Japan Geoscience Union Meeting 2013
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Temperature variation of the cloud top of Venus obtained by photometry observation by LIR onboard Akatsuki

Tetsuya Fukuhara[1*], Yuuna Shima[1], Toru Kouyama[2], Takeshi Imamura[3], Masahiko Futaguchi[4], Makoto Taguchi[4]

[1]Hokkaido University, [2]AIST, [3]ISAS, [4]Rikkyo University

The Japanese Venus Climate Orbiter called Akatsuki was designed to study the meteorology of the Venusian atmosphere, which differs to that of the Earth in composition, density and circulation. Akatsuki was to orbit around Venus in an elongated equatorial orbit with almost the same angular velocity during most of the orbital period as that of the super rotation of the atmosphere at the cloud top altitudes, like a geosynchronous satellite. A 3-D structure of the atmosphere was to be reconstructed by multi-depth imaging using four cameras operating in the mid-infrared to near ultraviolet regions and using the radio occultation technique. The Longwave Infrared Camera (LIR), which mounts an uncooled micro-bolometer array (UMBA), is one of a suite of cameras onboard Akatsuki, designed to take mid-infrared images of Venus with a single band-pass filter of 8?12 um. LIR detects thermal radiation emitted from the layer where the cloud optical depth equals unity. The noise equivalent temperature difference (NETD) of LIR is 0.3 K and absolute temperature can be determined with an accuracy of 3 K. In addition, a cloud tracking technique could retrieve the horizontal wind vector field at the cloud-top height. Unfortunately, Akatsuki failed to enter the orbit because trouble occurred with the propulsion system on December 7, 2010. At present the spacecraft is orbiting the Sun, and it will have a chance to encounter Venus in 2015. During the spacecraft cruising, LIR successfully acquired 52 photometry data of day-side Venus between February and March 2011 at a distance of 1.2-1.7x10^7 km. The spatial resolution of LIR and an apparent diameter of Venus being almost equivalent, Venus' disk in the image extends to several pixels that include both Venus and the background radiation. All brightness pixels that included Venus were summarized and the background radiation component were removed from them to estimate a Venus' brightness component. Furthermore, it has been converted to the brightness temperature by using calibration data acquired in the laboratory before the launch and brightness temperature variation of the disk have been obtained. However, the discrete data set has large data gaps. Then, the Lomb-Scargle periodgram, which is better suitable than Fast Fourier Transform, has been applied and been obtained a spectrum. The result shows spectrum peaks at 5-day and 8-day period. The 5-day period may be caused by the super rotation, and the 8-day period may be a planetary-scale wave that has the phase velocity of ~50 m/s.

Keywords: Venus, atmosphere, Akatsuki, LIR

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Study of the Venus cloud upper haze

Seiko Takagi[1*], Arnaud Mahieux[2], Valerie Wilquet[2], AnnCarine Vandaele[2], Naomoto, Iwagami[1]

[1]Graduate School of Science, the Univ. of Tokyo, [2]Belgian Institute for Space Aeronomy

Venus is covered by H_2SO_4 clouds floating at 45-90 km. Despite Venus cloud is identified by previous Venus observation, there are many unknown things about Venus cloud because of small number of Venus observations. Moreover, knowledge of Venus cloud upper haze layer(70-90 km) is less than upper, middle and lower cloud remarkably because most of Venus probes observed only below the upper cloud layer (under 70km).

Solar Occultation at Infrared(SOIR), which is a part of the spectroscopy on board Venus Express, is designed to measure at high resolution the atmospheric transmission in the IR (2.2-4.3 um) using solar occultations. SOIR observe Venus atmosphere and cloud existed at high altitude (60-220 km), any latitude and longitude. In this study, analysis of SOIR data obtained between 2006 and 2009 is performed to obtain knowledge of Venus cloud upper haze layer.

Altitude distribution and time variation of upper haze extinction and mixing ratio are derived from SOIR data. Mixing ratio vertical distribution shows that haze creation is more dominant than vertical eddy diffusion at above 90 km. It is speculated that sulfide is contained in haze from comparison of this study and mixing ratio vertical distribution of SO/SO_2. Mixing ratio vertical distribution shows that vertical eddy diffusion is more dominant than haze creation at 70-90 km. It is speculated that sulfide is contained in haze from comparison of this study and time variation and latitude distribution of SO/SO_2.

Keywords: Venus, cloud, Venus Express, SOIR

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Venusian upper hazes observed by Imaging-Polarimetry system HOPS

Takayuki Enomoto[1*], Takehiko Satoh[2], NAKATANI, Yoshikazu[3], Takashi Nakakushi[4], Takao M. Sato[5], Shoko Ohtsuki[6], Mayu Hosouchi[7]

[1]Grad.Univ.Advanced Studies, [2]Japan Aerospace Exploration Agency, [3]Kyoto University, [4]Wakayama University, [5]NICT, [6]Senshu University, [7]University of Tokyo

Physical properties of the aerosols in the Venusian upper atmosphere can be derived by measuring the polarization of light scattered by them. Kawabata et al. [1980] obtained polarization maps of Venus from the data of Orbiter Cloud Photopolarimeter (OCPP) onboard the Pioneer Venus Orbiter, and found that numerous haze particles distributed mainly on polar region. Kawabata [1987] and C. J. Braak et al. [2002] analyzed years of data observations and reported that optical depth of the hazes had rapidly declined. The variability of hazes and clouds can change longitudinal balance of solar absorption and atmospheric dynamics.

Two dimensional polarization maps are in general advantageous as they allow us to selectively pick up the local characteristics. We developed a planetary imaging-polarimetry system HOPS (Hida Optical Polarimetry System), which can take polarization maps as OCPP, and do observations for the purpose of monitoring of Venusian upper hazes.

The optical system of HOPS is composed of combination of a Wollaston prism and a half wave retarder, and the observation channels are 930, 647(650), 548(546), 438nm. One observation includes a total of four shots with the retarder position angle is incremented by 22.5 degrees. By arithmetic operations of the data, the degrees of linear polarization are obtained accurately after removing the effects of 'unevenness of the CCD sensitivities' and 'transparency of the atmosphere'. However, the uncertainties of registration and resulting polarization errors caused by the effect of the time-variable atmospheric turbulence are problems for planetary observations, which need to be taken care of.

The observations were performed in Hida observatory of Kyoto Univ. on May, Aug., and Oct. 2012. The phase angles of Venus at that time were 128, 85 and 58 deg., and apparent diameters are 42, 21, 14 arc second, respectively. The scale of one CCD pixel on the 65cm refractor is about 0.3 arc second, so the diameter of images of Venus on Aug., whose apparent diameter was about 21 arc second, was about 70pix. Polarization maps of this resolution are enough to pick up the local characteristics as PVO.

As a quick-look of the observations, we compared the data of 548nm and 930nm, whose channels are close to those of Kawabata et al. [1980], with them. The disk-integrated polarization degrees of 548nm matched with the past data. In contrast, the 930nm data were -3% ~ -2% while those of PVO were -2 ~ -1%. By comparison of equatorial and polar region, it was found that polarization degree of polar region is more negative than PVO data, this relatively lowered the disk-integrated polarization degree. These values are, however, less negative than those of ground-based observations in 1960s, this may indicate that the distribution of haze particles at the time of HOPS observation is somewhat similar to the situation of PVO arrival at Venus.

We are planning to observe at other phase angles and developing the calculation code of radiative transfer including polarization for the purpose of quantitative evaluations.

Keywords: Venus, Haze, Imaging-Polarimetry, Ground-based observation

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Latitudinal cloud structure in the Venusian northern hemisphere evaluated from VEX/VIRTIS with GCM

Morihiro Kuroda[1], Takeshi Kuroda[1], Yasumasa Kasaba[1*], P. Drossart[2], G. Piccioni[3], Kohei Ikeda[4], Masaaki Takahashi[5]

[1]Tohoku Univ., [2]Observatoire de Paris, [3]INAF-IAPS, [4]JAMSTEC, [5]Univ. Tokyo

The latitudinal characteristics of Venusian northern cloud, i.e, opacity, top temperature and top altitude are evaluated from the Venus Express/VIRTIS observations. The cloud optical thickness in the polar region (˜65 degN) is ˜1.5 times larger than in middle latitudes. It suggested that in the polar region the amount of cloud particles is larger or the properties of cloud particles are different. The averaged cloud top temperature is uniform in 0 - 40 degN (232+-2 K), gradually decreases north to 70degNN (223+-5 K), and increases again to north pole (233+-6 K). On the other hand, the averaged cloud top altitude is monotonously decreasing from equator (68.2+-1.6 km) to north pole (58.3+-1.0 km). Since the cloud top altitude sharply decreases beyond the polar region (˜65 degN), the structure of Venusian polar vortex is affected by the decreasing of cloud top. The abundance of carbon monoxide under the cloud layer was measured using Band Ratio Technique constructed by Tsang et al. (2009). As a result, the mixing ratio increases from 16+-3 ppm at equator regions to 24+-5ppm at 70 degN, and it decreases to 19+-5 ppm at 80 degN. Furthermore, there is a negative correlation between the CO abundance and cloud top temperature, and the peak of CO abundance is located in the cold collar regions (˜70 degN). Since CO under the cloud is transported from the upper layer, the CO enhancement in the cold collar can be interpreted the down-welling region of planetary-scale circulations, i.e., the Hadley-Circulation. We tried to evaluate the suggestion with a Venusian General Circulation Model (GCM). As a result, the cloud top altitude is monotonously decreasing from equator (67.3 km) to north pole (59.3 km) and the cloud top temperature is almost same from equator to 40o N (234 K), and gradually decreasing to 70 degN (228 K), and increasing toward north pole (242 K) again. In addition, the mean meridional stream-function indicates the existence of down-welling of Hadley-Circulation at the cloud top regions around 70 degN. It can be interpreted that the Venusian polar vortex structures (polar dipole and cold collar) seen from infrared wavelength are created from decreasing of cloud top due to the Hadley-Circulation.

Keywords: Venus, Cloud, altitude, latitude, Venus Express, GCM

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Development of a sulfuric acid cloud transfer/condensation/evaporation scheme in a Venusian GCM

Kato Fumiya[1*], NITTA, Akira[2], KURODA, Takeshi[1], KURODA, Morihiro[1], KASABA, Yasumasa[1], TAKAHASHI, Masaaki[2]

[1]Tohoku University, [2]University of Tokyo

We are investigating the cloud formation, chemical reactions, and their radiative effect which affect the atmospheric dynamics in the Venusian middle atmosphere, using a VGCM (Venus General Circulation Model). Recently we introduced evaporation/condensation processes of the sulfuric aerosol into the VGCM developed by Ikeda [2011], and reproduced the latitudinal/vertical distribution of the sulfuric aerosol which is consistent with previous observations. In this presentation, we will show the results and the future steps of our research.

Venusian sulfuric acid cloud deck, which exists in the altitude of 50km-70km, is considered to have a strong influence on the thermal balance of the Venusian atmosphere. The component of the cloud particle is mainly sulfuric aerosol which is formed by the reactions between SO_2, O and H_2O. The sulfuric acid droplets are divided into 4 groups according to the size; mode1 (0.3um), mode2 (1.0um), mode2' (1.4um) and mode3 (3.56um) as defined in Crisp. [1986]. Each mode has its own characteristics of vertical distribution and thermal absorption efficiency, so reproducing the vertical/latitudinal distribution of those modes in the numerical model is important to simulate the general circulations in the Venusian atmosphere.

We have investigated the cloud distributions in the Venusian atmosphere using a VGCM based on the CCSR/NIES/FRCGC AGCM [Ikeda, 2011]. The model has 32(latitude) X 64(longitude) grid points and 52 vertical levels from the surface up to 95km. It successfully reproduces the zonal and meridional winds including super-rotation and Hadley circulation in the Venusian atmosphere. The current model calculates the radiative effects of clouds and molecules from fixed distributions defined in Crisp [1986] and Pollack et al. [1993], so we plan to implement into the model the radiative effects which will be consistent with the calculated cloud distributions, as well as the chemical reactions for production of the clouds.

We introduced the evaporation/concentration process of H_2SO_4 and simulated the evaporation of aerosols in the lower atmosphere which has the higher temperature and the condensation of aerosols in the upper atmosphere. The model calculates the saturated mixing ratio in each grid from the saturated vapor pressure curve derived from Ayers [1980], and compared it to the H_2SO_4 mixing ratio at the grid. We assumed that if the H_2SO_4 mixing ratio (sum of vapor and cloud) is larger than the calculated saturated mixing ratio, the supersaturated H_2SO_4 concentrates as an aerosol, and if not the H_2SO_4 aerosol all evaporates. The generated H_2SO_4 aerosols are distributed into 4 modes at each altitude according to the abundance ratio based on the observation [Crisp, 1986]. We are implementing the effects of latent heat by the condensation /evaporation using the method of successive approximation.

Because of this improvement, every mode of the cloud now evaporates below 50km altitude. After the calculation of 1 Venusian day (117 terrestrial days), mode 3 aerosol gets the equilibrium state at 50km altitude.

Also the amount of mode2 aerosol largely decreased in low and mid latitudes of 60km-80km altitude, while increased in the atmosphere above 80km in all latitudes and 60km-80km altitude in high latitudes, in comparison with the model without the evaporation/concentration processes [Kuroda et al., 2013]. We consider that the difference is because the sulfuric aerosol is enhanced to evaporate especially in the equatorial middle atmosphere where the temperature is high, and the transport of H_2SO_4 to higher altitudes and latitudes by Hadley circulation is enhanced due to the phase change.

We will continue to improve our model to increase the accuracy of the simulation of the vertical/latitudinal cloud distribution. In the presentation, we plan to show the numerical results with radiative effects and chemical reactions which is connected to the cloud formation.

Keywords: Venus, GCM, sulfuric cloud, atmospheric material transport

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Temperature distributions in the Venus O2 night airglow layer by ground-based observations

Shoko Ohtsuki[1*], Naomoto Iwagami[2], Severine Robert[3]

[1]Senshu University, [2]University of Tokyo, [3]Belgian Institute for Space Aeronomy

Venus 1.27-micron O_2 night airglow can be used as a probe of chemistry and dynamics at around 95 km. The enhanced rotational temperature at around the anti-solar point found from the O_2 airglow has been supposed to indicate the evidence of downflow. However, the nightside temperatures at 90-100 km found by SPICAV/VEX differ from those by the airglow.

We conducted 5-days monitoring observation of the airglow to detect the planetary-scale waves with CSHELL/IRTF from 11-15 July 2012. 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.

Keywords: Venus atmosphere, airglow, ground-based observation

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The propagation characteristics of short-period gravity waves and acoustic waves in the Martian atmosphere

Ayuka Watanabe[1*], Takeshi Imamura[2]

[1]Department of Earth and Planetary Science,Graduate School of Science,The University of Tokyo, [2]Institute of Space and Astronautical Science

There are few observations and theoretical works about short-period waves in planetary atmospheres, because it is difficult to observe them. However, short-period waves suffer less damping by molecular diffusion than long-period waves, so they can propagate to higher altitudes. It is expected that upper atmospheres are affected by the dissipation of such waves.

Here we focus on the Martian atmosphere. In Martian atmosphere, airborne dust absorbs incoming sunlight and heats the atmosphere in short time scales. So short-period gravity waves and acoustic waves might be generated and propagate to high altitudes. Then we studied the propagation characteristics of such waves in the Martian atmosphere by using a non-hydrostatic, linear model which extends from the surface to thermospheric heights.

Keywords: acoustic waves, gravity waves, Martian atmosphere

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Feasibility study of the Mars ionospheric imaging

Atsushi Yamazaki[1*], Hiromu Nakagawa[2], Takeshi Sakanoi[3], Makoto Taguchi[4]

[1]ISAS, [2]Tohoku Univ., [3]PPARC/Tohoku Univ., [4]Rikkyo Univ.

The planetary atmospheric escape to the outer space is a universal phenomenon for planets, and the escape flux will determin the atmospheric evolution of each planet. Mars of the non-magnetization planet has dry and tenuos atmosphere, and it is severe environment for the survival of living matter. The observations of the recent Mars Express (MEX) spacecraft have shown that the molecular ion, whose outflow flux is very small conventionally, is escaped in large quantities. In addition, it is pointed out that there is possibility for low energy ions less than a few eV to be escaped. The quantity of escape rate of the atmosphere is one of indispensable values for the study of atmospheric evolution, but it is a physical amount to have the big error. It is caused by the fact that the physical mechanism to cause the escape of the molecular ions and low energy ions is not understood. Many physical mechanisms to the atmosphere escape derived by the solar wind and the solar radiation are suggested, including ionospheric ion outflow, ion pickup, sputtering, Jeans escape, and the outflow caused by the photochemical reaction.

We study possibility of the imaging observation instruments to obtain the two-dimensional structure that has not yet been performed for identification of these scatter mechanism until now. In particular, it is one of aims to catch the two dimensional structure of the ionopause where ionospheric ions escape. A fact that emission intensity of the outflow is very low and the albedo of the main body of Mars is very strong as a stray light, is a reason for the very difficult observation. However, because this observation method is thought as an instrument bringing a breakthrough for study on atmospheric evolution, and because it is predicted that it is an essential technique to future planetary probe, we started the research and development of the basic technology. In this paper an optics design of Mars ionosphere observation equipment is argued for example, and it is hoped that it is a beginning of the universal technique to detect the faint emission around the bright light source.

Keywords: Mars ionosphere, Imaging observation, Atmospheric escape, Atmospheric evolution

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Development of multi-fluid MHD simulation code of interaction between the solar wind and unmagnetized planets

Kyohei Koyama[1*], Kanako Seki[1], Naoki Terada[2], Kaori Terada[2]

[1]Solar-Terrestrial Environment Laboratory, Nagoya University, [2]Graduate School of Science, Tohoku University

Draping of the solar wind magnetic field can form the induced magnetosphere around a planet, even when the planet does not possess any intrinsic magnetic field. It has been pointed out that the solar wind induced escape processes such as the ion acceleration in the draped magnetic field and the ionospheric ion scavenging by penetration of the solar wind magnetic field into the ionosphere play important roles in the atmospheric escape from such an unmagnetized planet. The escape of the planetary atmosphere is an important phenomenon related to evolution of the atmosphere, and numerical simulations are an effective method to understand the global atmospheric escape processes. While there have been many previous studies of the interaction between the solar wind and the upper atmosphere of unmagnetized planets based on hybrid or MHD simulations, these models have not yet succeeded to well reproduce the actual observations, such as a large amount of heavy of molecule ion escape observed by Mars Express [Carlsson et al., Icarus, 2006] and difference of velocity between O+ and H+ [Lundin and Dubinin, ASR, 1992]. In order to reproduce the dynamics of multi-species plasmas around the unmagnetized planet, multi-fluid MHD approximation, in which each ion species is treated as an individual fluid, is effective. Particularly, it is an advantage of the multi-fluid MHD code that it can include ion-ion collisions and assess their effects on the ionospheric convection numerically. Combining the virtue of existing multi-species [Terada et al., JGR, 2009] and multi-fluid [Najib et al.. JGR, 2011] simulations, we have formulated a new multi-fluid code to simulate the solar wind-unmagnetized planet interaction. In this presentation, we report on the formulation and initial results of the multi-fluid MHD simulation code under development.

Keywords: unmagnetized planet, ionosphere, multi-fluid simulation

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Mission data processing and attitude control of the SPRINT-A/EXCEED mission

Fuminori Tsuchiya[1*], Atsushi Yamazaki[2], Takeshi Sakanoi[1], Kazunori Uemizu[3], Kazuo Yoshioka[2], Go Murakami[2], Yasumasa Kasaba[1], Masato Kagitani[1], Ichiro Yoshikawa[4]

[1]Tohoku University, [2]ISAS/JAXA, [3]NAOJ, [4]The University of Tokyo

The mission data processing and attitude control of extreme ultraviolet (EUV) spectroscope (EXCEED) onboard the SPRINT-A satellite are presented. SPRINT-A is an earth-orbiting extreme ultraviolet spectroscopic mission being developed by ISAS/JAXA. Two mission instruments are installed in EXCEED, an EUV spectrograph and a target guide camera, and the final quantification of them has been completed in the beginning of 2013. It is planned to launch on August 2013 and will begin observation of Venus and Jupiter on October. Collaboration with Hubble Space Telescope is approved on January 2014. The target guide camera is designed to capture a part of a target planet disk whose light is reflected from the front side of a slit. Mission data processor (MDP) acquires the image every 3 seconds, calculates the centroid position of the disk on the image, and sends it to the attitude control system. While the pointing accuracy of the bus system is at most 2 arc-minutes, scientific requirement for spatial resolution is 10-arcsec to derive radial structure of Io plasma torus and detect plasma emissions from ionosphere, exosphere and tail separately (Venus and Mars). The attitude control system keeps the centroid position with an accuracy of 10 arc-seconds to achieve the spatial resolution required. This pointing correction algorithm is applied to correct slow changes in the pointing direction which is mainly caused by changing thermal input from the sun and earth to the satellite. Though vibrations from reaction wheels installed in the bus system could cause random pointing error, the amplitude is estimated to be 1 arc-second for SPRINT-A. To test the centroid calculation algorithm, a small pinhole image was taken by the guide camera with flight-model optical layout. The size and brightness of the pinhole were equivalent to those of Jupiter. Changing the pinhole position, acquiring and processing of the image and centroid calculation were repeated many times. The designed algorithm has been confirmed to work well and the stability of the centroid position was found to be less than 0.3 arc-second. Final interface test between EXCEED and attitude control system is planned on March 2013.

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Study of the plasma environment near Ganymede by the Galileo spacecraft observation

Shinya Watanabe[1*], Takayuki Ono[1], Atsushi Kumamoto[1], Yuto Katoh[1]

[1]Department of Geophysics, Graduate School of Science, Tohoku University

Ganymede is one of Jovian moons and is known as the only satellite that has intrinsic magnetic field. Since Ganymede is located in the Jovian magnetosphere, magnetospheric plasma corotating with Jovian rotation period of 10 hours always blows toward Ganymede at a relative velocity of 176 km/s. So, the characteristic plasma environment is formed around Ganymede 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 well unknown and understanding of the interaction is necessary to reveal processes occurring in the Ganymede's magnetosphere.

In the present study, we have analyzed plasma waves observed near Ganymede by the Plasma Wave Subsystem (PWS) and the Magnetometer (MAG) on board the Galileo spacecraft. In particular we have analyzed emissions enhanced at Upper-hybrid resonance (UHR) frequency and have identified its spatial distribution around Ganymede from the data obtained during the four flybys (G01,G02,G07,G29) in which the UHR emissions are clearly seen among the all six Ganymede flybys. Based on the identified UHR frequency and the electron cyclotron frequency estimated from the background magnetic field intensity by MAG, we have analyzed the spatial distribution of electron density around Ganymede. The electron cyclotron frequency is estimated to be 5˜20 kHz in the Ganymede magnetosphere. The result of the analysis shows that fUHR is about 20˜100 kHz and becomes high when the spacecraft is near Ganymede. The maximum of the electron density is estimated to be 200 cm-3 when the spacecraft is at the location closest to Ganymede of 264 km altitude during the G02 orbit.

The Ganymede ambient magnetic field can be classified into three types of condition, (1) both ends are on Ganymede, (2) one end is on Jupiter and another end is on Ganymede, and (3) both ends are on Jupiter. We study the electron density profile and plasma wave measured in each region based on both the MAG data and the trajectory of the Galileo spacecraft. We also analyze the 10 kHz waveform data in order to discuss fine structures of the spatial plasma distribution and plasma waves around Ganymede. By comparing these results to the plasma environment around planets interacting with solar wind and satellites in the planetary magnetosphere, we discuss the characteristic of the Ganymede's magnetosphere.

Keywords: Ganymede, Jupiter, plasma waves, magnetosphere

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Short-term variation of Jupiter's synchrotron radiation: Their relation with the magnetospheric events

Hiroaki Misawa[1*], Takahiro Mizuguchi[1]

[1]Planetary Plasma and Atmospheric Research Center, Tohoku University

It is known that Jupiter's synchrotron radiation (JSR) has information on dynamics of the deep inner magnetosphere. Our Tohoku University group has implied that Jupiter's synchrotron radiation in several tens MHz sometimes shows rapid flux variations (RFV) by more than several tens % within a few to several days. It is quite difficult to explain its physical process by present theories on particle transport, such as radial diffusion because of their too fast change. This phenomena recalls the fast particle acceleration and transport in the earth's magnetosphere during substorm events. It is already confirmed that there are substorm like events also in Jupiter's magnetosphere, however, and it has not been revealed whether the events affect the deep inner region.

In order to reveal unknown dynamics of the RFV events in JSR, we have tried to investigate relationship between the RFV events and electromagnetic phenomena in Jupiter's magenetosphere. We have surveyed plasma and magnetic field data observed by Galileo. For searching the RFV events, we have used the daily JSR monitoring data at 327MHz observed using the large radio telescopes of STE Lab, Nagoya University. In this presentation, we show some results of characteristics of the RFV events and make preliminary discussion on their origin.

Keywords: Jupiter, synchrotron radiation, short-term variation, radiation belt, substorm

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Occurrence characteristics of Jovian auroral emissions in the low-latitude region

Kazuyuki Yamamoto[1], Hiroaki Misawa[1*], Fuminori Tsuchiya[1], Takahiro Obara[1]

[1]Planet. Plasma Atmos. Res. Cent., Tohoku Univ.

Jupiter has large magnetosphere and bright auroral emissions in the polar region. In the low latitude region, defined between the main oval region and the Io footpath latitudinal region, ”patchy emission” and/or ”extended emission” sometimes appear at the postnoon sector as an extended emission from the main oval region to near the Io footpath latitudes. Although these emissions reflect some activities of the Jovian inner to middle magnetosphere, it is little known what magnetospheric activities contribute to the auroral emission. In this study, we have researched their variations and occurrence characteristics to understand physical processes of the inner to middle magnetospheric activities using the data of Jovian UV and IR auroras observed with Hubble Space Telescope (HST) and NASA InfraRed Telescope Facility (IRTF). From the HST campaign observations in 2007, it is suggested that the low-latitude emissions have the duration time of several tens of hours and shift their emission regions in the direction of positive system 3 longitude; i.e., the emission region lagged from the corotation. . The shift velocities were derived to be several percent to more than ten percent. The velocities cannot be explained only by magnetic drift of electrons with the energy of several tens keV which is typical for UV aurora. The past in-situ plasma observations by Voyager and Galileo showed that the plasma bulk velocity in the inner to middle magnetosphere is a few to ten-odd percent slower than corotation speed. These values are similar to the lag of the extended auroral emissions. Thus, it is plausible that the lag of the low-latitude emissions is mainly caused by the corotation lag of the plasma in the Jovian magnetosphere.

In order to investigate causality of occurrence of the low latitude auroras, we have surveyed the IR aurora data for the Galileo’s Jupiter observation period. Mauk et al. [Nature, 2002] indicates one event of low-latitude patchy emission corresponding injection. In this study, we have examined correspondence between low-latitude emission and the phenomena relating to injection; i.e., injection, the location of Galileo satellites, solar wind and nKOM. We identified four low-latitude emission events for totally 43 days of the observation by IRTF for 1996 ? 2000. As the result, we could not confirm the correspondence between the low-latitude emission and injection due to lack of the Galileo data. Furthermore, we could not find relationship between the low-latitude emission and injection relating phenomena. The duration time of low-latitude emission identified in this study was a few dozen hours, while it is reported that the duration time of injection is at most 12 hours. This implies that the low-latitude emissions identified in this study are a new type and different from the event identified by Mauk et al. (2002). The confirmation of types of the low-latitude auroras and investigation of their occurrence processes are deferred in the future studies.

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Keywords: Jupiter, Jovian magnetosphere, aurora, injection

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Statistical analysis of the repetition frequency of S-bursts of Jovian decametric radiation

Suguru Kakimoto[1], Atsushi Kumamoto[1*], Takayuki Ono[1], Yuto Katoh[1], Hiroaki Misawa[1]

[1]Tohoku University

Repetition frequency of S-bursts of Jovian decametric radiation has been statistically analyzed based on the datasets of ground-based observations performed at the observatories of Tohoku University since 1985. In the Jovian magnetosphere, the radio waves are generated in decametric wavelength range due to the interactions between the rotating magnetic field and the satellite Io. Among them, the S-busts are intense emissions which show quasi-periodic frequency drift on a time scale of msec. The typical repetition frequencies are within 2-400 Hz [Carr and Reyes, 1999]. Based on the studies of the Earth's ionospheric Alfven resonator (IAR), Ergun et al. [2006] proposed that the periodicity of the S-bursts was caused by the Jovian IAR. According to the hypothesis, it is expected that the repetition frequency of S-bursts and IAR increase as the solar zenith angle at the Io footprint increases and plasma density in the Jovian ionosphere decreases. In order to verify the Jovian IAR hypothesis, we have analyzed repetition frequency of S-bursts.

We have analyzed datasets obtained by ground-based observations performed at the observatories of Tohoku University since 1985. The datasets obtained by new HF receiver system installed at Yoneyama observatory (141.2E, 38.6N) in 2012 are also utilized in the analyses. The frequency range, frequency and time resolutions of the new HF receiver system were 21.5 - 37 MHz, 1.2 kHz, and 0.8 msec, respectively. As a result of the statistical analysis of the datasets since 1985, it was found that the repetition frequency of S-bursts decreases as the increase of solar zenith angle at the Io footprint on the Jovian ionosphere. The result was opposite to the expectation. Some previous studies reported that the activity of the Earth's aurora depends on the solar zenith angle in the ionosphere [Newell et al., 1997]. They explained that it was because the growth of the feedback instability in IAR depended on the conductivity of the ionosphere. If the auroral electron precipitations increase in Jovian IAR when the solar zenith angle increase just as in the Earth's IAR, we can expect that the repetition frequency of S-burst decreases due to the increase of the plasma density and the temperature in the ionosphere.

Keywords: Jovian decametric radiation, S-bursts, Ionosphheric Alfven resonator, Solar zenith angle dependence, Jovian ionosphere, Feedback instability

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Time variability of [OI] 630nm emission from Enceladus torus

Kunihiro Kodama[1*], Masato Kagitani[1], Shoichi Okano[2]

[1]Geophys. Sci., Tohoku Univ., [2]IfA

There are many icy atoms and moleculars in Saturn's inner magnetosphere. This materials distribute like a torus, so called enceladus torus.

We successfully detected the forbidden line emission of atomic oxygen [OI] 630 nm at Enceladus torus by ground-based observation carried out in May. 2011˜.

We had assumed that main process for this emission is electron impact excitation. But other process like as photo dissociation of molecules as H_2O and OH are not ignorable. So we continued the observation to understand featuer of [OI] 630 nm emission on the torus. Long term observation will show many hint about relation between the emission and environment. However, lack of high-quality data restricted the data point against time.

Now we improved the analysis method and it enabled us to use mid-high quality data. The additional usable data was used for derivation of emission.

In this presentation, I will report results of new analysis.

Keywords: Enceladus, saturn, groundbased