Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

PCG033-P01 Room:Convention Hall Time:May 24 14:00-16:30

A modeling of Titan’s ionosphere

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A modeling of Titan’s ionosphere
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The Langmuir Probe (LP) onboard Cassini spacecraft has obtained that the ion mass is about 20 -40 amu at altitudes from 1200km to 1800km and exceeds 60 amu at ˜1200 km altitude (Wahlund et. al., 2005). However, the ion composition has not been understood yet.

We constructed an ion composition model in the Titan’s upper atmosphere which consists of nitrogen and methane. The result shows that the main ions are protonated hydrogen cyanide and protonated ethylene. The altitude of peak number density is ˜1100 km. We report the comparison between the modeling and the Cassini observation and photochemical processes in the Titan’s upper atmosphere.

Keywords: titan, upper atmosphere, ion composition, alltitude distribution, ionosphere

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PCG033-P02 Room:Convention Hall Time:May 24 14:00-16:30

A study of Jovian Radio Wave Observation using LLFAST (Lunar Low Frequency Astronomy Telescope)

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Jovian decametric radio emissions (DAM) have been observed since 1955, and it became the starting point to elucidate planetary magnetospheres. However, their radiation mechanism has not yet been fully understood because the spatial in-formation of the radio sources was not enough. The highest spatial resolution obtained by the ground based VLBI (Very Long Baseline Interferometry) observations can not resolve the radio sources with the resolution of 1000 km at Jupiter, so that it has been impossible to inspect proposed models.

LLFAST-1 is one of the candidate mission instruments which will be equipped on the Japanese post lunar explorer in SELENE series which will be launched in the latter half of 2010's. It is an on-orbit station of a space VLBI composed with decametric radio telescope on the lunar orbiter and ground stations. The main objective of this stage is to observe the low frequency radio emissions from Io-Jupiter system. The highest spatial resolution of LLFAST observations will be about 20 km for 20-25 MHz source at Jupiter, which is expected to shed light on the new science for the micro structures and beaming of Jovian radio sources. LLFAST-1 is also regarded as the first step of on-orbit display for the interferometer for the very low frequency, less than 10 MHz, radio wave observations on the lunar far side.

Long period ground observations combined with in-situ observations have suggested an existence of a conical-sheet beam structure [1]. Precise positioning of DAM sources by the modulation lanes methods [2] have also shown the angle of cone and the magnetic flux via Io to be about 60 degree [3]. However, the De (Jovicentric Declination of the Earth) effect suggests a part of the model of a Jupiter radio search-light beam structure [4]. Such micro structures in the Jupiter radio sources region also support a highly coherent source region. This new model shows that the beam structure of Jupiter radio emissions, which is thought to be like a hollow-cone, has a narrow beam like a search-light, which can be explained by assuming the three dimensional shapes of the radio sources expanding along the line of the magnetic field. This model predicts the size of the coherent source region along the line of the magnetic field to be around 1 km for each individual source frequency component.

The highest spatial resolution of LLFAST observations will be about 20 km for 20-25 MHz source at Jupiter. The structures of DAM sources with the expected size of ˜1 km can be confirmed by this spatial resolution using fringe visibility analysis with the coherent coefficiencies of more than 0.95. The positions of radio sources can also be estimated by the measurements of circular polarizations. It is also expected that our polarization observation can distinguish two of the wave-particle interaction mechanism; Cyclotron Maser Instability (CMI) mechanism [5] and Mode Conversion mechanism [6]. Our system will, thus, shed new light on the physics of planetary magnetospheres and plasmas.

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Keywords: Jupiter, Io, DAM, space-VLBI, SELENE-2

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PCG033-P03 Room:Convention Hall Time:May 24 14:00-16:30

Short term variations of Jupiter's synchrotron radiation derived from VLA data analysis

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Jupiter's synchrotron radiation (JSR) is the emission from relativistic electrons in the strong magnetic field of the inner magnetosphere, so it is the most effective prove for remote sensing of Jupiter's radiation belt from the Earth. Although JSR has been thought to be stable for a long time, observations for JSR have been intensively made after the collisions of comet P/SL9 to Jupiter in 1994, and short term variations of JSR on time scale of days to weeks have been confirmed by several groups.

Brice and McDonough (1973) proposed a scenario for the short term variations: i.e. the solar UV/EUV heating for Jupiter's upper atmosphere drives neutral wind perturbations and then the induced dynamo electric field leads to enhancement of radial diffusion. Miyoshi et al. (1999) showed that a short term variation event at 2.3GHz is well correlate to solar UV/EUV flux variations. Tsuchiya et al. (2010) showed that JSR at 325MHz and 785MHz have short term variation. Santos-Costa et al. (2009) reported that radio images at 5GHz showed longitudinally asymmetric short term variations from the VLA (Very Large Array) interferometer observation made from October to December, 2002. However, the mechanisms which cause the short term variations and the relationship with solar UV/EUV activity have not been revealed well.

In order to evaluate the effect of solar UV/EUV activity on JSR more precisely, we have made radio image analysis using the NRAO (National Radio Astronomy Observatory) archived data of the VLA [∗]. We have selected the data observed from January 28 to February 5, 2000 at 327MHz. During the period, solar UV/EUV flux expected on Jupiter showed monotonic decrease. A preliminary analysis shows that a radio flux variation occurred corresponding to solar UV/EUV variations density and radio images also show variations of dawn-dusk asymmetry. We will introduce the local time dependence or magnetic longitude dependence of the brightness distribution variations and discuss causalities of the short term variations.

∗The National Radio Astronomy Observatory is a facility of the National Science Foundation operated under cooperative agreement by Associated Universities, Inc.

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Keywords: Jupiter, radiation belt, synchrotron radiation, radio interferometer

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Solar wind response of Jupiter's magnetosphere viewed from the radio spectra analysis

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It is well known that aurorae and auroral radio emissions in the earth are primarily driven by interaction between the solar wind and the magnetosphere, while in case of Jupiter, it is thought that some internal processes, probably initiated by the rapid planetary rotation, primarily drive the auroral activity and the solar wind is a limiting control parameter. There are many in situ and remote observations support the idea, however, the role of the solar wind to the magnetic phenomena and pure characteristics of internal processes have not been revealed well.

In order to investigate characteristics of the solar wind and non solar wind controls on Jupiter's magnetic activities in detail, occurrence characteristics of Jupiter's radio emission, particularly in the hectometric wave range observed with WIND/WAVES, have been analyzed. The analysis period is particularly selected for June to September in 2008, when the solar activity was considerably calm and predicted solar wind condition at Jupiter was stable and also showed clear periodicity synchronized with the solar rotation. The results of the analysis show that there are 3 types of HOM: 1) Solar wind related HOM, 2) Non solar wind related and short lived HOM, and 3) Non solar wind related and quasi-periodic HOM. This implies that locations and/or plasma conditions in the source and propagation regions varies with the solar wind variations and effects of the solar wind variations reach to the inner magnetosphere.

Acknowledgement: We would greatly appreciate M. Kaiser, J.-L. Bougeret and the WIND/WAVES team for providing the radio wave data.

Keywords: Jupiter, magnetosphere, solar wind response, radio emission

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The high resolution MHD simulation of Kronian magnetosphere for northward and southward IMF

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In a series of studies we have reported vortices at the dawn magnetopause at Saturn in simulations when IMF was northward which we interpreted at resulting from the Kelvin Helmholtz (K-H) instability. Studies of the K-H waves using quasi-local simulations at the Earth have shown that the formation of the vortices can be highly dependent on the grid spacing used in the simulations. In particular there can be secondary variations in the vortex structure. However these simulations did not include the magnetic curvature which affects the occurrence of KH instability because they do not treat the global configuration. On the other hand, it has been hard to simulate the global magnetosphere with a sufficiently small grid interval to investigate these effects on the global configuration. Recently thanks to the developments of computer and numerical calculation techniques, we have been able to perform the global magnetospheric simulations of the magnetosphere with relatively high resolution (small grid spacing). As the results of this simulation of Kronian magnetosphere, we found that the formation process and configuration of vortex were different from the previous low resolution simulations for northward IMF. In particular, the growth rate of KH wave seems to be high and waves is appeared around dusk side clearly. On the other hand, we have not obtained the vortex configuration for southward IMF. In this study we will show the results of high resolution global simulation of the Kronian magnetosphere, analysis of the vortices, changes in the configuration of magnetic field lines related to the vortices and their effects on aurora at Saturn.

Keywords: Saturn, magnetosphere, numerical simulation

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BepiColombo Euro-Japan Joint mission to Mercury: MMO Project Status update

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BepiColombo is a ESA-JAXA joint mission to Mercury with the aim to understand the process of planetary formation and evolution in the hottest part of the proto-planetary nebula as well as to understand similarities and differences between the magnetospheres of Mercury and Earth.

The baseline mission consists of two spacecraft, i.e. the Mercury Planetary Orbiter (MPO) and the Mercury Magnetospheric Orbiter (MMO). The two orbiters will be launched in 2014 by an Ariane-5 and arrive at Mercury in 2020. JAXA is responsible for the development and operation of MMO, while ESA is responsible for the development and operation of MPO as well as the launch, transport, and the insertion of two spacecraft into their dedicated orbits.

JAXA has made conceptual design of the MMO spacecraft system (including the interface with the cruising composite system in collaboration with ESA) with model payload. MMO is designed as a spin-stabilized spacecraft to be placed in a 400 km x 12000 km polar orbit. The spacecraft will accommodate instruments mostly dedicated to the study of the magnetic field, waves, and particles near Mercury.

Selection of the PI responsible instruments was finished on 2004. Preliminary Design Review(PDR) for MMO project has finished on Mar. 2008. PDR for ESA BepiColombo project is closed on end of Oct. 2009.

Stand alone test with Mechanical Test Model(MTM) test and Thermal Test Model(TTM) was successfully finished on Nov. 2010. MMO TTM is under rehabishing to the MTM for attending the stack level MTM test will be held in this year. Subsystem level Critical Design Review (CDR) has been started from Mar. 2010. MMO stand alone Flight Model (FM) AIV will be started from early 2012.

6th BepiColombo science working team (SWT) meeting, which discusses science related matters, was held on Oct. 2009. In this paper, we will report the latest information of MMO project status.

Keywords: Mercury, Planetary Exploration, International Collaboration

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Development of Numerical Simulation Code for THz-Band Superconducting Hot-Electron Bolometer Mixer Designing

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THz region is an unexplored frequency band in heterodyne sensing technology fields, because a conventional SIS mixer does not work due to superconducting Cooper pair breakdown by photon absorption in the THz band. To overcome this obstacle, an alternative THz-band heterodyne device known as a hot-electron bolometer (HEB) mixer is studied, and successful laboratory experiments have already been reported. However, physical mechanisms of the HEB mixer device are not yet sufficiently understood. Thus we develop a new numerical simulation code to understand physical processes in the HEB mixer device, which aims to improve the fabrication process for superconducting HEB mixer microbridges. Since the microbridge consists of a coplanar line structure, we numerically model the coplanar line by using the FDTD (Finite-Difference-Time-Domain) method. We also introduced superconductors into the FDTD code by solving the London equation. By modeling the time dependence of the superconductivity by the power of input signals, the present mixer device has detected the intermediate frequency of a radio signal and a reference signal.

Keywords: detector, superconductor, terahertz, Heterodyne Sensing, Radio Astronomy

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THz band heterodyne spectroscopy with superconducting HEBM receiver

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Terahertz band heterodyne spectroscopy plays an important role in the study of the physical and chemical conditions in both astronomical targets and terrestrial and planetary atmospheres. The Nagoya University Southern Observatory has employed mm/sub-mm SIS receivers at Pampa la Bola in the Atacama desert, Chile (alt. 4860m), to carry out a broad range of work on both astronomy and atmospheric remote sensing. In addition, the National Institute of Information and Communications Technology of Japan has succeeded in constructing a balloon-borne superconducting submillimeter-wave limb emission sounder in the 0.6 THz frequency band. Currently, the University of Tsukuba is planning a project for a THz band radio telescope in Antarctica. For such projects, the preparation of 1.5-4.0 THz band heterodyne receivers is a common thread.

We are developing 1.5-4 THz band quasi-optical superconducting hot-electron bolometer mixer (HEBM) receivers for astronomical and atmospheric remote sensing applications. The microbridge of the HEBM was made at room temperature from a 4-7 nm thick niobium titanium nitride (NbTiN) film deposited on a 20 nm-thick AlN buffer layer, using a helicon sputtering technique with a slow deposition rate. The mixer was cooled to 4.2 K by using a vibration-free close-cycled mechanical 4 K pulse tube cryocooler with the temperature fluctuation of 1.6 mK. The performance of a large volume NbTiN HEB mixer was studied at 1.47 THz by changing local oscillator (LO) power with the mixer bias voltage fixed. The intermediate frequency (IF) signal measured at 1.5 GHz had a maximum peak as a function of the bias current of the mixer. The corrected receiver noise temperature was 1600 K at around the IF maximum peak. It was also found that the IF signal was the most stable at around the IF maximum peak under the condition that the instability of LO pumping level was induced by small mechanical vibration of the cryostat. This novel device will enable us to observe plasma gases such as ionized carbon and various highly excited transition lines of key species involved in photochemistry of planetary atmospheres.

Keywords: terahertz, superconductor device, heterodyne spectroscopy

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Heterodyne infrared spectroscopy for ultra high-spectral resolution observations of planetary atmosphere

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Most molecular bonds have strong absorptions and emissions in mid-IR region (3 to 12 um) at very specific frequencies for identifying molecules. These mid-IR fingerprints have been used in a wide variety of terrestrial and planetary atmospheric studies. In the case of the ground-based observations for planets and celestial bodies, the high-spectral resolution observations are indispensable to distinguish between the signal and the strong terrestrial absorptions. Up to now, the technology of commercial mid-IR spectroscopy has been mainly performed using Fourier-transform IR (FTIR) spectroscopy and the grating dispersive device. These direct measurements basically employ a huge system to obtain the high-spectral resolution. For, the highest possible direct detection instrument to date (e.g., TEXES/IRTF) provides a spectral resolution of 1E5, and already employs a 1 m grating.

The laser heterodyne spectroscopy is an unique powerful tool for atmospheric studies with ultra high-spectral resolution, high sensitivity, and downsizing. With the laser heterodyne spectroscopy, there is a unique instrument available to perform observations of planetary atmospheres, developed by NASA/GFSC [Kostuik et al., 1983] and University of Cologne [Sonnabend et al., 2008]. Ultra high-spectral resolution observations (1E7-8) enable us not only the definite detection of the tiny minor constituents, but also to obtain the vertical profiles of the molecules using retrieval method and wind velocity using Doppler shift of the emissions. The laser heterodyne spectroscopy has been also developed by Tohoku University to observe the minor constituents in the terrestrial atmosphere from 1980s [Taguchi et al., 1990]. In recent years, the quantum-cascade laser (QCL) was applied to our heterodyne system to observe the planetary atmosphere. In particular, it will be designed for the dedicated telescope named PLANETS (2012˜) at the top of the Haleakala mountain in Hawaii, for continuous monitoring of the planetary atmosphere.

In this study, we introduce (i) current status and performance evaluation of the compact heterodyne spectroscopy, (ii) interference experiments between QCL and CO2 gas laser, and (iii) an external cavity using FP-QCL and grating.

The heterodyne spectroscopy is a receiver in the mid-IR wavelength range between 8 and 12 um. The operating wavelength range of the spectrometer is determined by the tuning range of the local oscillator (LO). Currently, the distributed feedback (DFB-) QCLs at 9.6 and 10.3 um, and the Fabry-Perot (FP-) QCL at 8.0 um can be operated. These QCLs were manufactured by HAMAMATSU Photonics. Using FP-QCL with combination with an external cavity provides wider tuneability by a factor of up to 100, greatly expanding the accessible wavelength range and multi-detections. The QCL is mounted in a peltier cooling box, which can be operated in a room temperature. The spectral resolution is expected to be better than 1E7 when the stabilizer of the wavelength (e.g., diplexer) is applied, with a band width of two times 1 GHz (10 km/s at 10 um) with digital FFT spectrometer manufactured by Agilent. As for the sensitivity, in case of the University of Cologne, the system noise temperature could be lower than 3000 K at 10 um, or at only a factor of two above the quantum limit [Sonnabend et al., 2008]. Currently, we evaluate the system noise temperature ,reducing the standing waves and external noise. Continuous monitoring using this ultra high-spectral resolution observations, the understanding the evolution of the planetary atmosphere is expected to be significantly accelerated.

Keywords: heterodyne, spectroscopy, infrared, quantum-cascade laser

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Examination of MELOS 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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Classification and evaluation of noise and signal components in ENA data from Mars Express

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Characteristics of noise and signal of Neutral Particle Imager (NPI) on board of Mars Express was analysed. The NPI data contain various types of noise. We fitted a Gaussian mixture model to the recorded data for four of 32 channels of NPI and classified the data into multiple patterns. Each pattern would correspond to a different type of noise or signal. By examining the conditions of spacecraft position and attitude for each pattern, we will evaluate the quality of the recorded data.

Keywords: Mars, energetic neutral atom, ENA, Venus

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Heavy ion escape processes for non-magnetized planet: The comparison between Mars and Venus

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Mars and Venus do not possess a significant global intrinsic magnetic field, and hence the solar wind directly interacts with the ionosphere. Mars Express spacecraft observed the Martian tail and the heavy ions consisting of O^+, O_2^+ and CO_2^+ escape from Martian ionosphere. On the other hand, Venus Express spacecraft observed the tail and the heavy ions consisting of only O^+ and do not observed the O_2^+ and CO_2^+, which produced at the low-altitude region of the ionosphere. To investigate the discrepancy of the observed ion species between Mars and Venus we simulate the escape ions and escape processes by using a 3-D MHD numerical code including the realistic ionosphere.

Keywords: Mars, Venus, escape, simulation

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Response of the Martian thermosphere and ionosphere to short-term variations of the solar X-ray and EUV flux

Yoshinori Ichikawa[1*], Hitoshi Fujiwara[1], Yasumasa Kasaba[1], Naoki Terada[1], Kaori Terada[1], Naoya Hoshino[1]

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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 the escape flux of O∗ on response of temperature, wind, and composition distributions in the Martian upper atmosphere to long-term variations of the solar EUV flux e.g. solar maximum-to-minimum activities and seasons [Valeille et al., 2009]. 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]. Mendillo et al. [2006] showed that the enhancement of the solar X-ray flux (1.8-5 nm) range caused increase in the production rate of O2+ twice as much as the averaged cases during a big solar flare event at 110 km altitude. Moreover, recent models simulated the increase in the escape flux of O∗ from the Martian atmosphere, when the solar wind dynamic pressure was suddenly increased [Kaneda et al., 2009]. Kaneda et al. [2009] indicated that the escape rate of O∗ correlated negatively with the solar wind dynamic pressure (Psw) under steady state conditions, whereas the escape rate of O∗ correlated positively with Psw for a nonstationary condition because of the difference of variations of the ionopause. Therefore, in order to understand dependence of the Martian exosphere on the variations of the thermosphere/ionosphere and the spatial distribution of the Martian oxygen corona and escape of the Martian atmosphere, it is very important to estimate responses of the thermosphere/ionosphere to short-term variations of the solar X-ray and EUV flux and Psw, which are significantly different from those to the long-term variations.

A general circulation model (GCM) of the Martian thermosphere/ionosphere has been developed from the Venusian thermosphere GCM (VGCM), which has been developed at Tohoku University. This Martian GCM calculates wind, temperature and composition distributions in the Martian upper atmosphere (100-200 km altitude region) solving the conservation equations of momentum and energy and the continuity equation of composition. The distributions calculated by this GCM are in agreement with previous simulations and observations [e.g., Bougher et al., 1990]. In the present study, we investigate the response of neutral and ion densities in the Martian thermosphere and ionosphere to short-term variations of the solar X-ray and EUV flux (0.1-5 nm). This GCM will make it possible to investigate the responses of the Martian exosphere or escape flux to various solar activities, e.g., solar flares by coupling this GCM with an exospheric model [e.g., Kaneda et al., 2009].

Keywords: Mars, Thermosphere, Ionosphere, General Circulation Model, Solar flares