Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

PCG32-01 Room:A03 Time:May 25 15:15-15:30

Venus Orbit Insertion of Venus Climate Orbiter "AKATSUKI" in 2015

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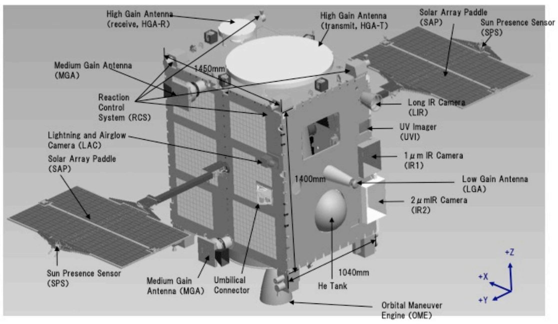
Venus Climate Orbiter AKATSUKI will be put into the Venus orbit in 2015. We will describe the detail of this challange.

Keywords: Venus Atmosphere, Exploration



PCG32-02 Room:A03 Time:May 25 15:30-15:45

Interannual Variability of Venus Albedo as Inferred from LASCO C3 Data

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Venus albedo in 4 bands (B, V, R, and IR) is measured in "superior conjunction" transits within LASCO C3 field of view. The data are available for 15 year period (1996-2011). The study is motivated by our recent finding of difference between 2 phase curves of Venus at small phase angles (Satoh et al., 2015; Mallama et al., 2006). The advantage of LASCO data is, needless to say, it is free of scattered light by the earth atmosphere to observe objects near the sun. With the field of view of LASCO C3 (30 R_{sun}), up to 11 degrees phase angle of Venus can be studied.

Because Venus is too bright for nominal exposure time of LASCO (a few hundred seconds for faint coronae), the images of Venus is highly overexposed, resulting in saturation and blooming in the direction of charge transfer in CCD. We have developed a method to integrate such signals and evaluated its accuracy by measuring the brightnesses of stars (Aldebaran and Antares in IR). Measured star flux is found to be stable at the level of +/- 10 %, which is quite good as red-giants exhibit similar magnitude of pulsation.

In Venus data, we have found that brightness in IR seems to have changed between 2003 and 2005 transits. The data in 1996-2003 are systematically ~20 % brighter than the data in 2005-2011. It is noteworthy that Mallama et al.'s phase curves include the data from the former and Satoh et al.'s phase curves are in 2011 (the period of latter group). Details of data analysis and possible cause of such change will be discussed.

Keywords: Venus, Albedo, Interannual variation, SOHO, LASCO, C3

PCG32-03 Room:A03 Time:May 25 15:45-16:00

The study of Venus transit for the extinction in the atmosphere of Venus and the plan for limb imaging by Akatsuki

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The study for the limb arc radiation from the solar photosphere observed during the transit of Venus will be reported following SGEPSS meeting in 2014. The occulted flux observed by SOT is determined from some parameters; the solar flux, the refraction angle through the atmosphere of Venus, and the extinction by the atmosphere.

The solar flux is determined as the average un-occulted solar flux from the photosphere. The solid angle for the flux must change by the focusing effect and the spread due to the refraction angle gradient to the altitude. The refraction angle to the encountering solar radiation is calculated.

The flux in the atmosphere of Venus is decreased by the extinction due to the absorption and scattering by the molecular and the scattering by the cloud particles and the haze. The phase function of the Mie scattering for the cloud particles shows the strong forward peak. When the source function for the radiative-transfer equation is supposed to 0, the extinction due to the cloud particles could be derived from the Beer's law. Our goal is the accuracy on determining the number density of the cloud particles is better than 10 km and 1/cc in the atmosphere of Venus. The observation wavelength is 388.3 nm.

Akatsuki is planned to be inserted into Venus orbit in this year. We will be able to take images capturing the limb of Venus around the apoapsis. The plan to obtain the three-dimensional map of the cloud particles and the haze will be discussed.

Keywords: The atmosphere of Venus, Hinode, The solar occultation, Akatsuki, Aerosol

Japan Geoscience Union Meeting 2015
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PCG32-04 Room:A03 Time:May 25 16:15-16:30

Ground-based observation of 4.7um Venusian airglow

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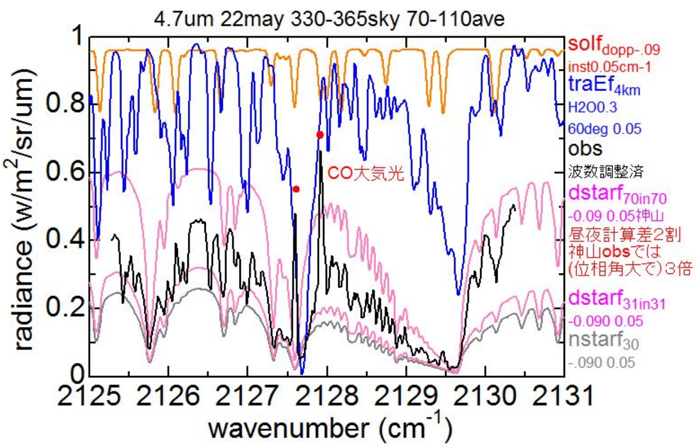
At first, the main part of the proposal on May 2014 to NASA/IRTF was 'To investigate the driving mechanism of the Super Rotation by comparing the waves at 60km by 1.7um spectroscopy and those at 70km by VEX/VMC'. Although agreement of simultaneous observation was there, it was canceled suddenly. Then we decided to get 70km data using 5um spectroscopy.

This is because cloud particles become black above 3um, and the height of tau=1 appears at 70km. This means the 5um observation will see waves at 70km.We selected 5.04um and 4.7um; the former is the region of least gas absorption and the latter is for comparison with Kouyama 4.7um data.

The 5.04um spectrum was successfully synthesized, but that at 4.7um was not with 2 emission lines appear at 2127.6 and 2127.9 cm-1. In the figure from top to bottom, solar(red), earth absorption(blue), Venus day(Kamiyama condition, pink), observed(black), Venus day(May condition, pink), Venus night(May condition, gray). A strong earth's CO absorption line is seen at 2127.6 cm-1. Those emission lines are seen even before sky subtraction on the Venus disk meaning them to be Venus origin.

However, no such pair of lines was found in HITRAN. I thought 'It may be a new finding?'. However, by searching old papers, it was found that the 4.7um Venus dayglow was observed 20 year ago. They are P4(1,0) and R2(2,1) lines, and the latter may be used to fined out CO distribution at the cloud top.

Keywords: venus, IR airglow, ground-based



Japan Geoscience Union Meeting 2015
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PCG32-05 Room:A03 Time:May 25 16:30-16:45

The cyclical nature of the propagation of planetary-scale UV feature changes within one Venus year

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Our ground-based Venus observations from mid-August 2013 to the end of June 2014 reveal that the periodical variation in the UV brightness changes within one Venus year and the traveling velocity is dominantly increased. Pioneer Venus spacecraft previously observed the periodical variation of UV brightness with the period 4-5 days, which caused by that the travel of planetary scale UV features [Del Genio and Rossow, 1982, 1990]. They suggested that the period of brightness variation corresponds to the propagation of planetary waves and it changes on a time scale of 5-10 years. Periodicity change can be argued as the vacillation of dynamical states and investigating the source of planetary waves is required to understand the Venus super-rotation.

Used instrument is an imager with 365 nm narrow-band filter installed on 1.6m Pirka telescope, which is operated by Hokkaido University, and we measured the UV brightness from equatorial to mid-latitudinal regions in both hemispheres. Our observations cover about one Venus year and have superiority for investigating the monthly change as compared to the Pioneer Venus observations.

We have two observational periods when the brightness has the prominent periodical variation. Latter season is considered to keep the periodicity for about two months. In August 2013, we detected about 5.2 days periodical brightness variation in equatorial and both northern and southern mid-latitudinal region. Bright and dark pattern had a prominent periodical and symmetric structure about the equator and we consider it is derived from a high contrast Y-feature such as previously observed by the Galileo spacecraft. On the other hand, after the mid-September 2013, there was no prominent and periodical brightness variation in the most of the observation time. In this season, the periodical and symmetric brightness structure has a cycle of being clear and unclear, and it suggests the Y-feature has a few weeks variation. From mid-September 2013 to the end of March 2014, periodical variation seems to be lost or one more accelerate and decelerate cycle should exist. In the last two months (from the beginning of May to the end of June 2014), however, it has 3.5 days period and perhaps last for about two months. Our study points out the possibility of the change of dynamical states occur in one Venus year.

Keywords: Venus, Pirka telescope, Super-rotation, UV feature

Japan Geoscience Union Meeting 2015
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PCG32-06 Room:A03 Time:May 25 16:45-17:00

Millimeter-Wave Band Monitoring Observations of the Terrestrial Planets in the Solar System with 10-m SPART Telescope

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For understanding the influence of the activities of central stars on the middle and lower atmospheres of terrestrial planets in the solar system and of exoplanets, we have been performing monitoring observations of millimeter-waveband spectral lines of carbon monoxide (^{12}CO: J=1-0 230.538 GHz, J=2-1 115.2712018 GHz; ^{13}CO: J=2-1 230.3986765 GHz) in the middle atmospheres of Mars and Venus with a 10-m telescope, Solar Planetary Atmosphere Research Telescope (SPART), since it was launched in 2011. SPART employs highly sensitive 100- and 200-GHz double-band superconducting SIS heterodyne detectors and a 1-GHz-band digital fast-Fourier-transform spectrometer with a frequency resolution of 67 kHz. The heterodyne spectroscopy with high frequency resolution is a powerful tool to trace the weak and narrow spectral lines of minor constituents in the middle atmosphere of planets.

The results obtained with SPART suggest that the disk-averaged mixing ratio of carbon monoxide derived at an altitude of approximately 80 km in Venus has steadily decreased since 2012. The X- and M-class solar events that reached Venus also seem to have decreased from 2012 to 2014. To study the electron production rate induced by solar energetic particles incident at different altitudes of the planetary middle atmospheres, we also developed an analytical model, using which ionization losses are numerically calculated on the basis of the Bethe?Bloch formula. The ionization of carbon dioxide induced by solar-energetic-particle events is considered to increase the production rate of CO. With a basic model under conditions of typically great solar-proton events with incident-proton energies of less than 1 GeV, it was found that the ionization rate reaches its maximum at an altitude of 80?90 km in the Venusian atmosphere. These results suggest that the decrease in CO in the Venusian middle atmosphere may be deeply related to the solar activities.

In this conference, we will present these results and the status of the SPART project.

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PCG32-07 Room:A03 Time:May 25 17:00-17:15

Scientific capabilities and measurement sensitivities of the IR heterodyne spectroscopy

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TAKAMI, Kosuke[1]

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Many molecules of atmospheric and astronomical interest exhibit rotational-vibrational spectra in the middle infrared (IR) regime. Fully resolved molecular features with high spectral resolution are possible retrieval of many physical parameters, such as density, velocity, pressure, excitation condition, temperature, and the vertical information from single line profile. In the mid-infrared wavelength region, the highest spectral resolution is provided by the IR heterodyne technique (Kostuik and Mumma, 1983). It is for the applications to astronomy and planetary atmospheric science in 7-13 micron wavelength at the spectral resolution of up to 1E7-8 (corresponds to 1-10m/s) with a very high sensitivity. Notable successes on Venus, Mars, Jupiter, Titan and Earth were given by NASA Goddard Space Flight Center, University of Cologne, and Tohoku University (Fukunishi et al. 1990; Taguchi et al., 1990; Goldstein et al., 1991; Kostuik, 1996; Kostuik et al., 2000; Sonnabend et al., 2012; Sornig et al., 2013) to date.

A new IR heterodyne instrument has been developed by Tohoku University for continuous monitoring of planetary atmospheres using dedicated ground-based telescopes (60cm and 1.8m) at Mt. Haleakala, Hawaii. Remarkable aspects of the instrument are (i) an excellent system noise temperature less than 3000K at 7-10 micron wavelength, (ii) a digital FFT spectrometer as a back-end with high resolution, stability, large dynamic range, flexibility, and the absence of optical or mechanical components, (iii) frequency tuneability over a wide range provided by the use of multi- room-temperature type quantum cascade laser as local oscillators to access various molecules.

Ultra-high resolution spectroscopic measurement (R=1E7) is one of the most powerful tools to explore the planetary atmospheres with several key capabilities: (1) fully resolved molecular features to address the atmospheric temperature profiles, abundance profiles of the atmospheric compositions and their isotopes, (2) direct measurement of the mesospheric wind and temperature with high precision, (3) sensitive detection of minor trace gases, and (4) its small beam size capabilities to allow global mapping. The instrument is set on the Coude focus of the Tohoku 60cm-telescope at Mt. Haleakala in September 2014 to demonstrate the feasibility. The first Mars CO2 non-LTE emission was successfully obtained in November 2014. Its continuous operation will be started from March 2015. Main targets in the verification process are Mars and Venus. Many interesting scientific issues have been targeted and more will be addressed in the future, i.e., planets, comets, the Earth, and the Sun. Extra solar objects like stars and stellar envelopes, proto-planetary disks are also possible targets of interest.

Here the scientific capabilities and measurement sensitivities of the instrument are specifically investigated by the radiative transfer models. We use the Advanced Model for Atmospheric TeraHertz Radiation Analysis and SimUlation (AMATERASU) that is being developed in the framework of NiCT. The model is based on the Microwave Observation and LInes Estimation and REtrieval (MOLIERE) (Baron et al., 2008; Mendrok et al., 2008). We simulated the temperature/wind retrievals from a single nadir observation of CO2 absorption line at R12 970.5472 cm-1. Good temperature retrieval achieves in the rage from surface to 30km on Mars and from 65km to 95km on Venus with better than 10K precision and 10km vertical resolution. The local wind and temperature is directly derived at the middle atmosphere on Mars (75km) and Venus (110km) with 10m/s and 10K precision, respectively. These will enhance our understanding for the middle atmospheric dynamics and its fluctuations caused by the atmospheric waves from the lower atmosphere. Continuous monitoring of planetary atmospheres with its ultra-high resolution will open new insight for understanding the temporal/spatial variations in various time-scales.

Keywords: infrared, heterodyne, spectroscopy, Venus, Mars

PCG32-08 Room:A03 Time:May 25 17:15-17:30

Time variation of wave structure in Jupiter's south polar region observed with ground-based telescope

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A Rossby wave plays an important role in atmospheric phenomena on planets. For example, stratospheric sudden warming in the Earth is caused by a Rossby wave. The south polar wave at about 67^o S in Jupiter is considered as one of signatures of Rossby wave. Previous observations, such as by Cassini ISS in 2000 or the Hubble Space Telescope (HST) from 1994 to 1999 [*Barrado-Izagirre at al*., 2008], show that the polar region is covered by bright diffuse haze and its edge has a wavy structure spreading in longitudinal direction with wavenumber of 12 – 14 at 67^o S, which travels westward with a phase velocity of 0 – 10 m/s in System Ⅲ. These observations suggested that this wave structure is caused by a planetary Rossby wave. However, these observations had been carried out only every other year and the variance of short time scale (about month) is not clear.

We determine whether or not the wave observed at the edge of the stratospheric haze in south polar region is caused by Rossby wave. Using a methane absorption band filter at 889 nm installed at Multi-Spectral Imager (MSI) of the 1.6 m Pirka telescope, we investigated the meridional and vertical wavenumbers and phase velocity of the observed wave structure and zonal wind speed.

In this presentation, we introduce the results of analysis on the time variation of the wave structure in Jupiter's south polar region in 2011 to 2015 observed by the ground-based telescope. Each result is separated by two weeks to a few months in the periods that we can observe Jupiter. Our results show the wavy structure spreading in longitudinal direction at 67^o S. However, our results are different from previous studies in two points. First, we cannot detected an apparent longitudinal motion of the wave structure in our observation periods. Second, there always exist darker areas by about two percent than surrounding longitude in the period of 2011 – 2014. In particular, longitude of about 50^o and 130^o in System Ⅲ are always dark. These dark regions at 889 nm suggest that the cloud top altitude at 67^o S is lower than pressure altitude of 360 mbar. We think there are another atmospheric structures, such as a local eddy or cloud convection, in Jupiter's south polar region other than those caused by a Rossby wave at 67^o S. Our results may suggest that a combination of a planetary Rossby wave and local structure that is less than longitudinal width of 15^o exists at about 67^o S.

Keywords: Jupiter, haze, Rossby wave, polar area, ground-based telescope

PCG32-09 Room:A03 Time:May 25 17:30-17:45

Mechanism for the formation of equatorial superrotation in forced shallow-water turbulence with Newtonian cooling

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The zonally banded patterns and latitudinally alternating zonal jets are striking features of the atmospheres of Jupiter and Saturn. To explain the origin of these zonal structures, a series of studies considers large-scale motions within a shallow surface layer of a planetary atmosphere. One of the models for this "shallow layer" theory is forced shallow-water turbulence on a rotating sphere. This model can reproduce zonal structures and also other features observed in Jupiter and Saturn, such as vortical motions predominating in the polar region and zonal jets having larger amplitudes near the equator (Scott and Polvani, 2007). However, a problem of this model was that it cannot produce a robust equatorial superrotation, as observed in Jupiter and Saturn. This problem was overcome by Scott and Polvani (2008). They revealed that forced shallow-water turbulence can produce robust strong equatorial superrotation, if Newtonian cooling is adopted as the dissipation process instead of Rayleigh friction.

The purpose of the present study is to elucidate the mechanism of the robust formation of equatorial superrotation reported by Scott and Polvani (2008). It is shown that the Newtonian cooling term distorts the structure of the Hough modes. This distortion can be visualized as either the westward or eastward tilting of the equiphase line with increasing the absolute value of latitude; the structural change of the Hough modes leads to the acceleration of the zonal-mean flow. A statistical analysis based on a weak-nonlinear theory predicts that stochastically excited Hough modes generate a prograde equatorial jet, the profile of which is quantitatively consistent with that of the ensemble-averaged zonal-mean flow obtained in nonlinear time-evolutions. The predicted prograde equatorial jet originates mainly from the acceleration produced by Rossby modes, the equiphase line of which is tilted westward by the Newtonian cooling term.

(This work was recently published as Saito and Ishioka (2015))

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Saito, I. and K. Ishioka, 2015: Mechanism for the formation of equatorial superrotation in forced shallow-water turbulence with Newtonian cooling. J. Atmos. Sci., in press, now available in Early Online Release form.

Keywords: Jupiter, zonal pattern, forced shallow-water turbulence, equatorial superrotation, Newtonian cooling, Hough mode

PCG32-10 Room:A03 Time:May 25 17:45-18:00

Disappearance of surface banded structure produced by thermal convection in rapidly rotating thin spherical shells

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[1]Department of Mathematics, Kyoto University, [2]Research Institute for Mathematical Sciences, Kyoto University, [3]Department of Earth and Planetary Sciences, Kyoto University, [4]Department of Earth and Planetary Sciences, Kyushu University, [5]Department of Earth and Planetary Sciences, Kobe University

Surface flows of Jupiter and Saturn are characterized by the broad prograde zonal jets around the equator and the narrow alternating zonal jets in mid- and high-latitudes. It is not yet clear whether those surface jets are the result of fluid motions in the ”shallow” weather layer, or they are produced by convective motions in the ”deep” region. ”Shallow” models consider atmospheric motions driven by the solar differential heating and the intrinsic heat flow from the deeper region under the assumption of hydrostatic balance in the vertical direction as a result of the thin atmospheric layer compared with the radius of the planet. These models can produce narrow alternating jets in mid- and high-latitudes, while the equatorial jets are not necessarily prograde. On the other hand, ”deep” models, which describe thermal convection in rapidly rotating spherical shells whose thickness is comparable to the radius of the planet, can produce equatorial prograde flows easily, while it seems to be difficult to generate alternating jets in mid- and high-latitudes.

Heimpel and Aurnou (2007)[1](hereafter, HA2007) proposed thin spherical shell models and show that the equatorial prograde zonal jets and alternating zonal jets in mid- and high-latitudes can be produced simultaneously when the Rayleigh number is sufficiently large and convection becomes active even inside the tangent cylinder. However, they assume eight-fold symmetry in the longitudinal direction and calculate fluid motion only in the one-eighth sector of the whole spherical shell. Such artificial limitation of the computational domain may influence on the structure of the global flow field. For example, zonal flows may not develop efficiently due to the sufficient upward cascade of two-dimensional turbulence, or stability of mean zonal flows may change with the domain size in the longitudinal direction. Further, since time integration of their numerical experiment is so short as 1600 rotation period (0.024 viscous diffusion time), their result may not reach statistically steady state. Therefore, in the present study, we perform long time numerical experiment of thermal convection in the whole thin spherical shell domain, where the experimental setup is same as that of HA2007.

We consider Boussinesq fluid in a spherical shell rotating with constant angular velocity. The non-dimensionalized governing equations consist of equations of continuity, motion, and temperature. The non-dimensional parameters appearing in the governing equations, the Prandtl number, the Ekman number, the modified Rayleigh number, and the radius ratio, are fixed to 0.1, $3x10^{-6}$, 0.05, and 0.85, respectively. The initial condition of the velocity field is state of rest and that of the temperature field is conductive state with random temperature perturbations. After time integration for 7500 rotation period, An equatorial prograde surface zonal jet and alternating banded zonal jets emerge, which seem to be consistent with the result of HA2007. However, extending time integration further, mid- and high- latitudinal regions are entirely accelerated eastward, zonal banded structures disappear, and finally one broad eastward zonal jet appears in mid- and high- latitudes of each hemisphere around 12800 rotation period. Formation of these broad zonal jets is attributed to the angular momentum transport in the radially outward direction by topographic Rossby waves, which are excited by thermal convection inside the tangent cylinder. Note that further time integration is necessary to obtain statistically steady state since kinetic energy still increases in the final state of the present calculation.

Acknowledgement : Numerical computations were carried out on the Earth Simulator (ES2) at the Japan Agency for Marine Earth Science and Technology.

Reference : [1] Heimpel, M., Aurnou, J. (2007) Icarus, 187, 540–557.,

Keywords: atmospheres of the gas giant planets, banded structure, equatorial prograde jet, Rossby waves, Jupiter, Saturn

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PCG32-11 Room:A03 Time:May 26 09:00-09:15

Recent study of atmosphere change and proposed global water system on Venus and Mars

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Introduction: Air and sea water of the Earth-type planets are applied from detailed database of global Earth planet, because huge database of water planet Earth which has been accumulated precisely by our human activity on global Earth is considered to be applied easily and precisely [1].

Characteristics of atmosphere formation: Global atmospheric gas of planets should be continued to be erupted from the interior of the planets with the gravity effect. Venus and Mars with volcanoes along the equators followed the planetary rotations have been released volatile molecules of carbon dioxides previously or now [1].

Characteristics of global water system: The presence of sea-water of Earth planet has been applied for the evidence of past global sea water because of volatile elements in the interior deposits.
However, the phase diagram of the fluid (water and carbon dioxide) suggests that liquid can be stable by sandwiched with solid and air phase [2, 3]. Therefore, global seawater system can be formed basically only for global air system of any planets (Venus and Mars), it is difficult problem of local fluid ions or molecules enough for global water system.

Challenge for changes in atmospheric composition: Primordial planet's atmosphere shows composition with carbon dioxide gas, where it's significant challenge of changed atmospheric composition for future habitable planet. Cold carbon dioxides on Martian air for melting and solidification are generally possible realistically. However hot carbon dioxides (on Venus) are generally difficult to be changed locally and globally. It might be possible to apply present artificial method to change hot gas solidified [4] on the surface (not underground interior) for global system finally.

The possible formation of water system: Volatile systems of air and water separated from solid rocks produce planets of higher density as in Earth and Venus. Therefore there are two dynamic methods to form water system on Venus and Mars of 1) step-by-step method , and 2) rapid evaporation and cooling method. It would be effective proposed methods to form global water system (Venus and Mars) by natural celestial collisions and artificial methods of present science and technology finally [4].

Summary:
1) Formation of air and water systems for waterless Venus and Mars might be possible by experimental study based on new proposed research.
2) Air systems of Venus and Mars are considered to be internal volatile molecules emitted mainly by the planetary rotations.
3) Larger air-planets of Venus and Mars have environments for possible formation of water planets experimentally and naturally.
4) Global changes of cold air (Mars) and hot air (Venus) are possible based on effective scientific processes.
5) Global sea-water system for Venus and Mars by celestial activity and artificial methods is considered to be effective proposed methods.

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[3] Miura Y. (2015): LPSC2016 (LPI), #1811, 1666.
[4] Miura Y. (2009): Patent application.

Keywords: Venus, Mars, Air system, Sea water system, Compositional change, Hot carbon dioxides

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PCG32-12 Room:A03 Time:May 26 09:15-09:30

An MHD simulation study of magnetic reconnection in the dayside Venusian ionosphere

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Venus and Mars have no significant global intrinsic magnetic field. However, it is considered that magnetic reconnection can occur in their ionospheres and magnetotails through the direct interaction with the solar wind. The occurrence frequency distribution of magnetic reconnection at the 400km altitude of Mars has been obtained from magnetic field and electron observations by Mars Global Surveyor [Halekas et al., 2009], but the occurrence frequency at other altitudes is yet to be obtained because of the limitation of its trajectory. In addition, the role of magnetic reconnection in determining the structure and dynamics of the ionospheres of unmagnetized planets has been unclear because there is no observation that constrains the relation among them. Not only observational studies but also theoretical studies have been needed for further understanding magnetic reconnection around unmagnetized planets, and we have studied magnetic reconnection caused by the rotation of interplanetary magnetic field (IMF) in their dayside ionospheres, using a two-dimensional multi-species magnetohydrodynamic (MHD) simulation.

We would infer that magnetic reconnection has a possible relation to some unexplained phenomena observed around the ionospheres of Mars and Venus, considering the dependences of their occurrence rate and spatial distribution on the rotation of IMF. One example is the ejection of plasma 'clouds' from their ionospheres [Brace et al., 1981; Crider et al., 2004]. The occurrence rate of this phenomenon is relatively high when the direction of IMF changes [Ong et al., 1991], and plasma 'clouds' can be ejected by magnetic reconnection caused by the IMF rotation. Another example is the existence of small magnetic rope-like structures called 'flux ropes' [Russell and Elphic, 1979; Cloutier et al.,1999]. When the solar wind dynamic pressure is low, 'flux ropes' are most often observed in the lower ionosphere [Elphic et al., 1983]. So far some models to generate the 'flux ropes' in the ionospheres have been proposed, e.g., Kelvin-Helmholtz instability at the ionopause [Wolff et al., 1980] and nonlinear effects in the lower ionosphere [Kleeorin et al., 1994], and Dreher et al. [1995] suggested that magnetic reconnection due to the IMF rotation generates 'flux ropes' using a numerical simulation.

In this presentation, we will show the time evolution of magnetic reconnection in the dayside Venusian ionosphere and the structure of plasmoids obtained from the two-dimensional multi-species MHD simulation. We will present, in particular, the altitudes where magnetic reconnection effectively develops, the time scale of the development of magnetic reconnection, and the spatial scale of plasmoids generated by the reconnection. Our simulation result shows that multiple magnetic reconnections occur in the current sheet and plasmoids are generated above 240 km altitude, where the Lundquist number is more than 10^6. It has been found that the inflow condition of the current sheet and the growth time of the fast resistive magnetic reconnection [Loureiro et al., 2007] are important factors in determining the altitudes where reconnection effectively develops. Plasma flows into the current sheet from the both side of it above a certain altitude, and reconnection is likely to occur under this inflow condition. However, the intrinsic downward flow in the Venusian lower ionosphere inhibits plasma from flowing into the sheet, which diminishes the reconnection rate below a certain altitude. In addition, we find that the growth time at the lower regions where the fast resistive reconnection does not occur is comparable to or shorter than the time scale of the transportation of magnetic filed. We will examine whether the magnetic reconnection caused by the rotation of IMF generates the ejection of plasma 'clouds' and the 'flux ropes'.

Keywords: Venus, ionosphere, reconnection

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PCG32-13 Room:A03 Time:May 26 09:30-09:45

UV Space Telescope for extrasolar planetary systems

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Many observations have been performed for exoplanets since the first discovery in 1995. The number of detected exoplanets is more than 1800. Some of them orbit around a star with an orbital radius shorter than that of Mercury, which suggests that the high-intensity UV irradiation causes large amount of atmospheric loss.

Many exoplanets were discovered by observing transits. Exoplanetary atmospheric atoms and molecules absorb stellar photons, which causes wavelength-dependent transit depth, though transit depth of an exoplanet without any atmosphere is not wavelength-dependent. Therefore, we can know atmospheric composition from the result of spectroscopic observation of exoplanet transit.

The radius of the exoplanet HD209458b is approximately 1.4 Rj and its semi-major axis is only 0.047 AU. It is called Hot Jupiter. Sodium, hydrogen, magnesium, and H2O have been detected in its atmosphere. Hydrogen was detected using the Hubble Space Telescope and the result shows the optically thick hydrogen atmosphere extends to three times farther than its radius. This also suggests that very large amount of atmospheric loss occurs in the exoplanetary system, which is not in the solar system.

NASA and ESA have already launched and are planning to launch space telescopes dedicated for exoplanets, however, their spectral range is limited to visible and infrared. Though the Hubble Space Telescope is the only telescope for UV range, the operation will be stopped in the near future because of its aging. In this presentation, we introduce our plan for a small UV space telescope project.

Keywords: exoplanet, ultraviolet, space telescope

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Long-term temporal variation of Mercury's sodium exosphere

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Mercury has a very thin atmosphere. It has been observed by space probes Mariner 10 and MESSENGER, and by ground-based observations, to have hydrogen (H), helium (He), oxygen (O), sodium (Na), potassium (K), and calcium (Ca) atoms in its atmosphere. These atoms emit light, with resonance scattering caused by energy from sunlight. Because of its high intensity, the emission of sodium atoms is well suited for studies by ground-based observations. The source processes of Mercury's exosphere are considered to be solar-photon-stimulated desorption, "sputtering" by impacting solar wind particles crashing into Mercury's surface and releasing atoms, and interplanetary dust vaporization. Combination of these three processes is considered to arise, but the primary process among them is unknown as yet.

At the Haleakala Observatory in Hawaii we have observed daily variation of Mercury's sodium exosphere. The observations were performed using a 40 cm Schmidt-Cassegrain telescope, a high-dispersion spectrograph, and a charge coupled device (CCD) camera. During observation seasons, elongation between Mercury and sun is more than 15 degrees, and observation time varies from 30 min to 1 h before sunrise or after sunset. The exospheric emission observed from the ground is part rather than entire dayside. The ratio of the observed emission varies by phase angle. Thus, we estimated the number of sodium atoms above entire dayside, using the exospheric model and assuming constant exospheric temperature.

Interplanetary dust is known to be distributed densely to the plane called dust symmetry plane, but the detailed distribution in the vicinity of Mercury is not known. To verify the contribution of interplanetary dust impact to exospheric yield, model parameters which maximize correlation coefficient was derived, based on simplified dust distribution model by Kelsall et al. [1998]. Inclination and ascending node in this model are based on observation of zodiacal light by Helios 1, 2. This model fitting shows that the number of sodium atoms correlates highly with interplanetary dust density. The correlation coefficient is 0.856. This result indicates that interplanetary dust vaporization may contribute significantly to the exospheric yield.

The impact of interplanetary dust mixes grains at the surface and replaces depleted grains with fresh grains. This is known as gardening effect. In addition, interplanetary dust contains sodium and therefore supplies sodium atoms to the surface, which increases the source rate by other processes.

Keywords: Mercury, exosphere

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Heavy ion kinetics in Mercury magnetosphere with offset dipole

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Based on observations by MESSENGER, Mercury magnetosphere is thought to be a miniature of the Earth magnetosphere. These two magnetospheres have several characteristics in common, however, some critical differences are also evident. First, there is no atmospheric layer, but only tenuous exosphere. Second, the kinetic effects of heavy ions might not be negligible because Mercury magnetosphere is relatively small compared to the large Larmor radii. Trajectory tracings is one of the dominant methods to estimate the kinetic effect of heavy ions which originate the exosphere, though the results of the simulation are quite sensitive to the electric and magnetic field. Therefore, it is important to provide a realistic field model in the trajectory tracings. In order to construct a large scale structure, we developed a MHD simulation code, and adopted to the global simulation of Mercury magnetosphere. We performed four solar wind conditions of the northward IMF, and the results showed that the global configurations such as the location of magnetopause depend heavily on the dynamic pressure, while the solar wind electric field contributes little to the magnetospheric configuration. On the other hand, the results of statistical trajectory tracings of exospheric sodium ions depend not only on the dynamic pressure but also on the solar wind electric field. In the results, we identified two efficient acceleration processes and formation of the sodium ring which is formed by the accelerated ions drifting around the planet by magnetic gradient of the dipole field. When the solar wind dynamic pressure is low, acceleration by magnetospheric convection is efficient in the vicinity of Mercury. When the dynamic pressure is high, entry of the accelerated ions picked-up in the magnetosheath into the magnetosphere becomes dominant. The entry point of sodium ions changes due to the variation of the solar wind electric field, which causes a difference in the sodium ring's shape for the same solar wind dynamic pressure cases. Recent observation by MESSENGER revealed the weaker dipole field of Mercury than the past estimation based on Mariner 10 as well as large offset of dipole which could change the global configuration of Mercury magnetosphere and behavior of sodium ions. In the presentation, we will also discuss the ongoing simulation including the above configuration of intrinsic magnetic field of Mercury especially focus on how will this affect the distribution of sodium ions and its acceleration mechanisms.

Keywords: Mercury magnetosphere, MHD, test particle, sodium ion, offset dipole

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Formation of vortex configuration in the high resolution simulation of Kronian magnetosphere

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In a series of our simulation studies we have found turbulent convection and vortices formed at Saturn's dawn and dusk magnetopause in simulations when IMF was northward. We interpreted these vortices as resulting from the Kelvin Helmholtz (K-H) instability. The resolution of simulation is important parameter for formations of vortex and turbulent convection to catch the small configuration of convection which can be a trigger of vortex. Recently we can perform the higher resolution simulation (0.06Rs) of our previous simulation (0.3 or 0.1Rs) thanks to the evolution of computer technologies. In this study we run the simulation of Kronian magnetosphere with various IMF conditions to see the configuration of vortex and magnetospheric convection.

As the results of simulations the vortex does not appear in the no IMF and weak northward IMF condition. Adding the mean magnitude of northward IMF, we obtained the vortex along the magnetopause in the dawn and dusk. The difference of overall configuration between the weak and normal northward IMF is formation of vortex and other configurations very resemble. From these results we will discuss the formation condition of vortex in the Kronian magnetosphere and their configurations.

Keywords: Kronian magnetosphere, numerical simulation

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Fine structure of Jupiter's decametric modulation lanes observed by LWA1

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The Long Wavelength Array (LWA) is a low-frequency radio telescope designed to produce high-sensitivity, high-resolution images in the frequency range of 10-88 MHz. The Long Wavelength Array Station 1 (LWA1) is the first LWA station completed in April 2011, and is located near the VLA site in New Mexico, USA. LWA1 consists of a 256 element array, operating as a single-station telescope.

The sensitivity of the LWA1 combined with the low radio frequency interference environment allow us to observe the fine structure of Jupiter's decametric modulation lanes. At frequencies in the vicinity of 22 MHz, most modulation lane patterns have frequency-time slopes between +100 and +180 kHz/sec for Io-B storms and between -90 and -200 kHz/sec for Io-A and Io-C storms. The lanes generally display a strong periodicity in time, with periods ranging from about 1 to 5 sec and an average of about 2 sec.

We refer to the modulation lanes possessing frequency-time slopes and periodicity within the above ranges as the major component. There is a minor modulation lane component, representing a considerably smaller fraction of the total number observed, for which the frequency-time slopes are of opposite sign than for the major component or are of the same sign but of smaller absolute value. For these cases the lanes are usually broader and their separations in time are longer.

There are significant differences of characteristics between the major and the minor components of modulation lanes. Minor component lanes are apparently of somewhat different origin from major component lanes. We show the fine structure of the major and minor modulation lanes observed by the LWA1. The origin of minor modulation lanes is discussed.

Keywords: Jupiter radio, decametric wave, modulation lane, fine structure