Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

PCG33-P01 Room:Convention Hall Time:May 25 15:30-17:00

1 micro-m camera IR1 onboard AKATSUKI: Current status and results of observations

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”Akatsuki” spacecraft which has launched by the Japan Aerospace Exploration Agency in 2010 is keep cruising to Venus for 2015. The results of the imaging carried out by IR1 camera onboard ”Akatsuki” during the cursing phase after the Venus fly-by in December 2010 are described.

The images taken by IR1 in 2011 are followings.

(1) Photometry of the dayside of Venus from a distance of over 10 million kilometers in March 2011

(2) Star imaging to check the change of the absolute sensitivity.

(3) Deep space imaging to check the normal operation of the camera after perihelion.

The phase curve of Venus at 0.90 micrometer covering phase angle from 1 deg to 56 deg has been obtained by the photometry observations of Venus. Simultaneous analysis with the phase curve at 2.02 micrometer by 2 micron camera IR2 onboard ”Akatsuki” constrains cloud model of Venus.

Current status and problems of detector are also discussed based on images of star and operation tests.

Keywords: AKATSUKI, near infrared, Venus atmosphere, phase curve, cloud particle

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A model to study the Venus cloud structure based on several Venus observations, wherein SOIR solar occultations on Venus

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Venus is our nearest neighbor, and has a size very similar to the Earth's; however, previous spacecraft missions discovered an extremely dense (92 bar at the surface) and CO2-rich atmosphere, with H2SO4 clouds located at altitudes between 40 and 70 km. These clouds cover the whole planet.

A cloud model was proposed by Pollack et al. (1993), with a vertical distribution of optical thicknesses of the different cloud particles (modes 1, 2 and 3). However, this model might be improved using new data obtained in the recent past from ground-based observations (IRTF telescope in Hawaii) and in-situ measurements from spacecraft observations (SOIR on Venus Express).

A new cloud model, correcting for some Pollack model's problems, is proposed using data from previous entry probes [Takagi & Iwagami, 2011]. However, this model does not describe the global Venus cloud structure.

The purpose of this work is to construct a more realistic cloud model. Ground-based spectroscopic observations of the Venus low-latitude region and Venus Express/SOIR observations of high-latitude will be used to construct this new cloud model.

Keywords: Venus, cloud, Venus Express, SOIR

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Venusian cloud structure in the northern high-latitude region estimated from VEX/VIRTIS-H data

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This paper present the characteristics of northern high-latitude cloud, i.e ,its opacity, cloud top temperature and altitude, and these relationships estimated from Venus Express (VEX) observations.

Venusian clouds mainly consist of sulphuric acid droplets in the altitude of 40-70 km. Recent long-term observations by Venus Monitoring Camera (VMC) and Visible and Infrared Thermal Imaging Spectrometer - M channel (VIRTIS-M) aboard VEX has investigated the south polar vortex [e.g., Luz et al., 2011]. For an example, the lower cloud top altitude at southern polar region is reported [Ignatiev et al., 2008]. We investigated the cloud structure in these regions by the data observed by VIRTIS - High spectral resolution channel (VIRTIS-H), which can get information of northern hemisphere that has not been well reported by VMC and VIRTIS-M. We compared these characteristics with previous reports for the Southern hemisphere, and investigate the opacity, cloud top temperature and altitude, and these relationships between them.

(1) In the 2.3um thermal radiation from the night side, we could not find enough flux from the region more than 70degN in latitude. In the study combined to a radiation transfer analysis, the cloud optical thickness in high latitude region is constantly about twice of that in lower latitudes. It suggests that the clouds in polar region are thicker or has different aerosol characteristics.

(2) We retrieved the cloud top temperature from 5um radiation and the cloud top altitude by 2.2um CO2 absorption band. The averaged cloud top temperature increased from 75degN to North Pole. On the other hand, the averaged cloud top altitude at 80degN (65.4+-0.7 km) was lower than that at 50 degN (69.3+-0.5km). This is consistent with the characteristics in the southern hemisphere [Ignatiev et al., 2008]. In an event study, it was also shown that the cloud top altitude in the cold collar regions surrounding the hot polar vortex is ˜1km higher.

(3) We retrieved the averaged latitudinal distributions of cloud opacity, cloud top temperature and altitude in the northern hemisphere from 15 orbits nadir observations, with the resolution of 1 deg. in latitude. There was a negative correlation between the cloud top temperature and its altitude. No other correlations were not clear.

In the paper, we will report the results with the discussion on their interpretations.

Keywords: venusian atmosphere, polar vortex, cloud top altitude, cloud top temperature, cloud optical depth

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Venusian wind velocity distributions in middle-to-high latitude regions derived from the UV/IR images observed by Venus

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We tried to derive the wind velocity distribution in the southern high latitude regions of Venus using the UV images taken by the Venus Monitoring Camera (VMC) on Venus Express (VEX). We focused on the longitudinal distributions of wind velocity, and found a possible correlation between the distributions of cloud-top temperature and meridional wind.

The UV images of Venus has contrasting distributions. They have been thought to show the distributions of unknown UV absorber which exists in the altitude of approximately 70km around the cloud top where the wind vectors have been estimated by tracking the cloud motions.

In addition, we can estimate the cloud top temperature from the brightness images in the mid-infrared region. The atmospheric vortices on both polar regions have been observed, and the vortices are made of two parts; one is high temperature regions near the pole called ”polar dipole”, and the other is low temperature regions called ”polar collar” outside of the dipole. The dipoles have a structure with the wave-number of two and rotate with the period of 2 to 2.5 days. The collars have a crescent structure with the wave-number of one and the phase fixed to the local time.

It is suggested that there is a correlation between the distributions of temperature and wind velocity. For example, the adiabatic heating due to a descending flow has been pointed out as a possible cause of the dipole. Indeed, poleward meridional winds have been found at the limbs of the vortices by observations in the UV region [Sanchez-Lavega et al., 2008; Moissl et al., 2009].

In this study, we aimed to derive the wind velocity distribution by tracking UV cloud images in middle-to-high latitude taken by VMC, and examine the correlation between the longitudinal distribution of temperature seen in the IR region and wind velocity seen in the UV region.

We adopted the cloud tracking method developed by Kouyama et al. (2009) for the detection of wind fields in high latitude regions. We modified this method to achieve the cloud tracking in high latitude regions where the tracking was hard. We got the result of wind velocity consistent with Kouyama et al. (2009) in middle-to-low latitude.

To get the wind velocity fields with respect to the dipole, we need to define a coordinate system fixed in the dipole. We fitted an ellipse to the dipole in mid-IR region and derived the distribution of wind velocity on the basis of its long axis. We analyzed data obtained from 5 orbits. The results show that there is no clear longitudinal distribution for zonal wind. In contrast, we found the structure which can be approximated to the zonal wavenumber of two in the meridional wind velocity. It suggests that we can approximate the streamline of wind by a dipole-like ellipse.

However, there is a difference in the longitudinal phase between the dipole in temperature and meridional wind structure. In addition, there is a significant variation in the phase difference with a period of as short as about 1 day. This result suggests that the longitudinal structure of the dipole is not made by wind steadily, and we need to consider the possibility that the dipole is made by another factors such as the wave phenomena. We need some additional analyses mainly to track the time variation of the phase difference.

Keywords: Venus, Polar vortex, Wind velocity, Longitudinal distrubition, Venus Express, Venus Monitoring Camera

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Westward acceleration of the mesospheric and thermospheric atmosphere in Venus caused by gravity waves

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We present the numerical simulations for the investigation of the effects from gravity waves to the Venusian mesosphere and thermosphere dynamics. The results reproduced the fast westward wind acceleration above 90 km in altitude. The result first showed that westward acceleration at 110km occurs mainly in the nightside.

Momentum transport from the cloud layer (50-70km) toward the upper atmosphere by gravity waves is essential to understand the circulation in the Venusian mesosphere (70-110km) and thermosphere (>110km) (e.g. Bougher et al. [2006]). Zhang et al. [1996] performed simulations with a gravity wave parameterization and showed that the momentum transport by gravity waves drove the retrograde zonal wind (RZW) as fast as 15 ? 30 m/s above about 140 km. They also showed the westward shift of the O2-1.27um nightglow emission region because of the RZW.

We use the parameterizations which can consider the wave-wave interaction and the attenuation of gravity waves caused by molecular viscosity. We introduced these physical processes by using the new gravity wave parameterization developed by Medvedev et al. [2000] (Medvedev scheme) into our GCM calculation, which enabled us to investigate the effects of gravity waves on the Venusian mesosphere and thermosphere.

In the Medvedev scheme, the characteristic horizontal wavelength and the spectrum of the vertical wavelength at the lower boundary are the adjustable parameters. For the former, it is set to be 500 km [Kasprzak et al. 1988] in this calculation. For the latter, we assume the Desaubies spectrum, which is the familiar spectrum shape of the terrestrial gravity waves, at the lower boundary. In this calculation, the wind velocity distribution at the lower boundary (80 km) is the solid body rotation with the equatorial wind velocity of 40 m/s.

The result shows that gravity waves, which transport the westward momentum upward, drive the RZW above about 90 km. The strength of the RZW becomes stronger with height in the 90-125 km region. The maximum RZW velocity is about 120 m/s at about 125 km. The RZW velocity is weaker with the height in the 125-140 km region and becomes constant (about 60 m/s) above about 140 km. The vertical change of the RZW strength is interpreted as the result of the wave filtering caused by the background wind.

We also first showed that in the horizontal wind velocity distribution at about 110 km, where wind velocity is observed with the CO and CO2 absorption/emission lines, the westward acceleration caused by gravity waves occurs mainly in the nightside. On the other hand, the subsolar-to-antisolar flow is dominant in the dayside in spite of the existence of the RZW.

(This paper will be submitted to J. Geophys. Res.)

Keywords: Venus, GCM, mesosphere and thermosphere, wind velocity field, gravity wave

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X-ray observation from Venus upper atmosphere by HINODE

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Venus transit across the Sun will occur on 5 June, 2012. X ray is emitted by the charge exchange of the high charge state solar wind ions due to electron capture from Venus corona. In this study, the X-ray emission from Venus corona is estimated and the possibility of the observation by HONODE satellite is discussed.

The solar wind ions impact on the ionspheric particles happens to charge exchange to result into the excited emission. Emission lines of charge exchange are 1.7-2.21nm of O^{7+}, 2.7-4.1nm of C^{6+}, 2.6-3.38 nm of C^{5+}. We estimated that the intensity of the charge exchange emission is totally estimated $2.30x10^{-7}$ photons/cm^2/sec at limb. The X-ray emissions from Venus corona will be detected by observation for at least13 hours. Venus nightside X-ray image let us know the distribution of the neutral corona.

The solar wind particle induced to the ionosphere has asymmetry with north and south direction. The short length band of EIS includes 18.4nm emission lines of O^{6+} charge exchange and 19.3nm emission line of O^{7+}. The emission of 18.4nm(O^{6+}) is $1.51x10^{-7}$ photons/cm^2/sec and the luminosity is 6.8W.

Keywords: Venus, upper atmosphere, HINODE

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Response of the Martian thermosphere to the EUV flux enhancement during solar flare events with a GCM

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The Martian oxygen corona in the exosphere consists of non-thermal oxygen atoms (O∗) produced mainly by the dissociative recombination of O2+ ions produced in the lower thermosphere/ionosphere. The dissociative recombination is the major process of the Martian atmospheric escape in the present solar condition. This means that, in order to calculate the accurate escape flux of O∗, it is needed to understand not only the spatial distribution of O∗ in the exosphere but also the behavior of O2+ in the thermosphere/ionosphere. Many researchers have indicated the dependence of temperature, wind, and composition distributions in the Martian upper atmosphere on long-term variations of the solar EUV flux e.g. solar maximum-to-minimum activities [e.g., Bougher et al., 1991]. Recently, observations by Mars Global Surveyor (MGS) indicated that the Martian lower ionosphere varied significantly in association with enhancement of the solar X-ray and EUV flux range during a solar flare [Mendillo et al., 2006]. It may suggest that the Martian thermosphere also vary largely in association with short-term variations of the solar X-ray and EUV flux. It is also shown time-dependence of terrestrial planet thermospheres on instantaneous variations of the solar EUV flux [Bougher et al., 1999]. This work indicates that time-dependent of each planet thermosphere are different because of difference of main cooling processes. Moreover, it is indicated that temperature of the past Martian thermosphere was much larger, because the solar X-ray and EUV flux of the early sun was more powerful [Valeille et al., 2010]. Solar flares were also more powerful in the early sun, so response of the Martian thermosphere to short-term variations of the solar X-ray and EUV flux may be different from that of the solar X-ray and EUV flux in the present solar condition.

In this sudy, we investigated response of the Martian thermosphere to the short-term variations of the solar X-ray and EUV flux with a Martian Global Circulation Model.

1.This Martian GCM calculates enhancements of the temperature and scale height at the sob-solar point of the exobase by about 42 K and 13 km, respectively, when the solar X-ray and EUV flux (1-20 nm) increases 60 times as much as the usual one for an hour. In this study, variations of the global mean temperature and scale height were 80 K and 27 km, respectively, during a solar cycle. This means that the temperature and scale height of the Martian upper atmosphere would increase by about 50 % during a big solar flare event even in the present condition.

2.This Martian GCM calculates enhancements of the temperature at the sob-solar point of the exobase by about 20 % (42 K) for 2 hours, and it takes 9 hours to decrease to the value of steady state. On the other hand, the Venusian GCM, which was updated by changing the Martian parameter to Venusian parameter, calculates enhancements of the temperature at the same point by about 31 % (63 K) for 1.25 hours, and it takes 3 hours to decrease to the value of steady state. This means that increasing rate of temperature of Venusian thermosphere is larger than that of Martian thermosphere, while time variation of the Venusian thermosphere to the solar X-ray and EUV flux enhancement is shorter than that of Mars, because of deference of main cooling processes.

3.This Martian GCM produces the Martian thermosphere when solar X-ray and EUV/UV flux increases between twice and 20 times. In this state, we simulate the same solar X-ray and EUV flux enhancement of the present sun’s flare. This model calculates enhancements of the temperature at the sub-solar point of the exobase by about 59 % (205 K). This means that effects of solar flares in the early sun on the Martian thermosphere might be larger 3 times than that in the present solar condition.

Keywords: Mars, thermosphere, solar flare, Venus

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Examination of Orbiters for Martian Atmospheric Escape Study

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The atmospheric escape from Mars is considered to be closely associated with the evolution of the Martian atmosphere as well as the existence of the water on Mars. We are now investigating a project to study the global feature and the physical process of the atmospheric escape from Mars. It is expected to consist of at least two orbiters; one of the orbiters is aimed to make in-situ observation of plasma and thin atmosphere at about 100 km altitude, and the other is for the atmospheric imaging and solar-wind monitor. We are planning to make simultaneous observation of the atmospheric escape by the interaction with the solar wind by both of in-situ measurement orbiter and remote-sensing one. Now we are examining the quantitative measurement targets to fully understand the Martian atmospheric escape. At the same time, the sorts and performance of scientific instruments on these orbiters are examined. And furthermore, the preliminary spacecraft design, orbit design and mission plan to achieve the scientific goal are investigated.

Keywords: Mars, Atmospheric escape, Planetary exploration, Solar wind

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Feasibility study of Mars' wind observation from a satellite orbit using a sub millimeter wave sounder

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In order to know the atmosphere circulation of Mars, there is a need to know the distribution of wind speed on Mars. By observing Doppler shifts of molecular emission spectra of the Martian atmosphere, vertical profiles of wind speed in the Martian middle/upper atmosphere can be measured. In this study, we present a feasibility study of Martian wind measurement using a submilimeter sounder from an orbiting platform. The spatial and time resolutions achievable by submillimeter wave observations from Martian orbits are investigated.

Keywords: submillimeter wave, doppler shift, mars, wind

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Progress of the SPART project to monitor planetary middle atmospheres

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Investigating the abundance and time variation of minor constituents and their isotopes provide us an important information about the dynamical and chemical balances and evolutionary processes of planetary atmospheres. To study how activities of the Sun, a typical G-type star in our galaxy, influence the physical conditions and (photo) chemical reaction network of the atmospheres of Venus, Mars and gas-giant planets, we have promoted regular and long-term observations of these planetary middle atmospheres at 90 ? 345 GHz bands developing a 10-m ground-based Solar Planetary Atmosphere Research Telescope (SPART).

In November 2011 we succeeded first detection toward Mars and mapping observation toward Orion Molecular Cloud 1 with a spectral line for rotational transition of carbon monoxide (J=1-0: 115 GHz) by using the SPART. Now we are just starting to carry out test regular observations. In this talk the current status of this project will be presented.

Keywords: millimeter wave, submillimeter wave, planet, middle atmosphere, solar system, ground-based telescope

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Mercury's sodium tail distribution and the source processes of the exosphere

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Mercury has a thin atmosphere. In the past, Mercury has been observed by Mariner 10 and MESSENGER, and ground-based observations have also been carried out. H, He, O, Na, Mg, K, and Ca were detected in its atmosphere. Solar-photon-stimulated desorption, sputtering by impacting solar particles, and meteoroid vaporization are considered to be the source processes of Mercury's exosphere. However, the primary process among these three processes is unknown as yet. Sodium atoms are excited by the energy from sunlight, and they return to the ground state by emitting energy isotropically. The resonance scattering constitutes exospheric sodium emission. This emission well suited for study by ground-based observations because of its high intensity. The sodium atoms are accelerated in the anti-sunward direction due to their isotropic scattering. This is called sodium tail. Past observations have shown that the intensity distribution of exospheric sodium emission changes with time. This study aims to make ground-based observations of exospheric sodium emission, to determine the distribution of the sodium tail, and to consider the source processes of Mercury's exosphere.

We have observed Mercury's sodium exosphere at the Haleakala Observatory since April 2011. The observations were made using a 40 cm Schmidt-Cassegrain telescope, a high-dispersion spectrograph, and a CCD camera. In this term, the telescope system at the Haleakala Observatory was remotely-operated in Japan. At this observation, the slit of spectrograph was set on Mercury, and its direction was set parallel to the anti-sunward direction. The slit width is 2.5 arcsec, and apparent diameter of Mercury was from 5.0 to 10.4 arcsec. The sodium distribution was scanned by changing slit position. Exposure time was 50 second, and it took 30 minutes to get a whole image of the sodium tail.

We analyzed observational data collected from April 27, 2011, to May 30, 2011, and from June 24, 2011, to August 5, 2011. The observation times were from Mercury rise to before sunrise in the former observation period, and from just after sunset to Mercury set in the latter observation period. We determined the intensity distribution of exospheric sodium emission by using the observational data. We compared the intensity distributions on May 18, June 24, and July 1. These distributions have two characteristics. The first is temporal variation of the intensity of sodium emission from the equator of Mercury changed. The second is the emission from the northern part of Mercury was not detected on June 24.

In this study, we discuss the variation of the sodium emission of the equator of Mercury changed. Sputtering by impacting solar particles, one of the source processes of Mercury's exosphere, is that solar wind ion arrives at the surface of Mercury from cusp region of Mercury's magnetosphere. So we think that change of solar wind magnetic field causes change of variation of the sodium distribution. The magnetic reconnection in the case of northward interplanetary magnetic field is different in the case of southward interplanetary magnetic field. This causes change place where solar wind ion arrives at the surface of Mercury. We compared our observational data with the data of solar wind magnetic field observed by MESSENGER. In this presentation, we discuss between the sodium distribution and the variation of solar wind magnetic field.

Keywords: Mercury, Sodium, Ground-based observation

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Interaction between solar wind and mini-magnetosphere

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Interaction between the solar wind and the mini-magnetosphere of dipolar magnetized objects is investigated by a three-dimensional hybrid simulation, which treats the ions as kinetic super particles via particle-in-cell method and the electrons as a massless fluid. The hybrid simulation is suitable for the study of the mini-magnetosphere which scale is the order of the ion Larmor radius of the solar wind ions at the magnetopause boundary, because the ion kinetic effects are important for its structure. In the northward interplanetary magnetic field (IMF) condition, the shape of the mini-magnetosphere is similar to a down-sized geomagnetosphere. However cusp reconnection twists the field lines over of the cusp region due to the Hall effects. In the southward IMF condition, patchy reconnection is generated in the dayside magnetopause boundary and generates plasmoids or Flux Transfer Events as large as a quarter of the magnetosphere. We will discuss the boundary structures of the mini-magnetosphere.

Keywords: Interaction between solar wind and mini-magnetosphere, 3D hybrid simulation

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Estimation of OI 630nm emission from Enceladus torus by various process

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It has been known that there are H2O molecules and their dissociative products. Cassini mission discovered plume on Saturn's icy moon, Enceladus. And this small moon supplies molecules and ice grains to the Saturn's magnetosphere. This materials distribute like a torus, so called enceladus torus. If we can monitor distribution and time variation of the Enceladus torus continuously, we can get more clear understanding about Saturn's magnetosphere and its variability. In order to accomplish remote-sensing of the Enceladus for a long period, we made ground-based observation of OI 630nm emission of the Enceladus torus at Haleakala observatory.

We successfully detected the line emissionwith 1200 minutes total exposure time by ground-based observation carried out in Mar. 2011. In order to derive physical information, we must clear what process cause this emission. We had assumed that main process for this emission is electron impact excitation. But other process is also existing, photo dissociation of H2O and OH.

In ths presentation, I will report the contribution of non electron impact excitation process.

Keywords: Saturn, Enceladus, ground-based observation, emission, neutral

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Electron density observations from Cassini RPWS in the Enceladus torus

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One of Cassini's most exciting results is a detection of a plume which expels water vapor and ice grains from south pole of the moon Enceladus [Dougherty et al., 2006; Spahn et al., 2006; Porco et al., 2006; Waite et al., 2006]. This water creates an extended torus around Saturn. A large amount of gas is ionized within the plume and becomes the major source of plasma for E ring and Saturn's magnetosphere. The inner magnetosphere consists of a dense and cold plasma in the shape of a disk [Persoon et al., 2005]. Recently, observations from Cassini Radio Plasma Wave Science (RPWS) revealed the presence of dusty plasma and indicate the interaction between plasma disc and dusty plasma E ring [Morooka et al., 2011]. However, these observations were only near Enceladus. We investigate the plasma distribution on Enceladus orbit. We use Cassini RPWS data and analyze the electron densities in the Enceladus torus, and plan to analyze the azimuthal distribution of Enceladus.

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Characteristics of the transient evolution of the auroral acceleration region of Saturn derived from radio spectra

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We show the preliminary result for the characteristics of the altitude profile variation seen in the lower- frequency extensions of Saturn kilometric radiation (SKR) associated with substorm-like events.

SKR is an intense radio emission with a peak frequency between 100 and 400 kHz. It is thought to be emitted from energized electrons accelerated along auroral field lines via the Cyclotron Maser Instability (CMI) [Wu and Lee, 1979]. Compared with Earth and Jupiter, SKR shows several unique characteristics such as the modulation at or close to the planetary rotation period [Desch and Kaiser, 1981], long-term variation of modulation period [Galopeau and Lecacheux, 2000], North - South asymmetry of modulation period [Gurnett et al., 2009].

During the high activity of SKR, It is commonly seen that SKR expands toward lower frequency. It can be interpreted as an expansion of the auroral acceleration region to higher altitude with weaker magnetic field strength because SKR is emitted at approximately local electron cyclotron frequency. Similar characteristics have been known in the terrestrial auroral kilometric radiation (AKR) for a long time. For example, using this characteristic in AKR frequency variations, Morioka et al. [2010] derived the two-step evolution model of the auroral acceleration region during substorms. Our motivations are to adopt similar analysis to Saturn and to compare auroral field line accelerations between two planets.

In a previous study, Jackman et al. [2009] reported the general relationship between the lower-frequency extensions of SKR and substorm-like events seen as plasmoids in the magnetotail. We focus on short variations of such phenomena, from several minutes to hours. We use SKR spectra data observed from Cassini/RPWS high frequency receiver (HFR). Its high time resolution, approx. 15 sec, is enough to show that the time scale of lower-frequency extension of SKR, several hours, longer than that of AKR. In this case, we should consider not only the visibility effect (i.e., beaming at the source and propagation along the light-path from the source) but also the unique enhancement due to the rotation of SKR sources. In order to reduce the former effect, we use the data when Cassini locates specific position (in this preliminary study, radial range from 10 to 100 Rs, latitudinal range from -5 to +5 degrees, SKR phase range from -45 to +45 degrees). Based on this analysis, we now try to grasp (1) the relationship of maximum/minimum/central frequency of SKR versus its total flux (as a proxy effect from the amount of field-aligned current), and (2) the relation of maximum/minimum/central frequency of SKR versus specific SKR phase (as a proxy effect from the rotational enhancement). These characteristics will be used for event studies of short-term evolution of auroral acceleration region during substorm-like events.

Keywords: Saturn, SKR, Cassini/RPWS

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Simulation study of the current-voltage relationship of the Io tail aurora

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Subcorotation of Iogenic plasma in the Io plasma torus has been understood as electric drift by a perpendicular electric field with respect to the Jovian magnetic field. It has been considered that a part of the radially integrated electric field would be imposed along the magnetic field lines and would cause the Io's trailing tail aurora. Observations have been shown that the Io tail aurora extends for approximately 100 degrees downstream in longitude from the Io's magnetic footprint. It remains unresolved why the precipitating electron energy corresponding to the voltage is constant with longitude despite the decreasing parallel current density. The purpose of this study is to clarify how the current-voltage relationship of the Io tail aurora realizes.

We applied a semi-discrete central scheme to extended multi-magneto-fluid equations which include the electron convection term and investigated the relationship between a parallel current density and voltages of transition layers in the Io-Jupiter system. If the ionospheric proton density decreases at the same rate as the parallel current density, the timescale on which the high-altitude transition layer disappears is consistent with the longitudinal extent of the Io tail aurora. The voltages of the high- and low-altitude transition layers remain constant until the auroral cavity disappears, as expected from observations. These results suggest that the origin of the current-voltage relationship of the Io tail aurora is the same decrease rate of the ionospheric proton density as the parallel current density.

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Relationship between the occurrence frequency of Jovian substorm-like event and plasma density in the magnetosphere

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Jupiter has the largest magnetosphere in the planets of solar system, which has been produced by its rapid rotation period (about 10hours), strong intrinsic magnetic field and internal source of heavy plasma originated from Io.

The observations of the Galileo orbiter revealed that there are quasi-periodic flow bursts of energetic particles and the variation of the B-theta component implying magnetic reconnections in the Jovian magnetosphere. The signatures of these events are similar to the terrestrial substorm, so they are called substorm-like events.

In the preceding studies (Kronberg et al., 2007; Woch et al., 1998), their generation processes are proposed as follow based on a hypothesis of plasma mass loading in the Jovian magnetotail region; First, the magnetotail is stretched because of the large centrifugal force by the rapid rotation and heavy ions. Second, a reconnection occurs and a plasmoid is released. Third, the magnetic field configuration returns to the initial (non-stretched) state, but then the magnetotail stretching starts again and the cycle repeats to make the periodicity.

Studying physical processes of the events is important to understand global dynamics of the Jovian magnetosphere. Their characteristics, such as their variable periodicity (2.5 - 7 days) and existence of unobserved period etc., have been known well, however, it has not been revealed yet what factor controls the periodicity of the events.

In this study, we have examined the plasma mass loading hypothesis by investigating the plasma density inside the plasma sheet by using the data obtained by the Plasma Wave Subsystems (PWS), Energetic Particle Detector (EPD) and Magnetometer (MAG) onboard the Galileo orbiter.

As a result, it is suggested that there is some correlation between electron density in the magnetotail region obtained from the plasma frequency and the occurrence frequency of the substorm-like events derived from the changing of the north-south component of the magnetic field from the preceding study by Vogt (2010), and that there is also some correlation between energetic sulfur ion density and the occurrence frequency. These results support the proposed hypothesis; the Jovian substorm-like events are driven by an internal process.

Keywords: Jupiter, Jovian magnetosphere, magnetospheric dynamics, substorm, plasma density, Galileo

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Reconsideration of generation processes of Jupiter's Io-related radio emission

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The following questions; 'What kind of magneto-ionic wave Jupiter's auroral radio emission is?' and 'How the radio emission is generated?' have been long years of subjects. I have investigated the subjects based on numerical calculations using several kinds of magnetic field and plasma density models, however, the questions have not been resolved yet: a hypothesis of a special energy transporter which does not meet with the observation results was needed. Recently Jupiter's new magnetic field model 'VIPAL' was proposed based on the satellites' foot print aurora data observed by the Hubble Space Tellescope (Hess et al., JGR, 2011). I have tried to make a 3D raytracing analysis for Io-DAM using the VIPAL model. The preliminary analyses show that R-X mode waves are preferable as Io-DAM and the VIPAL gives more natural explanations for the origin of Io-DAM, though there still remain some questions on restriction of 'Io-DAM' and on origin of Io-C.

Keywords: Jupiter, Io, decametric radiation, generation process, magnetic field model

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Extension of HF radio observation system in Fukui University of Technology through the introduction of GnuRadio

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In Fukui University of Technology, radio observations in HF band (20-40MHz) have been carried out from 2000 for Jovian decameter radiation and Solar radio bursts. At the observation site which is located at Awara campus (N36deg., E136deg.), 3 antenna towers height of 20m was set up and 9-elements cross log-periodic antenna was mounted at the top of each tower. The observation system has worked as 3 short baseline interferometer system with a baseline length of 100m class.

In Fukui University of Technology, ”Formation of research centers involved in the measurement and conservation of the environment in Hokuriku region” project has been started from 2011 with the support of MEXT. In the project, we are planning to take advantage of the radio observation system in Awara campus for observation and monitoring of lightning or thunder storm activity. Therefore, we are currently developing a high-performance receiving system by introducing software-defined radio (SDR) GnuRadio+UHD into our observation system in order to realize wideband waveform observation.

GnuRadio+UHD is an open software package which is consists of a lot of signal processing blocks written by C++. A user can produce one’s own receiving system by combining of a user-made program using the signal processing blocks and a digital receiver. Currently, we are investigating the performance of GnuRadio+UHD with USRP2 (Universal Software-defined Radio Peripheral) supplied by Ettus Research Co. Ltd. as a digital receiver. As the result of performance test carried out so far, it has been clarified that this system has characteristics of (i) wideband (1-250MHz), (ii) high sampling rate (25MHz), (iii) wide dynamic range (90dB) and (iv) high phase stability. We conclude that this SDR system has a good performance as a receiver for interferometer system and are scheduled to advance the development of new observing system by using GnuRadio+UHD.

Keywords: software-defined radio, GnuRadio, USRP, radio observation

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Averaged characteristics of flux distributions and variations in Jovian infrared H3+ aurora: Comparison with UV's

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This study is using imaging data that Satoh et al. observed Jovian infrared H3+ aurora for long term, and it's purpose is to suggest the typical flux distribution,variation and the picture of intensity variation in each auroral region. The aurora emitted UV wavelength ray in Ly-alpha band is observed by Hubble Space Telescope (HST), and it's data is more higher space resolution and more shorter time interval. So, We consulted on analysis approach, which is taken until now, to enable to compare characteristic between IR aurora and UV aurora.

Jovian Auroral flux distribution and the variation is different by mapping magnetospheric region. Auroral high latitude region, mapping open flux, shows variation driven by Solar wind at short times.On the other hand, Main oval, mapping inner magnetospheric region, is considered that more stably exists, because the energy source ,that high Jovian roration ingenetates ,effects brightening.There is a direct temporal-spatial correlation between UV aurora and injected electron,because H and H2 directly emit electric transition emission.

On the other hand, The IR auroral process is that H2 and H2+ ,injected particle produced, collided with each other,and this event producted H3+ and thermal excitation of H3+ emit infrared ray. So, IR aurora reflects thermospheric temperature and may be different from the picture of UV auroral flux distribution and intensity variation.

In Nichols et al.,2009,They first resulted in Jovian UV auroral typical flux distribution ,using data Hubble Space Telescope observed emitted UV wavelength ray for two months. This analysis circularly separated auroral region, and shows the response of solar wind dynamic pressure and correlation between each auroral region.

In this study, we apply UV auroral flux distribution in Nichols et al.,2009 to IR auroral region with the intent to verify difference of the characteristic UV aurora showed.

About analysis data,we use image data observed emitted infrared ray by NSFCAM using 3.4265um narrow bandpass filter attached to NASA/IRTF in 1995-2004, and The typical seeing of this data is 1arcsec(under 0.1 arcsec in HST data).Obsevational days are discrete,however, we can analyze 57days worth of data. Thus far, we compare between dynamic pressure and the intensity variation during dynamic pressure is continually high or low for several days. About the dynamic pressure, we refer to 1DMHD model extrapolates solar wind observed near earth to Jovian orbital.

(A)There is slightly not only the positive correlation between in high latitude region and dynamic pressure,but also it in mainoval region and dynamic pressure(r=0.8).(B) While there is the positive correlation between the variation of intensity in high latitude region and in mainoval region is high similar to UV's, the polar inner region is more brighter than UV's. The latter is seen in Saturn, it is considered that upper high latitude region is more heat reflected the adiabatic compression.

In main oval region, the typical emitted power is 334.1GW , and the range of variation is 180.86GW-613.01GW.

After this,we will progress to analyze data all over.There is potentially four problems, but they are fatally common problems in past Jovian auroral observation.

(1)The spatial resolution is one digit lower than HSTdata,(2)This analysis data isn't simultaneous observation between the IRTF observation and the HST observation,(3)There is the period of low accuracy of solar wind(5days),(4)The number of data isn't enough to bung up compared to response time of Jovian magnetosphere.

In this presentation,based on above-reference,we will report tentative result using all data.

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Development of the InSb array sensor drive system for infrared observations

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Jupiter is a biggest planet in the solar system. There are the aurora phenomena in UV, Visible and IR range that reflected magnetosphere activity. Especially, in H_2 H_3^+ NIR aurora, ground based observation is possible because earth atmosphere transmissivity is high. So H_2 H_3^+ aurora are suitable for long-term observation.

However, the number of the devices is limited by difficulty of the development of the infrared measurement, and it is difficult to observe long-term continuation from a problem to large-sized telescope machine time. The development of the infrared imaging camera is carried out in Takahashi (2005) so far in Tohoku University, and the development of the infrared echelle spectrum device is carried out in Uno (2009).

However, the problem that a count level of the output image did not change into even if I changed an exposure occurred because it was defective in infrared sensor (InSb sensor) drive system. Radical new development InSb sensor drive used for these devices was started in the Kobuna (2008). It is the joint development with the Tohoku University astronomy specialty Professor Takashi Ichikawa classroom, and the design of the analog circuit is performed in an astronomy classroom, and this development examined digital circuit pro-development and synthesis movement in Kobuna (2008),but does not reach the completion.

It is expected what is utilized as drive system of the infrared imaging device which I produced in Takahashi (2005) and the infrared echelle spectroscope that development was carried out in Uno (2009). The InSb sensor drive system can contribute to continuation observation for a long term of the planetary atmosphere including Jovian IR aurora.

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Development of a New Telescope Dedicated to Observation of Planets at Haleakala, Hawaii : VIII

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We are constructing a 1.8m new telescope at the summit of Mt. Haleakala, Maui, Hawaii. It is under the collaboration with the Institute for Astronomy (IfA), University of Hawaii. In 2011, the fabrication of the primary mirror has been done. And plans of development timeline, facilities required for the development, telescope mechanical structure, and the dome were made. In 2012, we will start actual development along the timeline, and go into the most key phase in the development. The first light will be, if everything goes well, in 2014.

Clear sky and good seeing condition are definitely important for any ground-based observations. The summit of Mt. Haleakala in Maui, Hawaii is not the highest place (elv. 3050m), but one of the best sites with clear skies, good seeing, low humidity conditions, and good accessibility for us. At the Haleakala High Altitude Observatory at the summit, our group has been operating a 40cm Schmidt-Cassegrain telescope, and we have so far observed faint atmospheric and plasma features around bright planets, Io plasma torus, Mercury and Lunar sodium tail, and so on. Atmospheric escapes from Mars and Venus, the exoplanets close to mother stars are also possible topics. However, when we try to observe those faint emissions surrounding the bright objects, intense scattered light is always the most serious problem.

The new project, called PLANETS (Polarized Light from Atmospheres of Nearby Extra Terrestrial Planets), is dedicated to the observation of solar system planets and exoplanets. It consists of an off-axis primary mirror with a diameter of 1.8m, and Gregorian optics on an equatorial mount. State-of-the-art adaptive optics and masking technologies will be adopted to eliminate the scattering light. Based on these designs, it can avoid diffractions due to a spider structure that holds a secondary mirror and to minimize the scattered light from mirror surfaces as far as possible. In addition, the telescope optics will have a ultra-smooth mirror surface, the roughness of less than 1/20 lambda, with a new polish technology called HyDra, a water jet polishing technology developed by a group at Univ. Nac. Aut. de Mexico (UNAM). (This project is also a test for this new technology applied to off-axis mirrors.) Since a telescope completely optimized to a wide dynamic range does not exist yet, it can provide us a unique facility for spectroscopic and polarimetric observations of faint environments around the bright bodies, like planetary environments, stellar disks, etc.

This project is based on the collaboration among PPARC / Tohoku Univ., IfA / Univ. Hawaii (USA), Kiepenheuer Inst. Sonnenphysik (Germany), UNAM (Mexico), Univ. Turku (Finland), Harlingten Center for Innovative Optics (Canada), Stan Truitt (USA), Craig Breckenridge (Canada), and other collaborators. In 2011 March, after the Earthquake, the primary mirror glass blank completed in Japan was shipped to US, and now in the generating process. We also established the team structure, development timeline, and facilities required for the development. The main development will be at ATRC (Advanced Technology Research Center) of IfA in Maui. In 2012, all designs of the telescope mechanical structure and the domes will be finalized, and construction of development facility and structures will actually be started.

For promoting the project, Dr, Kagitani has been staying in Maui in 2011FY, and is contributing to the optical fiber Echelle spectrograph developments at ATRC. From June 2012, Prof. Okano will also be staying at ATRC/IfA. Associated with such residence, we are also preparing to move a 60cm telescope of Tohoku Univ. to the summit. In the paper, we summarize the overview of our drastic steps toward this future expected in this year.

Keywords: PLANETS, telescope project, optical and infrared, planetary observations