Japan Geoscience Union Meeting 2014
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PCG38-P01 Room:Poster Time:May 1 18:15-19:30

Study of the Venus' upper haze

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Venus is completely shrouded by a thick cloud deck floating at 45 – 70 km. The major material of the cloud deck is thought to be H_2SO_4 – H_2O droplets. The upper haze on Venus lies above the cloud layer surrounding the planet, ranging from the top of the cloud (~70 km) up to as high as 90 km. The upper haze particles with an effective radius of ~0.25 μm was suggested from Pioneer Venus Orbiter (PV) measurements. The particles were most likely composed of sulfuric acid in terms of refractive index ~1.45. The haze vertical optical thickness in the polar region at 365 nm was found to be 0.8 above the main cloud of 1 μm particles by PV measurements. By comparison, the optical thickness of the haze above the main cloud at low latitudes was found to be 0.06 [Kawabata et al., 1980]. Knibbe et al. (1998) and Braak et al. (2002) observed a gradual decrease of the haze particle column density during the PV mission. Braak et al. (2002) reported a correlation between the decrease of SO_2 abundance [Esposito et al., 1988; Na et al., 1990] and that of the polar haze optical thickness. However, it is unclear how haze are produced and composition of haze.

The upper layer detected (above the clouds) is characterized by a SO_2 mixing ratio increase with altitude from 85 to 105 km [Belyaev et al., 2012]. It shows a new source of SO_2 at high altitude. One possible source of SO_2 in the upper haze layer could be photo-dissociation of H_2SO_4 vapor resulting from evaporation of acid aerosol droplets. However, recent upper limit of H_2SO_4 from sub-mm ground-based observation makes this theory less likely [Sandor et al., 2012]. The cause of the phenomena given above is still controversial.

The Solar Occultation at InfraRed (SOIR) on board Venus Express (ESA) is designed to measure the atmospheric transmission at high altitudes (70 – 220 km) in the IR (2.2 – 4.3 μm) with high resolution by solar occultation. The SOIR data obtained in 2006 – 2009 are analyzed to examine the upper haze at altitude above 90 km. Vertical and latitudinal distribution of haze extinction, optical thickness and mixing ratio are calculated in using SOIR data statistically. Extinctions and optical thickness at low latitude are two times thicker than those of high latitude. One of the notable results is that mixing ratios increase at altitude above 90 km at both high and low latitudes. It is speculated that sources of haze are transported upward from under altitude 90 km and haze is produced at high altitude. From comparison with the vertical distributions of SO and SO_2 mixing ratios reported by Belyaev et al. (2012), it is speculated about the correlation between sulfuric compound and haze.

Keywords: Venus, upper haze, Venus Express, SOIR, cloud

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Observation of CO2-ice cloud in the Martian mesosphere by using PFS onboard Mars Express

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Almost all of constituent of martian atmosphere is CO2 (95%). It condenses at very high altitude (60~100km) and become cloud. CO2-ice cloud have been observed by many instrument , but it was difficult to clearly judge whether observed cloud is made of CO2 or not. However OMEGA, visible and near-infrared imaging spectrometer onboard Mars Express, have provided the first spectroscopic identification of a cloud as being composed of CO2 (Montmessin et al, 2007) CO2-ice cloud has characteristic spectral feature emission peak at 4.26μm. Recent study reported that CO2-ice cloud distributes around equator in spring equinox to early summer and mid latitude in local autumn. (Maattanen et al,2010 , Montmessin et al,2007 2006, Clancy et al 2007) However, it is not clear about cloud feature (particle size or opacity).

We try to observe CO2-ice cloud using high spectral resolution instrument PFS, infrared fourier spectrometer onboard Mars Express. Strong point of PFS is that spectral resolution is ten times greater than that of OMEGA and We can see spectral feature of CO2-ice cloud (spike at 4.26μm) more clearly. Another point is that PFS and OMEGA observe almost the same point , so two instruments can observe CO2-ice cloud at the same time. For the first step, we check the data where OMEGA observed CO2-ice cloud (10 orbits) and found CO2-ice cloud like feature all of the 10 orbits. However emission peak appears at shorter wavelength (at 4.25 μm) . In order to judge whether this signal is real or not, we compared PFS spectra and OMEGA spectra observed at the same point. When PFS observe signal at 4.25μm , OMEGA also show strong signal at 4.26μm ,so we can say PFS signal is real. In some orbit, PFS observed different signal from that of OMEGA. It is double spike feature at 4.25μm and 4.28μm which OMEGA can not resolve. It is possible that double peak feature shows different cloud feature, for example, particle size.Now we are trying radiative transfer model and discuss how cloud spectral feature changes when we changes cloud parameter (size distribution, altitude, cloud opacity).

Keywords: Mars, CO2-ice cloud

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Numerical Modeling of Moist Convection in Giant planets

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It is now widely accepted that moist convection is a common phenomenon in giant planets atmosphere. The moist convection is thought to play an important role in determining the mean vertical structure of the atmosphere; the mean vertical profiles of temperature, condensed components, and condensible gases in the moist convection layer is thought to be maintained by the statistical contribution of a large number of clouds driven by internal and radiative heating/cooling over multiple cloud life cycles. However, the averaged structure of the giant planets atmosphere and its relationship to moist convection remain unclear. For the purpose of investigating the above problem, we developed a cloud resolving model and investigated a possible structure of moist convection layer in Jupiter′ s atmosphere with using the model (Sugiyama et al., 2009, 2011, 2014). In this presentation, we perform two-dimensional calculations of moist convection and demonstrate a possible structure in the atmospheres of Saturn, Uranus, and Neptune.

The basic equation of the model is based on quasi-compressible system (Klemp and Wilhelmson, 1978). The cloud microphysics is implemented by using the terrestrial warm rain bulk parameterization that is used in Nakajima et al. (2000). We simplify the radiative process, instead of calculating it by the use of a radiative transfer model. The model atmosphere is subject to an externally given body cooling that is a substitute for radiative cooling. Because the vertical profile of net radiative heating is not observed in giant planets except Jupiter, the layer between 2 bar level and the tropopause, which corresponds to the observed cooling layer in Jupiter, is cooled. The body cooling rate is set to be 100 times larger than that observed in Jupiter′ s atmosphere in order to save the CPU time required to achieve statistically steady states of the model atmosphere.

The domain extends 960 km in the horizontal direction. The vertical domains are 400 km for Saturn case and 600 km for Uranus case and Neptune case, which are based on the one-dimensional thermodynamical calculation (Sugiyama et al., 2006). The spatial resolution is 2 km in both the horizontal and the vertical directions. The temperature and pressure at the lower boundary is also based on the thermodynamical calculation. The initial temperature profile follows adiabatic from lower boundary to tropopause and is constant above the tropopause. The abundances of condensable gases used in the each calculation are taken at 0.1, 1, 3, and 10 times solar.

The results obtained in Saturn case with 1 times solar abundance of condensible gases are discussed below; the results of other planets and the dependency on the abundances of condensable gases will be demonstrated at the meeting. The major characteristic of vertical motion in the moist convection layer obtained in Saturn case is that downdrafts are stronger than updrafts; this characteristic is obviously different from that obtained in Jupiter case (Sugiyama et al., 2009). Sugiyama et al. (2009) demonstrates that the vertical motion in the moist convection layer of Jupiter is characterized by narrow, strong, cloudy updrafts and wide, weak, dry downdrafts. On the other hand, the characteristics of mean vertical structure are consistent with those obtained in Jupiter case. Due to the active transport associated with convection, considerable amounts of H_2O and NH_4SH cloud particles exist above the NH_3 condensation level, while the mixing ratios of all condensible gases decrease with height from the H_2O condensation level. The stable layer associated with the H_2O condensation level acts as a fairly strong barrier for vertical convective motion; the vertical profile of root mean square of vertical velocity has local minimum at this level.

Keywords: atmosphere of giant planets, moist convection, numerical modeling, cloud resolution model

PCG38-P04 Room:Poster Time:May 1 18:15-19:30

Two dimensional numerical study on Venusian gravity waves by using mesoscale model

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Recently Venusian gravity waves are often observed. For example, Airglow measurements of O_2 found the gravity waves with horizontal wavelength of $\sim$100 km at 110 km altitude. UV images also detect gravity waves with the horizontal wavelength of 60-150 km at the cloud top level (70 km altitude). However, only a specific altitudes can be observed in these measurements, thus it is difficult to examine the propagation characteristics and momentum flux of waves. Radio occultation measurements also detect upward propagating waves from the vertical temperature profiles within the altitude range of 65-90 km and suggests that waves with the vertical wavelength of 5-10 km are dominant by the spectral analysis. However, horizontal resolution in this measurement is $\sim$200 km, then small scale gravity waves cannot be observed. Therefore, it is difficult to understand how these gravity waves have their influence on the Venusian atmosphere.

In this study we developed a new Venusian mesoscale model and examined the propagation characteristic of the waves. In the model, we simulated the generation and propagation of the waves including the convective motion in the Venusian cloud layer. We will make a presentation about the initial analysis results.

Keywords: Venus atmosphere, Gravity waves, Numerical study

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Temporal variations of Venus O2 night airglow using IRTF/CSHELL

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Venus 1.27-micron O_2 night airglow is the indicator of the general circulation at about 95 km in Venus. Recent observations reported that the airglow emission showed the temporal variations with a period of a few hours and days [e.g. Ohtsuki et al., 2008; Gerard et al., 2008]. Such variations may be caused by the upward momentum transport and fluctuations by atmospheric waves. In recent years, the importance of planetary-scale waves on the general circulation of the Venus atmosphere has been recognized. Forbes and Konopliv [2007] suggested the propagation of planetary-scale waves originated in the cloud deck into the upper atmosphere. However, effects of planetary-scale waves on the Venus upper atmosphere have not been investigated yet.

We conducted 5-days monitoring observation of the airglow to detect the planetary-scale waves with IRTF/CSHELL from 11-15 July 2012, 3 and 5 February 2014. The 1.27-micron O_2 night airglow in the Venus atmosphere can pass through the Earth's atmosphere with a help of the Doppler shift. We obtained spectral image cubes at the wavelength of R-branch of the airglow band, which includes several rotational lines. In order to cover spectral information continuously, a slit drifted across Venus' nightside disk. The spatial resolution of the image is governed by seeing. The typical seeing was 0.6" to 1.5" in our observing run and corresponds to 200-450km at the center of Venus' disk. Under such conduction, we may detect airglow structures of small scales due to atmospheric waves; this is smaller than the region of enhanced airglow having a horizontal scale of ~3000km. We can also derive the hemispherical distribution of the rotational temperature. To coincide with our observations, SOIR/Venus Express stellar occultations were conducted. We can try to compare our horizontal temperature map and vertical temperature profile from SOIR data.

In this presentation, we will show temporal variation of the airglow distributions in July 2012 and report a preliminary result of our new observations in February 2014.

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Observing plan for planetary atmosphere using IR heterodyne spectroscopy in 2014

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We propose a new developed infrared heterodyne instrument, called Mid-Infrared LAser Heterodyne Instrument (MILAHI), for our dedicated telescope at the top of Mt. Haleakala, Hawaii. It addresses the key physical/meteorological parameters, such as the atmospheric temperature profiles, abundance profiles of the atmospheric compositions and their isotopes, and wind velocity. The observational sensitivity of MILAHI is discussed in this paper. The scientific target of MILAHI is to understand highly variable phenomena in the planetary atmospheres. The nature of atmospheric activity in various time-scale will be investigated by continuous monitoring with our dedicated telescope, in order to increase our understanding of planetary atmospheric dynamics, photochemistry, and meteorology. New measurements with high spatial/spectral resolutions constrain the three-dimensional distributions of temperature and compositions. The D/H and other isotopic ratios, diagnostic of the terrestrial atmosphere evolution, will be accurately measured in H_2O and CO_2. The atmospheric chemistry will be studied by monitoring O_3, H_2O_2, H_2O, and HDO. Mapping of the H_2O isotopes reveal the mechanism of complex interaction between regolith-aerosols-atmosphere-polar caps on Mars. Direct measurements of wind velocity and temperature allow the first monitoring of the middle atmosphere oscillations to investigate the effects of the gravity waves from the lower atmosphere on the upper atmosphere for various seasons and dust loadings. A number of organics molecule bands in the mid-infrared regime will be accurately measured in planetary/cometary/stellar atmospheres. In addition to these interconnected objectives, serendipitous searches with our advantage of dedicated use for astronomical/atmospheric transient events which occur at frequent and unpredictable intervals (e.g. dust storm) will enhance our knowledge of the composition and dynamics of the astronomical sources.

Keywords: infrared spectroscopy, heterodyne, laser, observation, planetary atmosphere, isotopes

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Visual Orbit Design for the Next Mars Exploration Mission

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In December, 2011, the working group concerned with the Japanese next Mars exploration mission began to study the use of orbiters to investigate the mechanisms of carbon dioxide and water escape from the Martian atmosphere, and the role played by the solar wind. This will be the successor to the first Japanese mission to Mars involving the NOZOMI spacecraft, and two different orbiters will be deployed around the planet. Orbiter-A will carry out in-situ observations of electric and magnetic fields, particles, plasma and the atmosphere at an altitude of about 100 km above the Martian surface. Orbiter-B will capture images of the escaping atmosphere and monitor solar-wind conditions. The mission life will be a Mars year. This paper describes a visual method for determining the orbits of both spacecraft, and presents examples of possible orbits.

The orbital constraints proposed by the working group are as follows.

Orbital constraints for Orbiter-A

A1. The periapsis altitude is around 150 km.

A2. The apoapsis altitude is between 5000 and 7000 km.

A3. The period during which periapsis occurs on the dayside of the planet is more than two thirds of the mission life.

Orbital constraints for Orbiter-B

B1. The apoapsis altitude is about 4-6 R_M.

B2. The period during which the orbiter is exposed to the solar wind is more than three quarters of the mission life.

B3. The period during which the orbiter can image the local time zone of 12-15 h at the planetary limb is more than three quarters of the mission life.

Orbital constraints for combined observations by both orbiters

C1. The number of times during which Orbiter-B is exposed to the solar wind and can also image Orbiter-A, whose solar zenith angle and altitude are less than 60 deg and about 300-800 km, respectively, is more than one hundred during the mission life.

C2. When C1 is satisfied, the angle between the line-of-sight of the imager onboard Orbiter-B and the velocity vector of Orbiter-A is within 90$\pm$20 deg.

The orbital elements are obtained by solving the Lagrange planetary equations for a two-body boundary-value problem, taking only the J2 perturbation into account. Constraint A3 is chosen as an example for explaining the visual method of orbital design. The orbiter's longitude of ascending node and argument of periapsis in a Mars-Sun fixed coordinate system are taken as design variables, and the orbital constraint is used as an evaluation function. A contour map for a period in which periapsis occurs on the dayside is plotted in a coordinate system in which the longitude of ascending node and argument of periapsis are the X and Y axes, respectively. A mission profile is placed on the map, along which the changes in the longitude of ascending node and argument of periapsis during the mission period are plotted. The mission profile can be placed at anywhere on the map, since its shape can be kept almost constant by selecting an initial position determined by the position and direction of the spacecraft during Mars orbit insertion. By looking at the map, it then becomes easy to identify an appropriate initial point for the mission profile that maximizes the period during which periapsis occurs on the dayside.

By the method described above, it is possible to visually determine rough values for the longitude of ascending node and argument of periapsis that are suitable for the mission. This technique is also applicable to the general design of orbits around a planet by choosing a coordinate system appropriate for the given orbital constraints.

Keywords: atmospheric escape of Mars, Mars orbiter

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A Circumpolar Stratospheric Telescope for Observations of Planets ? FUJIN

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It is important to conduct long-term continuous observations of time-dependent events in planetary atmospheres and plasmaspheres. The aim of the FUJIN project is to carry out continuous observations of planets using a telescope that is lifted by a balloon to the polar stratosphere. The FUJIN-1 experiment was organized at Taiki Aerospace Research Field in Taiki-cho, Hokkaido, Japan, from May to June 2013, but the experiment was canceled due to a failure found in the balloon operation system provided by JAXA. However, the results of various prelaunch ground tests clearly established the feasibility of the experiment.

We have recently begun organizing the FUJIN-2 experiment, in which scientific observations of planets will be conducted in the Arctic. Wind speed in the stratosphere is very low during April and May. The FUJIN-2 experiment will be conducted during this period in 2015 at ESRANGE in Kiruna, Sweden, since this is when Venus will be in the most favorable position for observations. The gondola will be recovered somewhere in the Scandinavian peninsula after one or two days of continuous observations.

In summer, an eastern circumpolar wind is dominant in the stratosphere. If a balloon is flown under these conditions, it will take a week to fly from Kiruna to Alaska and more than two weeks for it to fly back to Scandinavia along a constant-latitude path around the Earth. We are currently organizing another experiment (FUJIN-3) involving such a circumpolar flight that will be conducted in 2017 or later. The system used in FUJIN-2 will also be used for FUJIN-3, but with the inclusion of a high-sensitivity CCD camera and a liquid-crystal tunable filter. Venus, Jupiter, and Mercury will be the planets of interest for FUJIN-3. Moreover, a next-generation stratospheric telescope with a meter-class aperture, a mobile gondola to approach the center of the polar vortex, and a super-pressure balloon for year-round observations are being studied to upgrade the FUJIN system for future use.

Keywords: Circumpolar, Stratospheric, Telescope, Venus, FUJIN-project

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Study of fast resistive magnetic reconnection in the upper atmosphere of Venus

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Although Venus has no intrinsic magnetic field, magnetic field exists in the upper atmosphere through the interaction of the solar wind. In the dayside ionosphere of Venus, small magnetic rope-like structures called 'flux ropes'were often observed when solar wind dynamic pressure was low. Pioneer Venus Orbiter (PVO) observed flux ropes on more than 40% of the orbits passing through the dayside lower ionosphere, and founds its occurrence rate maximizes at altitude170km [Elphic et al., 1983].

So far some models to generate flux ropes have been proposed (K-H instability [Wolff et al., 1980], nonlinearity associated with the Hall effect [Kleeorin et al., 1994]), but the generation mechanism is not yet understood. In this study, we propose a new model to generate flux ropes based on recently proposed fast resistive magnetic reconnection [Loureiro et al., 2007]. This fast resistive reconnection occurs in a very long Sweet-Parker (SP) current sheet. The growth rate in the linear stage is proportional to the one-quarter power of the Lundquist number, and the current sheet is unstable under the condition that the Lundquist number is more than 10 to the power of 4. According to MHD simulation results [Samtaney et al., 2009], a chain of plasmoids is formed after reconnection at many points in the current sheet. Such a chain structure is similar to flux ropes. In the dayside ionosphere of Venus, a very long current sheet can form, where the fast resistive magnetic reconnection occur. Therefore, we considered a model to generate flux ropes through the formation of a very long current sheet and subsequent fast resistive reconnection in the dayside ionosphere of Venus, and then examined its applicability. The outline of the generation model we propose in this study is as follows: First, the interplanetary magnetic field (IMF) carried by the solar wind penetrates into the dayside lower ionosphere when solar wind dynamic pressure is high. Then, the field reversal structure resulting from an IMF turning penetrates there, and a very long SP current sheet is created. Finally, flux ropes are generated through the fast resistive reconnection in the current sheet.

In order to examine the applicability of our model, we estimated the altitude profiles of the Lundquist number, the growth rate of the fast resistive reconnection, and the SP current sheets thickness by using the result of a hybrid simulation in the upper atmosphere of Venus [Terada et al., 2002]. From the profiles, we chose the altitudes corresponding to specific Lundquist numbers, and we consider that the fast resistive reconnection can occur if the following conditions are satisfied at the chosen altitudes. First one is that the fast resistive reconnection can grow sufficiently. Second one is that the SP current sheet thickness is larger than the observed flux rope radius [Elphic et al., 1983]. Consequently, we found that our model is applicable between near 170 km altitude (Lundquist number is 10 to the power of 5 at this altitude) and near 230 km altitude (Lundquist number is 10 to the power of 6 at this altitude). We will show the result of MHD simulation performed with the parameters at these applicable altitudes.

Keywords: reconnection, ionosphere, Venus

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Estimation of the ion acceleration in the Ganymede polar magnetosphere by the Galileo spacecraft observation

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Ganymede is one of the Jovian moons and is known as the only satellite that has an intrinsic magnetic field [Gurnett et al., 1996]. Since Ganymede is located in the Jovian magnetosphere, corotating magnetospheric plasma always blows toward Ganymede's magnetosphere [e.g. Kivelson et al., 1998]. Since the spatial scale of Ganymede's magnetosphere is comparable to the Larmor radius of magnetospheric ions, the characteristic plasma environment around Ganymede is formed due to the interaction between Ganymede's magnetosphere and Jovian magnetospheric plasma. Although previous studies discussed the morphology of Ganymede's magnetosphere and its plasma environment, most of them are still unknown and understanding of the interaction is necessary to reveal processes occurring in Ganymede's magnetosphere.

In the present study, we discuss the plasma environment observed in Ganymede's polar region by the Galileo spacecraft. First, we have identified Upper-Hybrid Resonance (UHR) frequency by the Plasma Wave Subsystem (PWS) and have analyzed the electron density at the point of observation. We have analyzed four Ganymede encounters including those on orbits G01 and G02 which have been analyzed in the previous study. Since the most dominant ion in Ganymede's magnetosphere is O+ [Vasyliunas and Eviatar, 2000], we assumed that the O+ density equals the electron density. Based on the results of this analysis, we have plotted the distribution of O+ density in the altitude range from 264 km to 5262 km and have revealed that the number density decreases rapidly with distance from Ganymede. Next, we have discussed the ion outflow from Ganymede's polar region. Based on the obtained distribution, we have found that the density distribution can be expressed by r^-5.98, where r is the distance from Ganymede. Assuming that the flux is conserved along the path of the ion outflow and that the cross section of the flux tube of outflow is proportional to r^2 and r^3, we have estimated that the ion velocity reaches 17.3 km/s and 14.5 km/s, respectively, at the distance of 500 km from Ganymede. This result is consistent with the previous study which suggested the outflow O+ velocity is 18 km/s from observations of the Galileo PLS instrument [Vasyliunas and Eviatar, 2000]. We also discuss candidate mechanisms for the ion outflow from Ganymede's polar region and report the current status of a simulation code which we are developing so as to discuss the outflow process quantitatively.

Keywords: Ganymede, magnetosphere, outflow, acceleration

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In-flight calibration of HISAKI/EXCEED by stellar observations

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The extreme ultraviolet (EUV) telescope EXCEED (Extreme Ultraviolet Spectroscope for Exospheric Dynamics) onboard the Japan's small satellite HISAKI (SPRINT-A) will be launched in August 2013. The EXCEED instrument will observe tenuous gases and plasmas around the planets in the solar system (e.g., Mercury, Venus, Mars, Jupiter, and Saturn). One of the primary observation targets is Jupiter, whose magnetospheric plasma dynamics is dominated by planetary rotation. In the EUV range, a number of emission lines originate from plasmas distributed in Jupiter's inner magnetosphere. The EXCEED instrument is designed to have a wavelength range of 52-148 nm with a spectral resolution of 0.3-1.0 nm. The spectrograph slits have a field of view of 400 x 140 arc-seconds (maximum), and the attitude fluctuations are stabilized within 5 arc-seconds. The optics of the instrument consists of a primary mirror with a diameter of 20cm, a laminar type grating, and an EUV detector using microchannel plates (MCPs). The surfaces of the primary mirror and the grating are coated with CVD-SiC.

After the launch of the HISAKI satellite and the initial check out of the instrument for 2 months, we performed in-orbit calibrations of the EXCEED instrument by stellar observations. We observed the standard stars GD71, HZ2, and FEIGE110, and measured the absolute sensitivity and the spatial resolution of the EXCEED instrument. As a result, the absolute sensitivity was ~1-2 cm^2 and the spatial resolution was ~16 arc-seconds. In this presentation, we report the overview and initial results of the in-orbit calibration of EXCEED.

Keywords: HISAKI, EXCEED, EUV

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Coordinated observation of Io plasma torus using Hisaki/EXCEED and gourd-based telescopes

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EXCEED is an EUV spectrograph onboard an earth-orbiting space telescope, Hisaki(SPRINT-A). One of the primal mission goal of Hisaki/EXCEED is to reveal radial transport of mass and energy in the Jovian magnetosphere. At the begging of January 2014, intense campaign observations of Jovian aurora and Io plasma torus were made using Hisaki/EXCEED, Hubble Space Telescope and other ground-based telescopes covering wavelength range from EUV through IR. We will present results of spectroscopic observation of Io plasma torus using the R.C. spectrograph attached to Kitt-Peak 4-meter telescope and an Echelle spectrograph attached to Haleakala 40-cm telescope.

The 4-meter R.C. Spectrograph was set up covering 550nm through 800nm which could successfully detect NaD (589nm), SIII 631.2nm, SII 671.6/673.1nm, and OII 731.9/733.0nm as well. A field-of-view was 98 arcseconds along the slit and the slit center was pointed at the dawn or dusk edge of the centrifugal equator. We could get 54 spectra from the observation during January 4th through 10th, 2014.

The Haleakala spectrograph is a high-resolution echelle spectrograh with an integrated field unit (IFU) which enables to capture 2-d distribution of [SII] 671.6/673.1nm emission with spectral resolution of 67000 over a field-of-view of 41" by 61". The 40-cm telescope was observing Io plasma torus all over the night during the observing campaign period.

Based on preliminary analysis of the EUV spectrum from EXCEED/Hisaki, visible spectrum from Kitt-Peak 4-meter and Haleakala 40-cm, emission peaks of SIII and OII was located outward compared to the SII emission peak which is consistent with results from previous studies. More accurate analysis including pointing calibration and flux calibration are ongoing, the result will be presented at the meeting.

Keywords: Hisaki/EXCEED, Io plasma torus

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PCG38-P13 Room:Poster Time:May 1 18:15-19:30

Coordinated observation of Jupiter thermosphere and radiation belt in January 2014

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In order to evaluate the solar UV/EUV heating effect on the Jovian radiation belt, we made coordinated observations for both temperature of the Jovian thermosphere using an infrared telescope and synchrotron radiation from the radiation belt (JSR) using a radio interferometer. JSR is the most effective probe for the dynamics of the Jovian radiation belt through remote sensing from the Earth. Recent intensive observations for JSR reveal short term variations of JSR with the time scale of days to weeks, but their causalities are not understood well. It is theoretically expected that the Jovian thermosphere is heated by solar UV/EUV radiation, and planetary atmospheric neutral wind is driven by solar UV/EUV heating. Then, induced dynamo electric field is mapped into the radiation belt and induces radial diffusion. From this scenario, the total flux density of JSR is expected to correlate with the solar UV/EUV flux.

Previous studies confirmed that the total flux density of JSR varied corresponding to the solar UV/EUV variations though it is unclear whether the temperature of the Jovian thermosphere actually varied during this event. The purpose of this study is to confirm whether sufficient solar UV/EUV heating occurs on the Jovian thermosphere and it actually causes variations of JSR total flux density. We made coordinated observations of the NASA Infra-Red Telescope Facility (IRTF) and the Giant Metrewave Radio Telescope (GMRT). From the infrared spectroscopic observations, we measured thermospheric temperature of H_3^+ ion. From the radio interferometer, we measured the total flux density and brightness distribution of JSR.

The IRTF is a 3 m infrared telescope located in Mauna Kea, Hawaii. The IRTF observations were made on Jan 3, 8, and 13 in 2014. We used the high spectral resolution spectrometer, CSHELL, and observed H_3^+ 3.9530 microns emission (Q(1,0)) and 3.4547 microns doublet emission (R(4,3) and R(4,4)). We assumed local thermodynamic equilibrium at the equatorial region and calculated thermospheric temperature from the two emission line ratio. The GMRT is a large radio interferometer located in India. The GMRT observations were made from Dec 31 to Jan 16 with a few days interval. The typical duration of observation time was 2 hours per day, and the observation frequency was 235 and 610 MHz. During this period, the SOHO satellite showed that the solar EUV flux increased from Dec 26, reached at the maximum flux on Jan 8, and then decreased to Jan 16. A preliminary analysis of the IRTF data showed that the temperature increased from Jan 3 to Jan 8, and decreased from Jan 8 to Jan 13. This is the first result that shows the temperature response of Jovian upper atmosphere to the solar UV/EUV heating. We will also introduce analyzed results of the GMRT data and discuss the relationship between Jovian thermosphere and radiation belt.

Keywords: Jupiter, thermosphere, radiation belt, infrared observation, radio interferometer

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Data analysis of Jupiter's decametric radio emission observed by LWA1

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We present new results in the study of Jupiter's decametric emission obtained using the newly commissioned Long Wavelength Array Station 1 (LWA1). The LWA1 is a low frequency radio array operating in the frequency band between 10 and 88 MHz. The array consists of 256 dual polarization dipole stands, and observations are possible with up to four simultaneous beams, each of which has two independent tuning frequencies. The LWA1 is well suited to studying details of Jovian phenomena due to its high sensitivity as well as high time and frequency resolution over a wide bandwidth. We present LWA1 observations and the developed data analysis software by using IDL. The observed Io-C dynamic spectrum on March 10, 2012 shows the modulation lanes of both left and right hand polarization components share the same lane structure. It indicates that the both left and right hand Io-C radiations are emitted from the southern hemisphere. And the locations of the radio sources along the Jupiter's magnetic field should be very close.

Keywords: Jupiter radio, decametric wave, data analysis, radio source, radio emission mechanism, LWA1

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Long Term Variations of Jupiter's Auroral Radio Emissions - II

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It is known that Jupiter's auroral radio emission (hereafter JAR) shows long term variations with the time scale of about a decade. The variations were first considered to be initiated by the solar activities in 1960's, however, longer term analyses in 1970's showed the variations relate with the Jovicentric declination of the earth (De). So far, their plausible causalities are considered to be brought by 1) De relating to amount of reachable rays to the earth, and 2) the geocentric declination of Jupiter relating to incidence angle of the radio wave to the terrestrial ionosphere. However, considering solar cycle dependence on the terrestrial auroral radio activity (e.g. Kumamoto et al., 2003), the solar activity control may not be negligible for the long term variations. Furthermore, we have not known well long term relationship between JAR and Jupiter's substorm-like process which may be controlled by Io's volcanic activity.

In order to assess the previously proposed causalities and the other effects, we have investigated occurrence features of JAR using the radio wave data observed outside the terrestrial ionosphere; i.e., by the WIND satellite after 1995. We have derived year-scale occurrence probabilities for 0.7 - 14 MHz around Jupiter's occultation periods, where the frequency range includes both Jupiter's decameter and hectometer radio emissions (so-called DAM and HOM, respectively). As the result, the yearly-scale occurrence probabilities show almost monotonous decrease from 1995 to 2005, then gradual increase after 2005, but change to somewhat complex nature with increase and decrease after 2009. The tendency is roughly similar for DAM and HOM, and also quite roughly similar for Io-related and non-Io-related DAMs. On the other hand, the JAR variation features do not seem to correspond to individual variation of De, solar activity and solar wind, but seem to somewhat correlate with those of Iogenic gas luminosity. These results imply that multiple causalities and/or Jupiter's internal process(es) control the long term variations.

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Keywords: Jupiter, auroral radio emission, long term variation, Io's volcanic activity, Iogenic gas