Commission G Report

March 26, 2014

1. Research Report

1.1. Report from Planetary Plasma and Atmospheric Research Center, Tohoku University (Yasumasa Kasaba, Tohoku University)

=== Report from recent papers ===

(1) Jupiter's sodium nebula showed an enhancement in late May through the beginning of June 2007. This means Io's volcanic activity and the magnetosphere's plasma content increased during this period. On the other hand, Jupiter's radio emission called HOM became quiet after the sodium nebula enhancement. The HOM emission is considered to be related to the activity of aurorae on Jupiter. These observation results therefore suggest that the increase in plasma supply from Io into Jupiter's magnetosphere weakens its field-aligned current, which generates the radio emissions and aurorae on Jupiter. By comparing our observation results to recent model and observation results, we add supporting evidence to the possibility that Io's volcanism controls Jupiter's magnetospheric activity.

(2) Observations of [OI] 630 nm emission in the Enceladus torus around Saturn have been made at the summit of Mt. Haleakala in Hawaii using a high-dispersion echelle spectrograph coupled to a 40 cm telescope in the period of 13 May through 19 June 2011. A slit of the spectrograph was aligned perpendicular to the equatorial plane of Saturn and placed at a distance of 4 Saturn's radii (Rs) from the planetary center in the dawn side to put the Enceladus torus within the field of view. As a result, [OI] 630 nm torus emission was detected with S/N ~ 7 for summed exposure of 20 h during the observing period. The observed brightness has a maximum value of 4.1 ± 0.6 Rayleighs (R) near the equator, and it extends to north-south (N-S) direction with a full width at half maximum of 0.8 Rs. We made estimation to explain mechanism of the observed brightness taking into account an excitation of [OI] 630 nm by electron impact and photodissociation of water group molecule (OH and H2O). Densities of electron, O, OH, and H2O and electron temperature derived from data taken by Cassini and Hubble telescope were used for the estimation. The observed brightness is reasonably explained, taking into account an uncertainty of estimation depending on N-S distributions of species and quiet solar activity conditions. The estimation also suggests that [OI] 630 nm emission is excited by photodissociation of OH and H2O and by electron impact of O with their contributions of 50%, 30%, and 20%, respectively, for quiet solar activity. We also note that the intensity due to photodissociation has considerable variability depending on the level of solar activity by a factor of 2.5.

(3) Auroral kilometric radiation (AKR) is known to be transient emissions generated by rapidly accelerated electrons together with sudden auroral activation in the polar magnetosphere of the earth. In contrast, the characteristics and relationship with the auroral acceleration of rather continuous AKR emissions are not well understood. We examine the emission using long-term data and report that the continuous AKR emission frequency changes with universal time (UT) as the Earth rotates, indicating that the Earth is a spin-modulated variable radio source. The observed UT variation of AKR frequency means that the acceleration altitude changes periodically with planetary rotation. The observations indicate that the diurnal wobble of the tilted geomagnetic field in the solar wind flow alters the magnetosphere-ionosphere (M-I) coupling state in the polar magnetosphere, giving rise to periodic variation of auroral particle acceleration altitude. These observations of planetary radio wave properties provide insight into the physics of planetary particle acceleration

(4) Solar radio type-I bursts were observed on 2011 January 26 by high resolution observations with the radio telescope AMATERAS in order to derive their peak flux distributions. We have developed a

two-dimensional auto burst detection algorithm that can distinguish each type-I burst element from complex noise storm spectra that include numerous instances of radio frequency interference (RFI). This algorithm removes RFI from the observed radio spectra by applying a moving median filter along the frequency axis. Burst and continuum components are distinguished by a two-dimensional maximum and minimum search of the radio dynamic spectra. The analysis result shows that each type-I burst element has one peak flux without double counts or missed counts. The peak flux distribution of type-I bursts derived using this algorithm follows a power law with a spectral index between 4 and 5.

(5) Black aurora is a small-scale (typically a few to 10 km) black structure seen in diffuse aurora, and its generation process has been studied with immense interest. We report the precise characteristics of black aurora based on simultaneous image and particle measurement data and possible generation process. Thirteen black auroral events are identified from the Reimei satellite data, and the relationship between particle and auroral images around the satellite's magnetic footprints is investigated in detail. We found that a number of small-scale deficiencies were embedded in precipitating electrons from the central plasma sheet with energies greater than 2–7 keV and that each deficiency corresponded exactly to black arcs and black patches at the magnetic footprint. Therefore, black arcs and black patches are not associated with a field-aligned potential (such as a divergent potential structure) but probably originate from the suppression of pitch angle scattering. In the black auroral region, low-energy (2–5 keV) inverted-V-type downward electrons (spanning channels that are several tens of kilometers wide) often appear to overlap with high-energy (several keV) plasma sheet electrons.

(6) This paper examines AKR spectra using the long-term observation from the Polar satellite to prove the comprehensive features of field-aligned auroral acceleration and to give observational constraints to the theoretical mechanisms for acceleration at substorm. The remote observations of substorm phenomena through auroral radio waves from the high altitude polar magnetosphere disclosed some fundamental characteristics of the vertical auroral acceleration region and provided new information on the formation process for field-aligned electric field at substorm onset. Furthermore, we reveal new aspect of the relationship between the plasma state in the plasma sheet and the formation of auroral acceleration.

(7) In order to monitor space environment and its temporal variations, JAXA Space Environment Group has been developing space radiation detectors as well as magnetometers and installing them on Low Earth Orbit (LEO) satellites, Geostationary Orbit (GEO) satellites, Geostationary Transfer Orbit (GTO) satellite, Quasi Zenith Orbit (QZO) satellite and Japanese Experimental Module (JEM) of the International Space Station (ISS). We are using these space environment data to know the situation of space environment and to provide warning messages to the satellite operators as well as ISS/JEM manager, when the space environment will be harmful. Based on our observation data, we also have constructed an advanced electron belt model for the use in satellite manufacturing. With space radiation data obtained by JAXA satellites and ISS, some findings related to the space radiation environment have been obtained. We will review our activities related to the space environment research and development in JAXA.

(8) The Space Environment Data Acquisition equipment (SEDA), which was mounted on the Exposed Facility (EF) of the Japanese Experiment Module (JEM, also known as “Kibo”) on the International Space Station (ISS), was developed to measure the space environment along the orbit of the ISS. This payload module, called the SEDA-Attached Payload (AP), began to measure the space environment in August 2009. This paper reports the mission objectives, instrumentation, and current status of the SEDA-AP.

(9) We have carried out ground-based observations, optimized to temporal and spatial characteristics of pulsating auroras (PAs) in the micro/meso scale, using an electron multiplying charge coupled device (EMCCD) camera with a wide field of view corresponding to 100 × 100 km at an altitude of 110 km and a high sampling rate up to 100 frames per second. We focus on transient PAs propagating southward around 1100 UT, in the early recovery phase of the substorm, on 4th March 2011. Three independent patches (PA1–3) each with different periods between 4 and 7 s were observed, which means that the periodicity was not explained by the electron bounce motion and strongly depended on local plasma conditions in the magnetosphere or in the ionosphere. One more insight is that only PA1 had also a sharp peak of modulations around 1.5 Hz, with a narrow frequency width of 0.30 Hz, and the strong modulations existed as a small spot in the center of PA1. We have also conducted cross spectrum analysis and have obtained coherence and phase distributions for auroral variations between 0.1 and 3.0 Hz. The results indicated that low frequency variations from 0.2 to 0.5 Hz inside PA1–3 propagated as a collective motion in well-defined directions. The estimated horizontal propagation velocities ranged from 50 to 120 km/s at the auroral altitude. The velocities are almost consistent with the Alfven speed at the magnetic equator, which suggests that compressional waves have an effect on PA via modulations of the ambient plasma environment.

(10) A new radio spectropolarimeter for solar radio observation has been developed at Tohoku University and installed on the Iitate Planetary Radio Telescope (IPRT) at the Iitate observatory in Fukushima prefecture, Japan. This system, named AMATERAS (the Assembly of Metric-band Aperture TElescope and Real-time Analysis System), enables us to observe solar radio bursts in the frequency range between 150 and 500 MHz. The minimum detectable flux in the observation frequency range is less than 0.7 SFU with an integration time of 10 ms and a bandwidth of 61 kHz. Both left and right polarization components are simultaneously observed in this system. These specifications are accomplished by combining the large aperture of IPRT with a high-speed digital receiver. Observational data are calibrated and archived soon after the daily observation. The database is available online. The high-sensitivity observational data with the high time and frequency resolutions from AMATERAS will be used to analyze spectral fine structures of solar radio bursts.

(11) The first coordinated observations of an active region using ground-based radio telescopes and the Solar Terrestrial Relations Observatory (STEREO) satellites from different heliocentric longitudes were performed to study solar radio type-I noise storms. A type-I noise storm was observed between 100 and 300 MHz during a period from 2010 February 6 to 7. During this period the two STEREO satellites were located approximately 65° (ahead) and –70° (behind) from the Sun-Earth line, which is well suited to observe the earthward propagating coronal mass ejections (CMEs). The radio flux of the type-I noise storm was enhanced after the preceding CME and began to decrease before the subsequent CME. This time variation of the type-I noise storm was directly related to the change of the particle acceleration processes around its source region. Potential-field source-surface extrapolation from the Solar and Heliospheric Observatory/Michelson Doppler Imager (SOHO/MDI) magnetograms suggested that there was a multipolar magnetic system around the active region from which the CMEs occurred around the magnetic neutral line of the system. From our observational results, we suggest that the type-I noise storm was activated at a side-lobe reconnection region that was formed after eruption of the preceding CME. This magnetic structure was deformed by a loop expansion that led to the subsequent CME, which then suppressed the radio burst emission.

(12) The relationships between solar radio type-I bursts and soft X-ray activities were investigated using Hinode/XRT and a ground-based radio telescope belonging to Tohoku University. Although a type-I burst is thought to be generated by high energy non-thermal electrons in the solar corona, the counterpart of this radio burst in X-rays or EUV have yet to be identified. In this study, we found some small scale soft X-ray activities on the XRT images around the onset time of the type-I burst when 10 percent of the soft X-ray flux enhancement around the onset time of the radio burst is defined as a

burst-related activity. However, the causal relationship between the observed soft X-ray activities and the onset of the type-I burst are unclear, and more simultaneous observations of radio bursts and X-rays are needed to investigate the coronal counterpart of the type-I burst.

(13) A model of the martian exosphere is built for average solar conditions. A Chamberlain's approach (Chamberlain, J.W. [1963]. Planet. Space Sci. 11, 901) is used to describe the O, CO, CO2, and O2 thermal exospheric components. The average thermal oxygen density at 300 km in altitude varies by about one order of magnitude with seasons. A Monte-Carlo test particle simulation is also developed in order to estimate the non-thermal oxygen component of the exosphere. The seasonal variation of the non-thermal oxygen average density is much less than the thermal component but displays clear seasonal variations of its spatial distribution. The neutral oxygen atomic escaping flux varies from 2.9 to 5.3 x 1025 s—1 in good agreement with Valeille et al. (Valeille, A., Combi, M.R., Bougher, S.W., Tenishev, V., Nagy, A.F. [2009a]. J. Geophys. Res. (Planets) 114, 11006; Valeille, A., Tenishev, V., Bougher, S.W., Combi, M.R., Nagy, A.F. [2009b]. J. Geophys. Res. (Planets) 114, 11005). Mars's oxygen exosphere is thermal below 600 km and non-thermal above 700 km at all seasons. The typical scale height is ~45 km for thermal O and ~500 km for the non-thermal oxygen density. The total photoionization rate above 300 km corresponds to a CO•2 /O+ total production ratio between 0.004 and 0.02. When compared to the composition of the escaping flux measured by ASPERA-3/Mars Express, this suggests that ions formed below 300 km should significantly contribute to the escaping ion flux and/or that a significant part of the newly O+ ions reimpacts Mars. The simulated oxygen density profile is also compared to the recent observed profile by Alice/Rosetta (Feldman, P.D. et al. [2011]. Icarus 214, 394-399). Although the scale height of our simulated non-thermal oxygen exosphere and the transition from thermal to non-thermal dominated exospheres are slightly higher than suggested by Feldman et al. (Feldman, P.D. et al. [2011]. Icarus 214, 394-399), a good agreement is found when taking into account the uncertainties of Alice/Rosetta observations.

=== Short notice of research facility ===

(14) IPRT (Iitate Planetary Radio Telescope) is a ground-based VHF-UHF radio telescope developed by Tohoku University, which has been developed at the Iitate observatory in Fukushima prefecture Japan since 2000 and dedicated for the observations of solar and planetary radio emissions. IPRT has two distinctive radio receivers; one is a low noise and quite stable receiver tuned at 325MHz and 785MHz, and another one is a 100-500MHz spectro-polarimeter, named AMATERAS (the Assembly of Metric-band Aperture TElescope and Real-time Analysis System). The former is mainly used for observing Jupiter’s synchrotron emission with the sensitivity of 0.1Jy, and enables us to investigate dynamical variations of Jupiter’s deep inner magnetosphere. The latter is used for observing solar radio bursts with 10ms accumulation time and 61KHz bandwidth, and enables us to clarify various micro structure of wave-particle or wave-wave interactions generated in the solar corona region.

References

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1.2. Report from Department of Geophysics, Tohoku University
(Yasumasa Kasaba, Tohoku University)

=== Report from recent papers ===

(1) We investigate the background magnetic field dependence of the saturated state of a magnetorotational instability (MRI) in an accretion disk by performing three-dimensional magnetohydrodynamic simulations. We assume an unstratified disk by employing the local shearing box approximation. Three different uniform background magnetic field configurations are treated for a wide range of field intensities. These simulations indicate that the time variations of the turbulent stress and the magnetic energy are altered by the presence of a poloidal component of the background field. We find that the saturation amplitude of the turbulent stress and the magnetic energy are determined by both the poloidal and azimuthal components of the field. In particular, when the poloidal component has the same intensity, the obtained turbulent stress for β y0 200 becomes smaller than those for a purely poloidal field case. Despite the fact that the background field affects the MRI turbulence, the correlation between the obtained

turbulent stress and the magnetic energy in the nonlinear stage is independent of the field topology. Our results indicate that the saturated turbulent stress has a stronger correlation with the power of the perturbed component of the magnetic field than with the power of the total magnetic field. These results suggest that both the intensity and the direction of the background magnetic field significantly affect the turbulent motion of the MRI in accretion disks.

(2) Io-Jupiter interaction leads to auroral emissions and Jovian decametric radiations (Io-DAM). The longitudinal distribution of the Io-DAM occurrence probability has been considered to be controlled by the footprint magnetic intensity of each hemisphere. Recent observations revealed that the brightness of the main auroral spot is mainly modulated by Io's magnetic latitude. In the present study, we propose that the Io-DAM occurrence probability is controlled by the north-south asymmetry of the footprint magnetic intensity, in addition to Io's magnetic latitude. Hall magnetohydrodynamic equations are solved in the corotating meridional plane, which includes the Jovian ionosphere of finite thickness. We assume that the ionospheric Pedersen conductance is inversely proportional to the footprint magnetic intensity; the conductance is nearly the same for both ionospheres at a longitude of 290°, while twice higher for the south than for the north at a longitude of 110°. Above the northern ionosphere, the parallel current density further than 20° downstream of the main spot is estimated to be 1.5–2.0 times larger for 290° than for 110°. This indicates that if the Io-DAM lead angle is large, the suppressed Io-DAM occurrence probability for the northern hemisphere around 110° would be caused by the north-south asymmetry of the footprint magnetic intensity. A large current density conducted into the south around 110° would be the source of the Io-D component, radiated from the southern hemisphere. The observed brightness of the Io-related auroras is discussed in the context of the intensity of the parallel current density.

(3) We have investigated the geological conditions below two lava flow units through determining the bulk permittivity and porosity in the uppermost basalt layer to depths of a few hundred meters. We use a newly developed method based on three data sets obtained by the Lunar Radar Sounder (LRS), Multiband Imager (MI), and Terrain Camera (TC) onboard the Selenological and Engineering Explorer (SELENE; Kaguya) spacecraft. The bulk permittivity of the uppermost basalt layer is calculated as the ratio of the apparent radar depth to the thickness of the uppermost basalt layer. Its thickness can be constrained from the excavation depths of two types of craters (haloed and nonhaloed craters). These craters are identified on the basis of FeO and/or TiO2 maps created from the MI data. These excavation depths are determined based on the measurement of the crater diameter using the TC data. The apparent radar depth is derived from the time delay between the surface echo and subsurface echo measured by LRS near the craters. The bulk permittivities are estimated to be 2.8–5.5 in a lava flow unit of Mare Humorum and 4.2–18.0 in a lava flow unit of Mare Serenitatis. These bulk permittivities are indicative of porous basalt layers with the porosities of 19%–51% in the unit of Humorum and 0%–33% in the unit of Serenitatis. The estimated porosities would be mainly explained by two different sources: intrinsic voids of lava and impact-induced cracks.

(4) By a series of self-consistent electron hybrid code simulations, we study the effect of the background magnetic field inhomogeneity on the generation process of whistler-mode chorus emissions. Chorus with rising tones are generated through nonlinear wave-particle interactions occurring around the magnetic equator. The mirror force plays an important role in the nonlinear interactions, and the spatial inhomogeneity of the background magnetic field is a key parameter of the chorus generation process. We have conducted numerical experiments with different spatial inhomogeneities to understand properties of the chorus generation process. We assume the same initial condition of energetic electrons at the magnetic equator in all simulation runs. The simulation results reveal that the spectral characteristics of chorus significantly vary depending on

the magnetic field inhomogeneity. Whistler-mode emissions are generated and propagate away from the equator in all simulation runs, but distinct chorus elements with rising tones are only reproduced in the cases of small inhomogeneities. In the simulation that had the smallest inhomogeneity, we find excitation of broadband hiss-like emission (BHE) whose amplitudes are comparable to discrete chorus elements found in other simulation runs. The BHE consists of many wave elements with rising tones nonlinearly triggered in the region close to the magnetic equator. We show that the small spatial inhomogeneity of the background magnetic field results in the small threshold amplitude for the nonlinear wave growth and allows the triggering process of rising tone elements to emerge easily in the equatorial region of the magnetosphere.

=== Short notice of research facility ===

(5) The Jovian and solar radio wave receiver system in HF range (15-40MHz) was continuously operated at Iitate Observatory of Tohoku University. Spectrograms of Jovian and solar radio wave with a time resolution of 0.5 sec were automatically archived and provided to the researchers through the internet. The discussion on combining this data archive with that of Nancay observatory has started between the researches of Paris Astronomical Observatory and Tohoku University.
In addition, the operation of RF waveform recording receiver system for the observation of Jovian decametric S-bursts was started at Iitate Observatory since October 2013. The data will be useful for the analysis of the repetition of S-bursts, which is caused by Jovian Ionospheric Alfven Resonator (IAR).

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1.2. Report from National Institute of Communications and Informatiion
(Takuya Tsugawa, NICT)

=== Comparison of meridional thermospheric winds observed by ionosondes and Fabry-Perot interferometers ===

We construct the first comparison of the estimated meridional wind velocities with meridional wind observed with FPIs. We analyzed data from the ionosondes and FPIs installed at Chiang Mai, Thailand, and Kototabang, Indonesia, from 2010. We found that the estimated and observed wind velocities were generally in good agreement on most nights, although on some nights, the wind velocities were different. The assumption that the meridional wind is equal anywhere between the two ionosonde stations would not be suitable for the days when the winds were not in good agreement. We also investigated the seasonal dependence of the correlation between the estimated and observed

meridional winds. They were in good agreement from February to April and were not in good agreement from May to July.

Reference

Michi Nishioka et al. (2014), Comparison of meridional thermospheric winds observed by ionosondes and Fabry-Perot interferometers (in Japanese), Arctic Record (ISSN 0085-7289), 57(3), 357.

1.4. Report from Solat-Terrestrial Environmental Laboratory, Nagoya University
(Kazuo Shiokawa, Nagoya University)

A campaign observation of auroras and VLF/ELF waves was carried out from January 28 to February 5, 2014 at Poker Flat, Alaska, in collaboration with an auroral rocket launch. Dual cameras were used to determine the height of auroras. A loop antenna with a 20kHz-sampling portable recorder was tested for VLF/ELF wave measurement at remote site without power line.

1.5. Report from Research Institute for Sustainable Humanosphere, Kyoto University
(Mamoru Yamamoto, Kyoto University)

=== Report from recent papers ===

(1) The so-called large scale wave structure (LSWS) at the base of F-layer is the earliest manifestation of seed perturbation for the Rayleigh-Taylor (R-T) instability. It has been found to play deterministic role on the development of equatorial plasma bubbles (EPBs). Except for a few case studies, a comprehensive investigation has not been conducted to determine the characteristics of LSWS. One reason is that it is not straightforward with existing sensors to detect LSWS, particularly, in the spatial domain. In this scenario, a comprehensive study was carried out, for the first time, on the spatial and temporal characteristics of LSWS. Observations were made over the African and Southeast Asian sectors during the year 2011. The observations confirm the findings from case studies, that these wave structures can occur a few degrees west of E-region sunset terminator, and can grow significantly in amplitude at longitudes east of sunset terminator. With the use of additional stations that are located on either side of dip equator, the phase fronts of these spatial structures are shown to be aligned with geomagnetic field lines over a wide latitudinal belt of 5-6o (~500 - 600 km) centered on dip equator. The zonal wavelengths of these structures are found to vary from 100 to 700 km which is consistent with the earlier reports. A new statistical finding is that EPBs were consistently observed when the amplitudes of LSWS were grown to sufficient strengths. These results provide better insights on the underlying physical processes involved in excitation of LSWS in terms of important roles being played by the E-region electrical loading and the polarization electric fields that are induced via spatially varying dynamo current due to neutral wind perturbations associated with Atmospheric Gravity Waves (AGWs).

(2) A new three-dimensional GPS ionospheric tomography technique is developed that uses total electron content (TEC) data from the dense Global Position System (GPS) receiver network, GPS Earth Observation Network (GEONET) in Japan, and it will not require an ionospheric model as the initial guess that will bias the reconstruction of electron density. The GEONET is operated by Geospatial Information Authority of Japan and consists of more than 1200 receivers; this high density and wide coverage helps to reconstruct the electron density distribution in the ionosphere with high spatial resolution. This tomography technique uses a constrained least squares fit to reconstruct the three-dimensional electron density distributions. This method is different to most other techniques as they require a background ionospheric model as an initial guess that could bias the reconstructed electron density. It rather uses a prior condition that the electron density should not exceed a certain value that is determined by the restrain parameter, which is derived from the

NeQuick model. Its independency of the initial guess from a model will make it useful even in disturbed conditions. This paper presents results that are obtained by using this new tomographic technique. The reconstruction of three-dimensional ionospheric tomograms is demonstrated using the GPS data, and the reliability and robustness are checked with simulated tomograms obtained using the synthetic GPS-TEC data produced using NeQuick model.

Reference

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2. Meetings

Meetings scheduled in relation to URSI Commission-G were conducted as listed below.

Japan Geoscience Union (JpGU) Meeting 2014
Pacifico Yokohama, Yokohama, Japan, April 28-May 2, 2014.
http://www.jpgu.org/meeting_e/

14th International Workshop on Technical and Scientific Aspects of MST Radar
- INPE - São José dos Campos/SP – Brazil, May 25-31, 2014
http://www2.inpe.br/climaespacial/MST14/

Asia Oceania Geosciences Society 11th Annual Meeting,
Royton Sapporo Hotel, Sapporo, Japan, July 28-August 1, 2014.
http://www.asiaoceania.org/aogs2014/

The 40th COSPAR Scientific Assembly
Moscow, Russia, August 2-10, 2014.
http://cospar2014moscow.com/

3. Publication list

Publications were listed in each section of research report.