Japan Geoscience Union Meeting 2015
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PCG32-P01 Room:Convention Hall Time:May 26 18:15-19:30

Feasibility of the exploration of the subsurface ocean of Jupiter's icy moon by Jovian decametric radiation spectra

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Subsurface liquid ocean of the Jupiter's icy moons, which is suggested by several studies, is one of the most important targets in the Jovian exploration missions. We propose a new method for determination of the depth of the boundary between the icy crust and liquid ocean below the icy crust by using interference patterns found in the spectrogram of the Jovian decametric radio emissions (DAM). If we can operate an wave receiver onboard the icy moon orbiter, we can obtain spectrograms of the DAM propagated from Jupiter. Because the emissions directly from Jupiter can be interfered with the emissions reflected at the icy moon's surface and subsurface boundaries, we will find interference patterns in the measured spectrograms. In case of the Moon, the lunar orbiter SELENE detected the interference patters in the spectrograms of auroral kilometric radiation (AKR) [Ono et al., 2010]. Because the interference occurs between AKR directly from the earth and AKR reflected at the lunar surface, the amplitude of the interference patterns are almost constant. In case of Jupiter's icy moons, DAM directly from Jupiter, DAM reflected at the icy crust surface, and DAM reflected at the boundary between icy crust and liquid ocean are interfered with each other. Due to slight phase difference between DAM emissions reflected at the surface and subsurface boundaries, the amplitude of the interference patterns will be modulated. The depth of the liquid ocean can be determined the frequency width of the modulation. Assuming that the frequency of DAM is ˜25 MHz, the permittivity of the icy crust is 3, permittivity of the liquid ocean is 87, loss rate in the icy crust is 1 dB/km, and the depth of the ocean is 5 or 10 km, spacecraft and receiver's specifications needed for measurement of the interference patterns in the spectrogram are as follows: (1) Spacecraft height below 200 km, (2) Receiver bandwidth of $<$1 kHz, and (3) Receiver level resolution of $<$5 dB. In addition, the following two issues have to be considered in actual application of this method: (a) DAM itself has band structures in the spectrogram due to anisotropy of the emission at the source. (b) The roughness of the surface and subsurface boundaries have to be within the wavelength (˜10 m) in order that the interference occurs.

Keywords: Jupiter's icy moon, Subsurface ocean, Jovian decametric radiation, Interference

PCG32-P02 Room:Convention Hall Time:May 26 18:15-19:30

The Circumpolar Stratospheric Telescope FUJIN for Observations of Planets

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The planets have been optically observed by spacecraft and ground-based and space telescopes, which have provided many information on their atmospheres and plasmaspheres. It is important to conduct long-term continuous observations for studies on time-dependent events therein. Observations by spacecraft have an advantage that it is able to observe planets intensively with high spatial resolution during a rather short period (several years), however the observation geometry is not constant as the spacecraft orbits around the planet. Moreover, it is difficult to detect a fluctuation with time scales close to an orbiting period or a decade using an orbiter. On the other hand, remote sensing from the Earth can monitor a planet from a fixed direction for a long time in succession. A ground-based observation may accomplish high spatial resolution by using a telescope with a large diameter, though it is usually limited by seeing. A period of planetary observation from an observatory in the middle and low latitudes is not as long as 10 hours. Three observatories are required at least to continuously monitor a planet. Thus, observations of planets by spacecraft and ground-based telescopes are complimentary.

Then, we have been promoting the FUJIN-project, which aims at continuous observations of planets using a telescope lifted by a balloon in the polar stratosphere. FUJIN-2 will be launched at ESRANGE in Kiruna, Sweden in the window from May to July in 2016. The gondola will be recovered in Scandinavia after a circumpolar flight for two or three weeks. Although the primary study subject of the FUJIN-2 was Venus, we changed Venus to Jupiter. Because the diameter and aspect ratio of Venusian disk changes as its phases, a study subject of Venusian atmosphere depends on its phase. However, a chance of observation is quite limited. A launch window of a balloon cannot be freely selected. A circumpolar flight can be performed only during the summer season from May to July. So we concluded that Venus is not a suitable target of FUJIN. But, Jupiter can be observed under an almost same condition throughout the year except for the period of superior conjunction. We will observe Jupiter at the deepest absorbing band, methane (˜890nm), in the visible to near-infrared region, and obtain a phase velocity and a wave number of planetary-scale waves and background wind velocity at a bright haze area near the polar region. Using these data, we will deduce parameters which are essential to identify the wave structure as the Rossby wave. Also, we will detect the cumulonimbus cloud in Jupiter and compare the positions of the clouds and the zones and the belts in the Jovian atmosphere, and study dynamics in the cumulonimbus cloud in Jupiter.

A simulation of the electric power in the polar orbit was performed. During daytime SCPs (Solar Cell Panels) of which the nominal maximum power is 540 W generates electric power for FUJIN-2, and during nighttime Li-ion batteries supply electric power. Under the condition of a circumpolar flight of FUJIN-2 from July 1 to 14 in 2016, we estimate that the SCPs can supply power larger than 330 W in average. Considering power required for charging the Li-ion battery the electric power which the system can consume is about 330 W and 191 W during daytime and nighttime, respectively.

Apart from that the control system of gondola (CMGs and DCP), a drive circuit of motors, an interface of CCD, a hood and its rotation system, and an extension of an airtight chamber of electric system are under development. Optical alignment of the telescope will be adjusted, and the image quality will be tested. After all of the sub-systems are integrated, a thermal vacuum test under the stratospheric environment will be conducted in fall in 2015. According to the test result the electric power required for the heaters will be determined. The functional tests will be completed by the end of 2015, and the FUJIN-2 gondola will be shipped to ESRANGE.

Keywords: FUJIN project, Jupiter, the polar stratosphere, continuous observations, balloon, FUJIN-2

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Mesospheric wind/temperature measurements in the terrestrial planetary atmosphere using the IR heterodyne spectroscopy

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The terrestrial planetary mesosphere is the transition region between thick lower atmosphere and thin upper atmosphere. The change of momentum between the surface and the mesosphere which occurs through breaking gravity waves perturbs wind and temperatures in the mesosphere, and potentially affects on atmospheric escape. Therefore, mesosphere provides us important information to understand atmospheric coupling between lower and upper atmosphere. However, there are still unsolved problems in the terrestrial planetary mesosphere due to the lack of observations. On Mars, the unexpected large amount of heavy ions ($CO_2{}^+$, $O_2{}^+$) was observed in the upper atmosphere [Carlsson et al., 2006]. The mechanism to propagate such heavy ions from lower atmosphere to upper atmosphere is necessary. On Venus, the characteristics of the transition region between retrograde zonal superrotation in the cloud layer and subsolar-to-antisolar flow in the upper atmosphere are not yet solved. Previous studies pointed out that the atmospheric waves have an important role on the transportation of momentum, energy and materials. The detailed measurement of atmospheric waves is required.

Ultra-high resolution heterodyne spectroscopy of CO_2 at mid-IR wavelengths is one of the powerful tools to study wind and temperatures in the terrestrial atmospheres. Kinetic temperature can be calculated from the width of the observed lines and the doppler shift due to the wind is estimated from the difference between the measured line frequency and the CO_2 rest frequency. In contrast to existing sub-mm observations, IR heterodyne spectroscopy offers a much higher spatial resolution allowing detailed study of temperature variations with latitude and local time. The IR heterodyne spectroscopy can achieve the spectral resolution $\sim 10^7$ and high spatial resolution of 3.5 arcsec with 60cm telescope at 10μm.

The purpose of this study is to investigate the methods to derive wind and temperature and its error estimation on Venus. Observations were carried out using Tuneable Heterodyne Infrared Spectrometer (THIS). The data was obtained in the east limb 33S on Venus in 4th June 2009 at the McMath- Pierce Solar Telescope of the National Solar Observatory on Kitt Peak in Arizona. Integration time is about 20 minutes. Because the exact altitude of the emitting region is predicted by the model to be $\sim$ 110km with a half width of 10km, we can directly derived the wind and temperature in its altitudinal region. Our results indicated that the accuracies of derived wind and temperature were $\pm$11m/s and $\pm$12K respectively. These errors were defined from $\chi^2 \leq 1$ of Gaussian fitting of the emission line. The estimated errors are sufficient to discuss disturbance of temperature on Mars and Venus (Mars:5-35K, Venus:5-40K [Deming and Mumma ,1983]) . The estimated error of the wind basically agreed with the expected values from the spectral resolution ($\pm$10m/s). The obtained mesospheric temperature 184$\pm$12K shows a good agreement with the in-situ measurement by Pioneer Venus([Clancy et al.,2008]).

We developed the new IR heterodyne instrument for the dedicated telescope at the top of Mt. Haleakala, Hawaii. Using the methodology shown here, we plan to perform the continuous monitoring of wind and temperature in the Venus/Mars mesosphere.

Keywords: mesosphere, infrared, heterodyne, error, Mars, Venus

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Jovian tropospheric aerosols inferred from the Cassini ISS limb-darkening data

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To obtain new observational constraints on the single scattering phase functions of aerosols in the Jovian upper troposphere, we have analyzed Cassini Imaging Science Subsystem (ISS) imaging data obtained at a wide range of solar phase angles (0-140 degrees) in two spectral channels (BL1: 455 nm, CB2: 750 nm) for a bright zone (STrZ) and a dark belt (SEBn). In this study, we applied the Mie theory for spherical particles to the tropospheric aerosols for simplicity. We found that the real refractive index (n_r) of aerosols is much higher (n_r = 1.85) than previous experimental values of nr for NH_3 ice particles. This would strongly suggest the idea that aerosols in the upper troposphere are not composed of pure NH_3 ice.

Jovian tropospheric aerosols have been expected to consist of nonspherical particles from the atmospheric temperature in the upper troposphere. Application of Mie scattering theory to the tropospheric aerosols in Jupiter is a controversial issue when deducing the scattering properties from remote sensing data. We investigate how much robustness there is in the results obtained from our latest study, by comparing the best-fit Mie scattering phase functions derived from the Cassini ISS limb-darkening data with those for various nonspherical particles. Assuming that shape of nonspherical particles in the upper troposphere is spheroidal, we calculate the scattering phase functions for a wide variety of real refractive index, effective radius, and ratio of long axis to short axis. T-matrix method is used for this calculation. The scattering phase functions for spheroidal particles which have a near value (n_r = 1.45) of real refractive index for NH_3-ice (n_r = 1.42) are found to have weaker backward scattering compared with our best-fit Mie scattering phase functions. It is obvious that these scattering phase functions cannot reproduce the observed limb-darkening data. Conversely, several scattering phase functions for spheroidal particles (n_r = 1.85) have similarity to our best-fit Mie scattering phase functions with respect to the strength and shape of scattering phase function. Based on this preliminary investigation, we can say that Jovian tropospheric aerosols are not composed of pure NH_3-ice particles even though we focus on the nonsphericity of these aerosols.

In this presentation, we will show the simulated limb-darkening curves calculated with the scattering phase functions for nonspherical particles, along with the observed limb-darkening curves.

Keywords: Jupiter, cloud structure, radiative transfer, Cassini

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Infrared imaging-polarimetric observations of Venus with NIIHAMA and SOLAR-C on Haleakala

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To best utilize the polarization data from Venus, as a useful tool to study its atmosphere and aerosols, one needs to cover enough either a range of phase angles or spectra by observations. While most of previous studies were based on "phase curves" in a few visible wavelengths, we are motivated to perform multi-wavelength polarimetry in the infrared at a few selected phase angles. To acquire infrared imaging-polarimetric data of Venus, preparative works were done at the Institute for Astronomy (IfA), University of Hawaii, Maui.

From recent our visible-wavelength observations (2012 - 2014) using HOPS (Hida Optical Polarimetry System), we found that the optical thickness of polar hazes of Venus are now in thinning phase. Since polarization is dominated by the main cloud, it is difficult to significantly derive the optical thickness of decreasing hazes without affected by the errors due to an assumption that main cloud parameters are same as Hansen and Hovenier (1974). Additionally because the previous observations take long time to obtain polarization data varying with phase angle changes of Venus, it is a problem that variation of polarization can contain its temporal variations.

Considering the polarization of the infrared light scattered by H_2SO_4 droplets with radius of 1.05 microns, standard Venusian cloud model (Esposito, 1980), the sign of polarization shall vary from negative to positive at middle phase angle range, between 60 and 80 deg. At this phase angle range, polarization degrees caused by single scattering vary like J: negative, H: neutral, K: positive (astronomical bands, central wavelength (microns) J: 1.25, H: 1.65, K: 2.2). Actually according to test calculations taking into account multiple scattering, disk-averaged polarization degree at phase angle 80 deg. J: -3%, H: -0.5% K: +2% are expected. In case that observed signs of polarization are different from that of expected, parameters such as radius of cloud particle can be different from standard cloud model. For example if main cloud particles are larger ($\sim$ 1.5 microns), these signs can vary like J: negative, H: negative, K: neutral. Inversely if the particles are smaller ($\sim$ 0.6 microns) J: neutral, H: positive, K: positive. From combination of these signs, we can know microphysical properties of the clouds with single observation run. Because especially phase angle around 80 deg. is near greatest elongation, which means that observation is much easier compared with other phase angles, we are planing to perform observations at that time.

To realize our idea, preparative works, optical design of SOLAR-C telescope with a polarizer (Savart plate) inserted into the optical system and test observations, were done from September through December 2014, and in February 2015 at IfA. The test observations were carried out by using NIIHAMA camera attached to SOLAR-C, off-axis gregorian telescope of diameter 45cm, at the top of Haleakala altitude about 3000m. The Savart plate separates the light into two beams whose vibrating plane is orthogonal each other. We could verify that the separation distance is about 200 pixels on images (pixel scale $\sim$ 0.45 arcsec./pixel) by the observations. For precise measurements of polarization degrees, calibration of polarization generated by primary mirror of SOLAR-C is future work.

Keywords: Venus, Aerosols, Imaging-Polarimetry

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5um spectro-imaging on the Venus dayside

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In the Venus atmosphere, the wind speed increases with height and reaches about 100 m/s at the cloud top, which corresponds to an angular velocity 60 times faster than the rotation of the planet. It is called super-rotation and its generation mechanism is unknown. To investigate atmospheric wave structures in the cloud region (50-70km), which is said to be important as the acceleration region, most studies have used the ultraviolet wavelength to image atmospheric waves at 70 km. Some studies have used the infrared wavelength and analyzed thermal emissions from the nightside to image atmospheric waves at 50 km. We performed infrared spectroscopic measurements using IRTF/CSHELL in May 2014. Our observation aimed at imaging the waves at 60 km and another altitude region simultaneously. We obtained the distributions of cloud height deviation at 60 km by quantifying carbon dioxide absorption in the 1.07um wavelength region. The distributions of cloud temperature at 70 km were also obtained from 5.04um wavelength region. In this presentation, we will show the latter results and discuss the wave structure at 70 km.

Keywords: Venus, super-rotation

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Implementation of sulfuric acid cloud into a Venus GCM

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Venus has global sulfuric acid (H_2SO_4) cloud deck in the altitude of 50-70 km. Past reproductions of cloud distributions in numerical models have been tried using VGCMs (Venusian General Circulation Models) with cloud parameterization (condensation / evaporation and sedimentation processes) in Lee et al. [2010] and our group (e.g. Kato et al. [2014]). However, they did not include chemical processes, and did not reproduce the cloud cycle based on realistic processes.

We have tried to implement the chemical processes related to H_2SO_4 clouds into our VGCM and to reproduce the realistic production and extinction of clouds. As Kato et al. [2014], we used a VGCM based on the CCSR/NIES/FRCGC AGCM [Ikeda, 2011]. Horizontal resolution is T21 (longitude and latitude grid : about 5.6 degree). In vertical, the model has 52 levels (the top altitude: about 95 km). For cloud condensation/evaporation processes, we assumed that if the mixing ratio of H_2SO_4(sum of vapor and cloud) is larger than the calculated saturated level, i.e., the supersaturated H_2SO_4 concentrates as an aerosol, and if not the H_2SO_4 aerosol all evaporates. The radius of cloud aerozol is distributed into 4 modes by ratios based on Haus and Arnold[2010]. It means that our model at the moment does not include the growth of particle size, and only traces the advection of produced clouds. We also note that the produced cloud distributions should modulate the thermal distributions through radiative effects but current our model assumes constant heat input profile (as well as the former code).

In this study, we implement following chemical reactions (1) – (4) into the VGCM.

$SO_2 + O + M \longrightarrow SO_3 + M$, (1)
$SO_3 + H_2O + H_2O \longrightarrow H_2SO_4 + H_2O$, (2)
$H_2SO_4 + H_2O \longrightarrow SO_3 + H_2O + H_2O$, (3)
$SO_3 + CO \longrightarrow SO_2 + CO_2$, (4)

After 15 Venus days, the cloud distribution in this model reaches equilibrium status. In this model, we succeeded to reproduce the cloud cycle, i.e., the formation of H_2SO_4 cloud particles in the upper cloud region (about 67-75 km altitude) and the formation of SO_2 and its extinction in the lower cloud region (about 50km altitude). This is consistent with the formation / extinction processes suggested by a two-dimensional model [Imamura and Hashimoto, 1998]. This model could also qualitatively reproduce the cloud top altitude with latitude. However, optical thickness in polar region (more than75 degree) was smaller than Venus Express observations [Haus et al., 2014]. Another problem is that the mixing ratios of H_2O and SO_2 were larger than those in a chemical model [Krasnopolsky, 2012]. We are now trying to solve these problems.

As the next step, we will implement the radiative effects of H_2SO_4 clouds into the VGCM, and enable to produce more realistic thermal structure. We will apply this model for studying qualitatively and quantitatively clouds global distributions and their variation which will be observed by Akatsuki mission from 2016.

Keywords: Venus, sulfuric acid cloud, General Circulation Model

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Study about the structure of Venusian lower atmosphere

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Venus is enveloped by a thick cloud, which is composed of sulfuric acid and located at the altitude of 50-70 km. The atmospheric structure above the cloud layer has been observed by optical measurements in Pioneer Venus and Venus Express missions. However, the thick cloud prevents us investigating the atmosphere below the cloud layer. There are few observations to examine the temperature and wind speed by probes, but probe measurements can observe only the specific place. One of the most useful methods to investigate the atmospheric structure below the cloud layer is radio occultation measurement, which can retrieve the vertical temperature profile with high precision (vertical resolution ˜1 km and temperature measurement error ˜1 K). In this study we analyzed the radio occultation data obtained in Venus Express mission and retrieved vertical temperature profile globally.

The analysis period of data is 2006 to 2010, and the number of temperature profiles is 280. All the temperature profiles are classified at each latitude bin, which is divided every 10? degree, and averaged in the vertical direction with the width of 1 km. In this study the hemispheric and localtime dependences are not considered. As a result, there is a clear difference of the atmospheric structure between low and middle altitudes and high latitudes. In low and middle latitudes the neutral stable layer is located in the altitude of 50-60 km, and the atmosphere is weakly stable under 50 km altitude. In the high latitudes the neutral stable layer is consecutively located in the altitude of 40-60 km. In this presentation we will discuss what generates the difference of the atmospheric structure below the cloud layer by comparing with the numerical result obtained in a general circulation model named AFES.

Keywords: Venus atmosphere, Venus Express, Radio occultation, GCM

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Radio holographic analysis of Venus' radio occultation data

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Gravity waves are considered to drive the atmospheric general circulation by vertical transportation of momentum and energy. Gravity wave breaking occurs via local instabilities such as convective instability and shear instability as the amplitude of the wave increases in the course of upward propagation. Turbulence following the gravity wave braking plays an important role in the diffusion of atmospheric substances, momentum, and energy.

Gravity waves with vertical wavelengths from a few tens of meters to kilometers have been observed in the Earth's atmosphere by radiosondes and radars. Also in the atmospheres of other planets, gravity waves are observed by various methods including radio occultation. The radio occultation method relies on the measurement of the frequency shift of the received signal caused by the bending of radio waves in the radial gradient of the refractive index in the atmosphere.

The geometrical optics method has long been used for the analysis of radio occultation data. However, this method cannot disentangle multipath rays and vertical resolution is limited by the size of the Fresnel zone (~1 km). Because of this limitation, only a limited part of the gravity wave spectrum has been covered, and thus the propagation and dissipation mechanisms of the gravity waves in other planets are poorly understood.

Radio holographic methods have been proposed for processing of radio occultation signals in multipath regions and obtaining atmospheric profiles with high resolution. One of them is the Full Spectrum Inversion (FSI), which was recently applied to GPS occultation data of the Earth's atmosphere. By applying this technique to Venus Express radio occultation data, we derived temperature profiles with high vertical resolution. In this presentation, the vertical wave number spectra will be compared among different altitudes, latitudes, and longitudes, and the spatial distribution of unstable layers will be investigated for studying propagation and dissipation of the gravity waves.

Keywords: Venus, Gravity wave, Radio occultation, Radio holographic analysis

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Effect of the terrestrial ionosphere for the lunar radio occultation observation

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The existence of the lunar ionosphere is an open question of the Moon. The lunar ionosphere was found by radio occultation observations of spacecraft, such as Luna 19, Luna 20, and SELENE (Vasilyev et al., 1974; Vyshlov et al., 1976; Imamura et al., 2012). However, the estimated electron densities of several hundreds to 1000 cm-3 are much larger than theoretical estimation (Daily et al., 1977). Although several kinds of theories have been proposed to explain the existence of the lunar ionosphere (Daily et al., 1977, Savich 1976, Stubbs et al., 2011), inadequate quality and quantity of the present data prevent to qualify the origin of the lunar ionosphere.

Principal factor of inadequate data is the terrestrial ionosphere. The amplitude for fluctuation of total electron content (TEC) of the terrestrial ionosphere is similar or larger than the TEC of the lunar ionosphere. The cause of the lunar ionosphere cannot be derived without removal of the terrestrial ionosphere.

Imamura et al. (2012) removed the terrestrial ionosphere by a polynomial fitting method. If we assume the lunar ionosphere exists under a certain altitude (for example 30 km), the time series of observed TEC can be divided to two parts depending on whether the radio signal paths the lunar ionosphere or not. Before the occultation starts, named A-part, only the terrestrial component of the TEC is included in the observed TEC. On the other hand, both of the terrestrial and lunar components are included in the occultation period, named B-part. To remove the terrestrial component of B-part, the observed TEC of A-part is fitted by polynomial function and extrapolated to B-part. The lunar TEC had been estimated by this method in SELENE mission. However, the polynomial approach was ineffective when the fluctuation of the terrestrial ionosphere was large (Imamura et al., 2012).

In this presentation, the effect of the terrestrial ionosphere for the radio occultation observation is estimated by using SELENE-derived terrestrial TEC data. The error of the polynomial fitting and extrapolation of above method is evaluated, and the possibility of the detection of the lunar ionosphere is discussed. The optimal configuration of the radio occultation observation is also considered for future exploration. Appropriate orbital elements are discussed to collect sufficient data set. We focus on a solar zenith angle dependency of observation that is a key parameter to derive a mechanism for generating the lunar ionosphere. Furthermore, we start to search the lunar ionosphere by using other data set of SELENE. That is the VLBI data obtained in VRAD mission. Both of S-band and X-band signals from sub satellite of SELENE, Vstar, were received at four ground stations of VERA. The result will be shown in the presentation.

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Keywords: Moon, ionosphere, radio occultation

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The Terrestrial Exosphere observed by Space Satellites

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The terrestrial exosphere is the outmost region of the atmosphere, where scale height of particles is longer than the mean free pass of them. Thus exospheric particles are collisionless each other. Hydrogen atoms are most abundance in the terrestrial exosphere and helium atoms are the sec-ondary components. These atoms resonantly scatter sunlight and build the ultraviolet glows surrounding the Earth, called "geocorona" .

In 1972, Apollo 16 obtained the first image of the geocorona from the lunar orbit with approximately field-of-view of 10 R_E. In 1988, furthermore, the Ultraviolet Imaging Spectrometer (UVS) onboad the Nozomi satellite gave us the geocorona expanding down to 20 R_E. Therefore the observation of Apollo-16 was not enough to image whole geocorona. No observations of the geocorona had been done so far.

The observations of the geocorona have also been conducted by the Earth-orbiting satellites. Recently, hydrogen atoms in the geocorona sur-rounding from 3 R_E to 8 R_E are reported to increase by approximately 10% during magnetic storms. However, the responsible mechanism has not been proposed.

In September 2013, HISAKI/EXCEED was launched by the Epsilon rocket. It is now observing the geocorona in the orbit. During the strong geomagnetic storms in February 2014, the brightness at the Lyman-alpha emission was identified. I found the responsible mechanism to increase the brightness during the magnetic storms and compared it with observations. As a result, I have made a conclusion that thermospheric expansion and charge exchange with plasmaspheric ions should be responsible for the increases of hydrogen atoms.

In December 2014, the ultra-small deep space satellite (PROCYON) launched together with HAYABUSA-2. Lyman Alpha Imaging Camera (LAICA) is boarded on PROCYON. The LAICA instrument observes the so-lar resonant scattering lights from hydrogen atoms. It takes pictures of whole geocorona with a wide FOV (corresponding to more than 25 R_E from Earth). I have calibrated the performance of the LAICA before the launch. As a result, the LAICA has a total sensitivity of 1.1×10^{-3} cps/Rayleigh/pix at H I (121.6nm). Then, on 5th January 2015, I succeeded in imaging the geocorona from the deep space (13,000,000 km away from Earth). Not only it was 42 years after the Apollo-16 observation, but also this geocoronal imagery has the widest perspective in the world.

Keywords: exosphere, plasmasphere, magnetosphere, magnetic storm, geocorona, lyman alpha

PCG32-P12 Room:Convention Hall Time:May 26 18:15-19:30

A global MHD simulation study of the ion outflow channels from the Martian ionosphere

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Mars has no global magnetic field, leading to the direct interaction of the solar wind with its upper atmosphere. As a result of the direct interaction escape of planetary atmosphere occurs. In the past, the Phobos2 spacecraft observed the acceleration and outflow of ions of planetary origin, and the oxygen loss rate from present-day Mars was estimated about 3×10^{25} ions/s [Lundin et al., 1989]. Also, Ion Mass Analyzer (IMA) aboard Mars Express (MEX) observed a large amount of heavy ions such as CO_2^+ escaping from the Martian ionosphere [Carlsson et al., 2006].

A variety of outflow processes that result from the direct interaction of the solar wind have been proposed, such as the ion pick-up process, sputtering, outflow from magnetic anomalies, and outflow of the ionospheric ions. Among them, the outflow process of low energy ions ($<\sim$ 10eV) from the ionosphere is especially uncertain because observations are technically difficult. Therefore, we performed a three-dimensional visualization using the result of a global magnetohydrodynamics (MHD) simulation of the Mars-solar wind interaction [e.g., Terada et al., 2009], and analyzed the outflow channels and acceleration mechanisms of the low energy ionospheric ions. The MHD simulation treats plasma as a fluid, and we used it because the fluid approximation relatively holds for the low energy ions due to their small Lamor radii. As results of a three-dimensional visualization, we found that a streamline extending from the dayside ionosphere goes through near a magnetic pole of Mars, and splits into east and west in the vicinity of the equatorial plane in the night side ionosphere and coils up. It eventually forms four vortices. Bulk velocity along these vortices increase near the ionopause, extending to outer space. In this study, at first, we followed the streamlines and examined where the ions originating from the dayside ionosphere were accelerated. Then, we chose some streamlines, checked the values of the bulk velocity, the magnetic field, and the plasma pressure along them, and quantitatively evaluated all the terms of the equation of motion. Thereby, we examined where and by what force the ions of the dayside ionospheric origin were accelerated over the chosen streamlines.

In this presentation, we will present the results of the analysis of the outflow channels and the acceleration mechanisms of the ionospheric ions at Mars using the global MHD simulation.

Keywords: Mars, ionosphere, atmospheric outflow, MHD simulation

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A simulation study of the Kelvin-Helmholtz instability at the Martian ionopause

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Because the Mars has no intrinsic magnetic filed, the solar wind flow directly interacts with the planetary ionosphere. Under the circumstances, planetary ionopause is a density discontinuity surface and a velocity shear surface between the magnetized solar wind flow and the planetary ionosphere. The ionopause is subject to the Kelvin-Helmholtz (KH) instability [Amerstorfer et al., 2010], which is expected to play a role in removing ionospheric materials from the planet. In addition, the KH instability may cause a dawn-dusk asymmetry at the magnetopause because of the finite Larmor radius (FLR) effect of ions [Nagano, 1978]. At an ionopause, for the same reason, the KH instability may cause an asymmetry in the direction of the solar wind motional electric field.

Terada et al. [2002] pointed out that the KH instability at the Venusian ionopause develops asymmetrically through the acceleration of ionospheric ions in the direction of the solar wind motional electric field, using a global hybrid simulation. It is well known that the ion FLR effect, the gravitational stabilizing effect, the effect of the thickness of the boundary layer, etc. determine the initial growth of the KH instability. Unfortunately, it was difficult to separately evaluate each contribution of these effects with a global simulation. In addition, a study of the ion FLR effect with the parameters around the Martian ionopause is yet to be done.

In this study, we will estimate the escape rate of the Martian atmosphere by the KH instability considering the ion FLR effect and the gravitational stabilizing effect. We will investigate contribution of each effect to the linear growth rate and non-linear evolution of the KH instability in a parameter range around the Martial ionopause. As a first step of this study, we compare an ideal MHD simulation to an MHD simulation including the FLR effect to investigate its effect on the linear growth rate and non-linear evolution of the KH instability. In this presentation, initial results obtained by these numerical simulations will be presented.

Keywords: the Kelvin-Helmholtz instability, the finite Larmor radius effect