
[1]Tohoku Univ., [2]MPS

本発表では，木星の上部対流圏および成層圏 (10^{3}～10^{-3} hPa) における大気分子による放射加熱・冷却率について，大気大循環モデル (GCM) への導入用に開発された大気放射スキームを用いた計算結果を示す．このスキームは相関*k*-分布法に基づいたバンドモデルで，CH_4 による太陽光吸収，および C_2H_6, C_2H_2, CH_4 分子ならびに H_2-H_2/H_2-He 衝突誘起吸収による赤外放射を考慮している．

このバンドモデルによる計算結果は，line-by-line 法と比較して誤差 10%以内の精度を達成しており，よってこのスキームを用いた炭化水素の混合比の変化による加熱・冷却率の変化，および放射対流平衡温度の計算結果を本発表で紹介する．放射対流平衡温度は赤道域において観測された鉛直温度分布に近い結果が得られた．またこのスキームを用いた計算では，上部成層圏の放射強制が Conrath et al. [1990] による示唆よりもはるかに強いことが示された．本研究での計算結果では放射緩和時間は上層に行くにつれて指数関数的に短くなり，対流圏界面付近では約 10^{8} 秒の放射緩和時間が上部成層圏では約 10^{5} 秒となっている．

キーワード: 木星, 大気放射, 巨大ガス惑星, JUICE
Keywords: Jupiter, atmospheric radiation, gas giants, JUICE

Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

PPS01-11 会場:418 時間:4 月 30 日 17:15-17:35

地球周回からみた木星と金星
EXCEED EUV spectral images of Jupiter and Venus

吉川 一朗 [1*] ; 吉岡 和夫 [2] ; 村上 豪 [2] ; 土屋 史紀 [3]
YOSHIKAWA, Ichiro[1*] ; YOSHIOKA, Kazuo[2] ; MURAKAMI, Go[2] ; TSUCHIYA, Fuminori[3]

[1] 東京大学, [2] 宇宙研, [3] 東北大学
[1]University of Tokyo, [2]ISAS, [3]Tohoku University

An earth-orbiting Extreme Ultraviolet (EUV) spectroscopy is the first mission of the Small scientific satellite Platform for Rapid Investigation and Test -A (Sprint-A) conducted by ISAS/JAXA. A single science instrument (EXCEED) is boarded on Sprint-A. We have started to observe the solar planets in the EUV spectral range, and will extend to the identification of extrasolar planet atmosphere.

SPRINT-A is the world's first observatory in space observing planets, Venus, Mars, Jupiter, and Saturn. Spectroscopic imaging in the spectral range of extreme ultraviolet (EUV), which cannot be observed on the ground, allows us to collect information on the atmosphere that flows into space and the magnetosphere. This enables us to analyze the composition of the atmosphere and the behavior of the magnetosphere. I will show the first light of the EXCEED and the next.

キーワード: 惑星大気光, スプリント A, 極端紫外光, 惑星プラズマ, 可視化
Keywords: Planetary Airglows, Sprint-A, EUV, plasma, visualization

Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

PPS01-12 会場:418 時間:4 月 30 日 17:35-17:50

Occurrence characteristics of Saturn's short-term radio burst
Occurrence characteristics of Saturn's short-term radio burst

丸野 大地 [1] ; 笠羽 康正 [1*] ; 木村 智樹 [2] ; 森岡 昭 [1] ; Cecconi Baptiste[3]
MARUNO, Daichi[1] ; KASABA, Yasumasa[1*] ; KIMURA, Tomoki[2] ; MORIOKA, Akira[1] ; CECCONI, Baptiste[3]

[1] 東北大, [2]ISAS/JAXA, [3]Obs. Paris
[1]Tohoku Univ., [2]ISAS/JAXA, [3]Obs. Paris

Saturn kilometric radiation (SKR) is emitted from auroral electrons and suggested to be correlated with Saturn's auroral processes. We extracted northern SKR (N-SKR) and southern SKR (S-SKR) burst events, by newly defined selection criteria, with radio data observed by the Cassini Radio and Plasma Wave Science (RPWS) instrument in the period from day 250 of 2005 to day 200 of 2006. The data was separated into northern and southern components according to its circular polarization degree. As a result, 16 N-SKR burst events and 36 S-SKR burst events were identified in this period. Based on statistical studies of these events, we obtained the following results: (1) We derived typical frequency profiles of N- and S-SKR during SKR bursts to compare the intensity of N- and S-SKR bursts. The profiles show that the S-SKR burst was more intense than the N-SKR by 7 dB in the main frequency range. From the recent studies, the north-south asymmetry could be explained by the difference in solar illumination due to the tilted the magnetic and rotational axis. (2) By comparing onset timings of N- and S-SKR bursts, we found that 67 % of S-SKR burst events were accompanied by N-SKR bursts or burst-like enhancements. (3) To elucidate what determines the timing of SKR burst onsets, we compared the onset timing of N- and S-SKR bursts with each SKR phase of the periodic modulations. The result showed that the timing of SKR burst onsets generally depends on both the N- and S-SKR modulation phases. This suggests the existence of the internal control of SKR burst onsets. It is, however, noted that some SKR bursts occurred out of phases with SKR modulation phases. That indicates the timing of SKR bursts can also be determined by the external process, i.e., solar wind compressions. (4) We investigated the time evolutions of SKR intensities in the main frequency range and the low frequency range before and after SKR bursts. By comparing them with AKR intensity evolutions at AKR breakup, we found that they had two similarities: the enhancement of lower-altitude source regions prior to onsets and the formation of the distinct higher source regions. On the other hand, their timescales are quite different. In addition, this study pointed out that the two-step evolution scenario could not be directly applied to Saturn's case.

In conclusion, our study demonstrated the north-south asymmetry, the conjugacy and the dependence on the SKR periodic modulations of SKR bursts. These results would be helpful for understanding the auroral process at Saturn's magnetotail reconnections by elucidating the relationship between SKR bursts and reconnections. We consider the third result is particularly important because this suggests that both northern and southern periodicities would affect magnetotail reconnections.

キーワード: 土星, SKR, aurora, Cassini
Keywords: Saturn, SKR, aurora, Cassini

Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

PPS01-P01 会場:3 階ポスター会場 時間:4 月 30 日 18:15-19:30

木星圏探査機 JUICE 搭載サブミリ波放射計 SWI の開発
Submillimeter-Wave Instrument (SWI) for JUICE: Current Status of the Instrumental Development

佐川 英夫 [1*] ; 笠井 康子 [1] ; 菊池 健一 [1] ; 西堀 俊幸 [2] ; 真鍋 武嗣 [3] ; 落合 啓 [1] ; 黒田 剛史 [4] ; 関根 康人 [5] ; Hartogh Paul[6]
SAGAWA, Hideo[1*] ; KASAI, Yasuko[1] ; KIKUCHI, Kenichi[1] ; NISHIBORI, Toshiyuki[2] ; MANABE, Takeshi[3] ; OCHIAI, Satoshi[1] ; KURODA, Takeshi[4] ; SEKINE, Yasuhito[5] ; HARTOGH, Paul[6]

[1] 情報通信研究機構, [2] 宇宙航空開発研究機構, [3] 大阪府立大学, [4] 東北大学, [5] 東京大学, [6] マックスプランク研究所 太陽系研究部門
[1]National Institute of Information and Communications Technology (NICT), [2]Japan Aerospace Exploration Agency, [3]Osaka Prefecture University, [4]Tohoku University, [5]University of Tokyo, [6]Max Planck Institute for Solar System Research

The Submillimetre-Wave Instrument (SWI) is a passive submillimeter-wave heterodyne instrument proposed as one of the scientific payload instruments for the Jupiter Icy Moons Explorer (JUICE) mission. It measures the thermal emission from atmosphere of Jupiter and its moons at the frequency region of 500 - 600 GHz (with keeping 1200 GHz range as an optional concept). Thermal emission from the surface of moons will also be measured. JUICE/SWI provides unique observational data for characterization of the Jovian stratosphere such as thermal structure, dynamics, and distribution of minor species; and for exploration of tenuous-atmosphere and surface environment of the Jovian moons. By detecting hydrogen and oxygen isotopes in the water vapor of Jovian moons' atmosphere, SWI can also contribute to understanding the origin and distribution of water in our solar system.

This paper presents the current status of the development of SWI instrument, including the updates on the science targets and their feasibility studies. The SWI instrument is being developed through international cooperation. The Japanese team contributes to the development of the submillimeter reflector (mirror). The submillimeter reflector is one of the key components of SWI, and it determines the spatial resolution of observations. Currently a 30-cm aperture diameter reflector is considered, providing a spatial resolution of 2 mrad (FWHM) at 600 GHz. In order to fulfill the stringent requirement of weight reduction, we evaluated the material of the reflector and optimized its rib structure. The side lobe suppression is also an important factor to improve the quality of observations.

キーワード: 木星, 氷衛星, JUICE, サブミリ波, リモートセンシング, 測器開発
Keywords: Jupiter, Icy moon, JUICE, Submillimeter wave, Heterodyne

Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

PPS01-P02 会場:3 階ポスター会場 時間:4 月 30 日 18:15-19:30

Development of JUICE/Ganymede Laser Altimeter (GALA)
Development of JUICE/Ganymede Laser Altimeter (GALA)

並木 則行[1] ; 木村 淳[2*] ; 小林 正規[1] ; Hussmann Hauke[3] ; Lingenauber Kay[3] ; GALA-Japan Team[4]
NAMIKI, Noriyuki[1] ; KIMURA, Jun[2*] ; KOBAYASHI, Masanori[1] ; HUSSMANN, Hauke[3] ; LINGENAUBER, Kay[3] ; TEAM, Gala-japan[4]

[1] 千葉工業大学惑星探査研究センター, [2] 東京工業大学地球生命研究所, [3] ドイツ航空宇宙研究所, [4]JUICE Japan Group
[1]PERC/Chitech, [2]Earth-Life Science Institute, Tokyo institute of Technology, [3]DLR Institute of Planetary Research, [4]JUICE Japan Group

The overarching theme for JUICE is: The emergence of habitable worlds around gas giants, and the focus is to characterise the conditions that may have led to the emergence of habitable environments among the Jovian icy satellites, with special emphasis on the three oceanbearing worlds, Ganymede, Europa, and Callisto. JUICE will be launched in 2022, and will arrive at Jupiter in 2030. After several fly-bys to Europa and Callisto, JUICE will be inserted into an orbit around Ganymede in 2032 and will continue scientific observations for eight months until the end of nominal mission in 2033. Ganymede Laser Altimeter, GALA, measures distance between the spacecraft and the surface of the satellite from time of flight of a laser pulse. Together with positions of the spacecraft and mass center of the satellite, surface topography of the satellite is calculated from measured distances. The GALA data are particularly important for finding of internal ocean.

1) if the ocean exists beneath icy crust, tidal deformation of the satellite is so large that temporal variation of the topography as great as a few tens meter shall be detected.

2) small eccentricity of orbit of Ganymede causes libration that will be observed as lateral shifts of footprint of laser beam at the surface.

3) improved determination of spacecraft orbits by cross over analysis results in precise estimate of low degree harmonics of gravity field. Thus accurate Love number will be calculated to infer internal density structure of the satellite.

Global topographic data derived by GALA are also important for the study of tectonic history at the surface, elastic and viscous structure of ice crust, and thermal evolution of interior of the icy satellite. For example, linear structures such as ridges and grabens reveal extension stresses due to past variation of thermal states. As well, flat surface and thin crust may indicate partial melting of the crust and consequent internal lake. These observations on various geologic activities lead to understanding of transport of heat and materials from interior to the surface. Further, a comparison of styles of tectonics of ice crust and that of silicate lithosphere will likely shed a new light on the theory of plate tectonics of the Earth.

GALA is developed by international collaboration of scientists and engineers in Germany, Switzerland, and Japan. Its conceptual design is based on the laser altimeter on board of Mercury orbiter, BepiColombo, and consists of transceiver unit (TRU) with laser optics and appropriate electronics, electronic unit (ELU) with digital range finder module, digital processing module and power converter module, and laser electronic unit (LEU) with laser control electronics. Japanese team provides receiver telescope, backend optics, detector, and analogue electronics of TRU. The transmission optics of TRU and entire LEU are developed at DLR in Germany, and ELU is developed at Bern University in Switzerland. Assembly and integration are conducted at DLR under a supervision of the principal investigator of GALA. We therefore need to pay special caution on interfaces between analogue electronics and range finder, low-temperature environment, and radiation environment that Japanese space scientists have never experienced before.
Keywords: Jupiter, Ganymede, Laser Altimeter, Exploration, Spacecraft, Habitability

Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

PPS01-P03 会場:3 階ポスター会場 時間:4 月 30 日 18:15-19:30

周惑星円盤への衛星材料物質の供給
Accretion of Solid Materials onto Circumplanetary Disks from Protoplanetary Disks

谷川 享行 [1*] ; 丸田 有希人 [2] ; 町田 正博 [2]
TANIGAWA, Takayuki[1*] ; MARUTA, Akito[2] ; MACHIDA, Masahiro[2]

[1] 北大低温研, [2] 九大理
[1]ILTS, Hokkaido University, [2]Kyushu University

We investigate accretion of solid materials onto circumplanetary disks from heliocentric orbits rotating in protoplanetary disks, which is a key process for the formation of regular satellite systems. In the late stage of gas-capturing phase of giant planet formation, the accreting gas from protoplanetary disks forms circumplanetary disks. Since the accretion flow toward the circumplanetary disks affects the particle motion through gas drag force, we use hydrodynamic simulation data for the gas drag term to calculate the motion of solid materials. We consider wide range of size for the solid particles (10^{-2}-10^{6}m), and find that the accretion efficiency of the solid particles peaks around 10m-sized particles because energy dissipation of drag with circum-planetary disk gas in this size regime is most effective. The efficiency for particles larger than 10m size becomes lower because gas drag becomes less effective. For particles smaller than 10m, the efficiency is lower because the particles are strongly coupled with the back-ground gas flow, which prevent particles from accretion. We also find that the distance from the planet where the particles are captured by the circumplanetary disks is in a narrow range and well described as a function of the particle size.

キーワード: 衛星形成, 周惑星円盤
Keywords: satellite formation, circumplanetary disks