Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

PCG31-01 Room:202 Time:May 27 15:15-15:30

Current status and future direction of sounding rocket experiments in Japan

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Sounding rocket is an effective platform which provides opportunity to make a vertical sounding for a short period through the thermosphere, ionosphere and magnetosphere while satellite generally flies in a horizontal direction. In short, the sounding rocket has a great advantage in conducting an instantaneous survey of the upper atmosphere in the vertical direction. The primary objectives of Japanese rocket experiments include various topics; studies of thermospheric, ionospheric, magnetospheric physics, and astrophysics, microgravity experiment, demonstration of various instrument and technique, and advanced engineering experiments. Among these topics, the upper atmospheric physics is one of the most frequently explored targets.

For further understanding the upper atmosphere and ionosphere, sounding rocket will be inevitably needed. In particular, it is the most effective platform to investigate a coupling between neutral atmosphere and plasma, in other words, coupling between thermosphere and ionosphere, because it is only a platform which enables in-situ observation at 100-250 km altitudes where a role of collision rapidly changes. Advanced ground-based instruments to observe thermosphere and ionosphere are deployed and now operational in many places in Japan, and those capability has a great advantage compared to other countries. Making use of such an advantage, it becomes possible for Japan to conduct the most advanced experiment by coordinating the sounding rocket and the ground-based observations. However, we cannot expect too much progress as long as we repeat similar observations. It is highly required to adapt a new perspective to the future experiment to proceed to the next step from our current understanding. Furthermore, it is desired to develop a new type of instrument which enables us to study the thermospheric and ionospheric physics from a new point of view.

Another advantage of sounding rocket is that a proposed experiment can be achieved within a few years after a mission proposal is approved, while it takes more than three time longer in the satellite project. On the other hand, it should be noted that it also takes several years to develop a new instrument. Therefore, it is necessary to make a plan by closely coordinating a future experiment of the sounding rocket and the instrument development. In this presentation, we will also discuss what kind of instrument should be developed in the future.

Keywords: souding rocket, Upper atmosphere, ionosphere

PCG31-02 Room:202 Time:May 27 15:30-15:45

A multi-satellite formation flight mission for aurora observation

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In 2000s, Fast and Reimei satellite revealed fine-scale plasma particle and wave structures which are considered to be playing a siginificant role in magnetoshere - ionosphere coupling. They carry plasma instuments with time resolution of tens of ms which is much higher than previous. In particular, Reimei conducted plasma particle measurements togather with auroral imagings in which ionospheric footprints were captured. It provides us a hint for fine-scale spatial plasma structures in the auroral region although it is a single-satellite platform. However, it is still difficult to investigate a dynamics of plasma processes by using the simultaneous observations without wave measurements, like Reimei. It would be necessary to make a simultaneous observation of plasma particles and auroral emissions togather with waves, which is never made so far. We are planning a multi-satellite formation flight mission for auroral observation. Main purpose of the mission is to reveal (1) time- and spatial-structures of auroral particle accelaration caused by Alfven waves and field-aligned electric field, (2) energy transfer between plasma waves and ions in supra-thermal energy range, and (3) fine-scale plasma structures which trigger global-scale changes and vice versa. We will discuss possible mission configurations.

Keywords: Aurora, satellite mission

PCG31-03 Room:202 Time:May 27 15:45-16:00

Science of Collisionless Shock Explorer

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The characteristic length scale of typical dilute space plasmas is much shorter than binary collision mean free path. A pronounced feature unique to such a collisionless plasma is that efficient energy and momentum transfer is mediated by plasma waves. The plasma waves often reach to large amplitude, suggesting critical importance of nonlinear effects. In addition, it is often found that a small fraction of particles acquire extremely large energies and forms a nonthermal tail.

A collisionless shock is a magnetohydrodynamic shock wave forms in a collisionless plasma, involving all the above mentioned intriguing features of the collisionless system. In the shock transition region, a cold upstream plasma is violently heated via dissipation involving a lot of plasma waves excited simultaneously. The understanding of the dissipation process is extremely complicated due to its intrinsic strong nonlinearity and inhomogeneity. Although we know an ion-scale shock structure from early in-situ observations, recent measurements of plasma waves in and around the shock clearly indicate the importance of small-scale substructures and nonlinear wave-particle interactions. However, the temporal resolution of distribution function measurements with available satellites is not sufficient to understand the detailed shock dissipation processes.

In this talk, we discuss the scientific significance of collisionless shock physics that may be learned with high time resolution (1-10 msec) in-situ measurements of electron and ion distribution functions within the shock transition region along with recent theory, simulations, and observations.

Keywords: collisionless plasma, shock wave, wave-particle interaction, particle acceleration

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Importance of integrated data analysis for geospace science

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The geospace environment is characterized by dynamic process which link sun/solar wind to the changes in the near Earth space environment. Many attractive phenomena in geospace occur in the inner magnetosphere, for example, enhancement of ring current that causes magnetic storms, and disappearance and rebuilding of the MeV electrons in the radiation belts. In-situ and ground-based observation systems provide various kinds of the observation data to support our understanding of the geospace. Since the geospace is a complex coupled system and elementary process at different energies and regions affect and are affected by each other, the integrated analysis system is needed in order to address the interconnection of each elementary process and to understand the geospace as a global coupled system. In order to realize such integrated analysis environment, the ERG-Science Center operated by ISAS/JAXA and STEL/Nagoya University have developed the integrated data analysis system. The standard data format and the common analysis software are a key technology for the system. The ERG project data are archived with the NASA/CDF format and opened to the public, and the analysis procedures that are plug-in of the SPEDAS are also developed. The data analysis system for the ERG project would be useful for not only the ERG project but also other geospace missions, and the system should be a heritage for the future geospace mission. In this presentation, we describe current activities of the ERG-Science center and the perspective on the integrated data analysis for the future geospace missions.

Keywords: integrated data analysis, satellite-ground based observations, future geospace mission

PCG31-05 Room:202 Time:May 27 16:30-16:45

A Piggyback Micro-Satellite for Aurora Observation

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Recently quite a number of 50kg-class micro-satellite has been developed. However, due to the limited function of the satellite as well as the limitation in the mass of the payload instruments, 50kg-class micro-satellite that can make comprehensive measurements of space plasma including plasma particles, plasma waves and electro-magnetic field does not exist. The multi-point in-situ measurements of space plasma by formation flying spacecraft have become usual in the field of Solar Terrestrial Physics (STP). In order to realize multi-point space plasma measurements by formation flying satellites with relatively small launch vehicle in Japan, it is indispensable to develop high performance micro satellite. 50kg-class micro-satellite for aurora observation will verify that even 50kg-class micro satellite can make world first class space plasma observation including magnetic field, electric field, plasma waves, plasma particles and optical aurora observations. We are planning to launch a 50kg-class micro-spacecraft as a piggyback satellite and to put the spacecraft into an orbit that crosses the auroral regions. If we succeed in realizing this 50kg-class micro-satellite, it will also become possible for us to plan a future mission with 5 formation flying spacecraft for aurora observation using a launch vehicle as small as Japanese Epsilon rocket. It will also give a way to realize future larger scale formation flying spacecraft mission with affordable cost. Although a 50kg-class micro-satellite was used for a daughter spacecraft of the Russian spacecraft Interball, the micro-spacecraft did not have enough performance necessary for world first class plasma in-situ measurements. The preliminary study on the piggyback micro-satellite for aurora observation is being made by a scientists' group who have been participating to the spacecraft missions such as REIMEI and ERG together with ISAS Research Group on micro-satellite. This piggyback micro-satellite mission is a precursor of the future small-class or medium-class spacecraft mission of Japanese STP community.

Keywords: Micro Satellite, Piggyback Satellite, Aurora

PCG31-06 Room:202 Time:May 27 16:45-17:00

Auroral camera required in the future small satellite missions exploring the magnetosphere-ionosphere coupling processes

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We propose the conceptual design of auroral camera required for future small-scale satellite mission to be launched for understanding the magnetosphere-ionosphere coupling system and fine-scale aurora. Reimei satellite showed that the simultaneous image-particle data are useful to investigate the fine-scale auroral dynamics, such as small-scale discrete aurora and time-varying pulsating aurora. However, Reimei does not carry the wave and field detectors, and therefore it is hardly measure the field aligned current, which is essential to understand the coupling process. Thus, the fundamental issues, such as the coupling process (time and spatial variation) via dispersive Alfven wave, radio wave emission from the auroral acceleration region, the relationship between large-scale auroral dynamics (like substorms) and small-scale aurora, etc., are still not understood.

We are now discussing on the possibilities for future small- and micro-scale satellites to understand the small-scale aurora and the coupling system between magnetosphere and ionosphere. In this talk, we focus on the scientific targets to be solved by the future satellite missions, and also show the conceptual design of auroral camera. These will be launched into a polar orbit at low-earth-orbit (LEO) or at mid-altitudes up to a few thousands km. We consider that the following specifications are required to this auroral camera. (1) Imaging optics is preferred. (2) At apogee, the field-of-view mapped on the ionosphere is wider than 400 x 400 km, which is about 6 times greater than that of Reimei. (3) Spatial resolution is better than 1 km/pixel to obtain fine-scale aurora. (4) Time resolution is higher than 1 frame/sec to obtain time variation of aurora. (3) It is preferred that the camera measures auroral emission in the nightside hemisphere under sunlit conditions.

To satisfy the requirements, we carried out the conceptual design of auroral camera as follows, assuming that the satellite is three axis stabilized and its apogee is 3000 km. The target is auroral N2 1P emission at 670 nm and/or O2 A-band emission at 762 nm. The objective lens is f=100mm (F1.5), and the preferred detector is 1k x 1k EMCCD of which pixel size is 13 x 13 um. Then, the field-of-view is 7.6 deg, which enable us to cover 400 x 400 km and 200 x 200 km with spatial resolution of 2 km/bin and 1km/bin (assuming 5-pix binning) viewed from altitudes of 3000 km and 1500 km, respectively. In the case of 10 frame/sec sampling and the EM gain 50, we obtain the S/N of 50 for 1kR auroral intensity and the data rate is 4.5 Mbps (assuming lossless data compression rate of 0.7). We also discuss the requirement for auroral camera measurement under sunlit conditions using a dipole or IRGF magnetic field model. We find that the satellite exists in the shadow of the Earth at altitude of 3000 km only in the limited period in the winter hemisphere in addition to that the magnetic pole tilts toward the anti-sunward direction. Thus, we suppose that we should take auroral image under the sunlit conditions using a baffle prior to the objective lens to reduce the strong scatter light.

PCG31-07 Room:202 Time:May 27 17:00-17:15

Solar System Explorations using DESTINY: the Demonstration and Experiment of Space Technology for Interplaneta

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Demonstration and Experiment of Space Technology for Interplanetary Voyage (DESTINY), which is a candidate mission of Epsilon Launch Vehicle, aims to demonstrate new technologies of high energy orbit insertion, large scale ion engine, ultra light-mass solar panel, etc. for low-cost deep space mission. It also plans to observe using scientific instruments with the mass of up to 10 kg during transfer and Halo orbit of sun to earth Lagrangian point L1 or L2.

Potential scientific objects include in-situ observation and remote sensing from L1 or L2 are, such as, plasma and energetic particles around the plasma sheet of terrestrial magnetosphere. X-ray Telescope will make imaging of the solar wind charge exchange (SWCX) with a full coverage from the distance of the Moon and the first full imaging for the magneto-sheath, cusp, and magnetopause. Ultraviolet Telescope with 10 cm diameter will simultaneously observe the Lyman Alpha emission from the geocorona. Neutral and Ion Camera will provide a side-view of the dynamical magnetosphere. It would be able to provide the first composite movies of how the terrestrial global magnetosphere changes in the solar wind. DESTINY is considered to be useful for the pilot observations for future infrared, gamma-ray, and cosmic-ray space astronomical telescope. It is probable to observe and monitor Near Earth Objects (NEO), inter-planetary and inter-stellar dust. Dust Analyzer and High Vision Camera will provide physical parameters, such as the size and density, and chemical features, such as the metallic and organic composition of the interstellar dust to elucidate the original material of the solar system and the life. These instruments would observe one of the most unusual asteroids 3200 Phaethon which has dust tails. High Vision Camera and Thermal Infrared Imager would also observe the impact flash of the Moon.

Applied missions of DESTINY will be able to go to deep space with higher mass of payloads. Using the Epsilon Launch Vehicle, it will convey instruments of up to 50 kg to the space between Venus and Mars. Ultraviolet Telescope with the larger size will observe the absorption lines from the extra-solar planets such as the hot Jupiter and the super earth. Infrared Telescope settled on the orbit of outside the ecliptic plane will observe the cosmic background radiation. DESTINY launched by the improved launch vehicle with the power of M-V rocket will carry payloads of up to 200 kg into the orbit of Venus and Mars. In this phase, climate observations of Venus using two orbiter, and dust-transport mechanism observation of Mars with the combination of Martian airplane and stationary satellite will be realized.

We will present the possible instruments and model missions for solar system sciences and space astronomy in the DESTINY series.

Keywords: Epsilon Rocket, DESTINY, solar system exploration, deep space, Lagrangian point

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PCG31-08 Room:202 Time:May 27 17:15-17:30

Super constellation of micro-satellites as a new platform for space investigations

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It is expected that micro-satellites with a weight less than 100 kg will play important roles in space development in the very near future due to extreme low cost and the rapid down-sizing. Adding to Surrey Satellite Technology Ltd., a venture company of Surrey University in UK and one of the pioneers of microsatellite, not a few institutes or companies started entering the international race of micro-satellite development. Micro-satellite had been considered as an educational or experimental tool, but it is not any more at present. Google bought US company, Skybox Imaging, which may launch several tens of, even hundreds of 100 kg-class micro-satellites in the near future for commercial services as a part of Google businesses. Recently, with telescopic camera on board RISING-2, our second 50 kg-class satellite, we succeeded in acquiring 10-m resolution spectral images with liquid crystal filter, which is the best performance in the world among all kinds of satellites. However, no standardized satellite BUS or scientific sensors exist in the world. One of the fascinating ideas to realize super multipoint measurement for space weather monitoring might be installing a standardized scientific plasma sensor package at every micro-satellite as a part of the BUS instruments. In the near future we may have an opportunity to realize the super constellation with more than several tens of micro-satellites, organizing international community. Here we would like to discuss how to implement our conception

Keywords: micro-satellite, micro-satellite

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PCG31-09 Room:202 Time:May 27 17:30-17:45

Development of TOF-MS for in-situ K-Ar dating

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In-situ age determination of planetary surface is quite important in understanding the evolution of planets. We are now developing a new instrument for in-situ Potassium-Argon (K-Ar) dating. The K-Ar dating is a radiometric dating method based on the measurement of ^{40}Ar that is produced from the radioactive decay of ^{40}K. This instrument is the combination of laser-induced breakdown spectroscopy (LIBS) and time-of-flight mass spectrometer (TOF-MS). K is measured using LIBS and Ar is measured using TOF-MS. In this presentation, we report the current development status of the TOF-MS.

In order to install the instrument on a rover, it is necessary to design the TOF-MS as small as possible due to the severe restrictions on the mass and power. To increase mass resolution while keeping the size of TOF-MS small, we have adopted a dual-stage reflectron that has two-stage reflector with two different electric field intensity. We have analytically optimized the size and electric field of the reflectron for achieving highest possible mass resolution. We have confirmed that the mass resolution of the designed reflectron is high enough for K-Ar dating.

We also need to measure a small amount of ^{36}Ar for the Ar isotope measurement. We have found that the ion detection rate should be more than 10 percent and the repetition frequency of the ion pulse acceleration should be a few kHz in order to keep good counting statistics estimating from the amount of the ions generated by LIBS. To improve the efficiency of ion detection, we simultaneously accelerated the ions within a finite area. We have confirmed that ion detection rate is more than 10 percent by numerical simulation. Furthermore, for improving the pulse repetition frequency, we have designed the drift tube to be negatively biased. Since the ion pulse acceleration voltage can be reduced, it is possible to increase the pulse repetition frequency to a few kHz.

Keywords: TOF-MS, K-Ar dating, Planetary Explora

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PCG31-10 Room:202 Time:May 28 14:15-14:30

Space-borne observation of the ionosphere, thermosphere and the mesosphere

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A micro satellite for imaging of the ionosphere-thermosphere-mesosphere-plasmasphere is being designed in aiming to be launched in the low-earth orbit. This new observation is expected to clarify the upper atmospheric processes that have been partially found by the ground-based techniques and the ISS-IMAP missions from the international space station. The new satellite can observe the Earth's upper atmosphere with a wide field of view that cannot be observed from ground-based instruments. Main targets of the observation are: (1) generation, evolution and decay mechanisms of mesoscale structures in the mesosphere and the ionosphere, (2) longitudinal and regional characteristics of the atmospheric gravity waves and tidal waves in the mesosphere, (3) disturbances of the thermosphere associated with the geomagnetic storms, (4) electron density distribution in the plasmasphere and its effect on GPS radio waves, (5) the ionospheric effect on the radio waves and development of the correction technique. Coordinated study among the satellite, ground-based instruments and numerical models is expected to expand our knowledge of the mesosphere, thermosphere, ionosphere and plasmasphere from the equatorial to the polar regions. The coupling mechanisms among high-, mid-, and low latitude regions, and between lower and upper atmosphere will be elucidated by this space-borne observation.

Keywords: Ionosphere, Mesosphere, Thermosphere, Plasmasphere, space-borne imaging observation

PCG31-11 Room:202 Time:May 28 14:30-14:45

Development of geocoronal hydrogen Lyman Alpha Imaging CAmera (LAICA) and observational results

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Exospheric hydrogen atoms resonantly scatter the solar ultraviolet radiation, causing an ultraviolet glow called geocorona. Previous research revealed that the geocorona extends to an altitude of about 20RE. The hydrogen Lyman alpha radiation (121.567 nm) is the brightest emission of the UV glow.

Bailey and Grantman (2011, 2013) reported that the geocorona has an asymmetric spatial distribution and the total number of hydrogen atoms increases abruptly (from 6% to 17%) during geomagnetic storms. These observations of the geocorona have mainly been performed using earth orbiters. Therefore, features of the geocorona, such as geocoronal distribution and variation in the number of hydrogen atoms during geomagnetic storms at high altitude are still unclear. In addition, only a few satellites have observed the geocorona from deep space and, among them, only Apollo16 had a 2D imager. However, its FOV was 10RE and was not wide enough to image the whole geocorona.

In this study, we developed a UV camera called LAICA (Lyman Alpha Imaging CAmera) for imaging the geocorona from deep space. We started developing the LAICA in October 2013. LAICA has a spherical Cassegrain telescope, a bandpass filter, and a detector (a micro channel plate and a resistive anode encoder). The detector is a copy of PHEBUS/FUV on board the Bepicolombo/MPO satellite. We designed and manufactured the LAICA optical system. Furthermore, we established the gluing method to attach the primary/secondary mirrors and the bandpass filter to the aluminum body. Finally, we completed the development of LAICA in July 2014. LAICA was then installed in the very small deep space explorer PROCYON, which was launched in December 2014. In this presentation, we will describe the details of the LAICA instrument and report our initial results.

Keywords: geocorona, Lyman alpha line, earth's atmosphere, space telescope

PCG31-12 Room:202 Time:May 28 14:45-15:00

Measurement of ionosphere by microsatellite "GAIA-I" and development of the electron density and temperature probe: EDTP

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Chiba University plans to hold orbital experiment by using a microsatellite named GAIA-I. The GAIA-I could investigate relationship between diastrophism and ionospheric phenomenon to seize precursors of earthquake. Many ground based observations show that ionosphere is modified before large earthquakes. The mechanism of the ionosphere modification is still not known. Recently, ionosphere observation by small and micro satellites has been proposed in order to study the mechanism of the ionosphere modification. However, conventional ionosphere measurement has some problems in small and micro satellites. In the case of Langmuir Probe, one problem is that satellite potential changes easily when sweeping voltage which is applied to probe and second problem is that the measurement is influence by the electrode contamination. We discuss here a new sensor to observe an electron density and temperature at the same time with one simple low cost, low power consumption and low data rate instrument. This sensor is called Electron Density and Temperature Probe (EDTP).

EDTP has a probe that is formed by two semicircular plate shapes. When a sinusoidal voltage whose frequency is lower than ion plasma frequency is applied to an electrode, the floating potential shifts to the negative potential. The electron temperature can be calculated from the ratio of the two floating potential shifts which are caused by applying two successive signal of amplitude a and $2a$. This principle to measure electron temperature is applied the instrument was developed in 1970, which is named Electron Temperature Probe (ETP).

In a high frequency region, plasma impedance is more dominant and the amplitude of sinusoidal signal which is applied between electrode and sheath edge is controlled by the combination of sheath impedance and plasma impedance. Based on this principle, we added one more function of ETP to measure electron density as well by replacing low frequency oscillator which was used for ETP to sweep frequency generator.

We tested ETDP experiment that compared ETDP with Langmuir Probe and Impedance Probe by using space chamber. Our experiment has revealed that EDTP is better than conventional ionosphere measurement.

Keywords: Ionosphere, electron density and temperature, microsatellite

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Submillimeter limb sounder for stratospheric and mesospheric temperature, wind, and chemical species

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Submillimeter-wave limb sounder has a potential for measurement of temperature, wind, and chemical species, such as H_2O and O_3, over the wide altitude range of the Earth's atmosphere, ie. from the lower stratosphere to the lower thermosphere. The submillimeter sounder has receivers in a couple of frequency bands to observe emission lines of several chemical species and O_2. Each band will be detected with high-resolution spectrometer on the back end of the sounder. Supposed mission in the working group of our project consists of highly sensitive receivers of two or four frequency band and spectrometers with a bandwidth of 2 or 4 GHz and a resolution of around 1 MHz. Its specifications will be determined in the working group in next 3 years. In this paper, we will report the present status of our study toward the design of SMILES-2, which will be an advanced version of the successful mission, JEM/SMILES, deployed on the international space station (ISS) from 2009 to 2010.

The sensitivity of submillimeter receiver using superconducting technology shows one order better than semiconductor devices operated in ambient temperature. The sensitivity restricts the range of the variation of observable molecules and the altitude range. The observation of the higher atmosphere above the mesosphere is especially limited by the sensitivity, because the emission from the atmosphere is comparatively weak while the noise in the received signal, that is dominated by the receiver noise, is constant in spite of disappearing of background emission. Superconducting receiver is preferable for the observation in such upper atmosphere. JEM/SMILES adopted superconducting mixer at 625 and 650 GHz, and successfully demonstrated excellent observation of ozone and chlorine compounds and so on. The SSB system noise temperature of the JEM/SMILES receiver was 297 K, which is less than a tenth of that of Schottky receiver of those days. The frustration of JEM/SMILES users was that the mission observed no oxgen line and no atmospheric tracer. The limitation of JEM/SMILES bandwidth had come from safe design avoiding electromagnetic interference in ISS. The thermal design of the JEM/SMILES cryo system had been also safe so that only two receivers were loaded in the cryo system. In SMILES-2, wider range of frequency band will be used in instrument of smaller weight. It will realized by utilizing wide-band intermediate frequency and reducing optics system. The antenna of SMILES-2 is steerable in elevation angle. The altitude resolution of the limb observation is targeted to around 2 km. The azimuthal direction of the antenna is under discussion. The calibration load in JEM/SMILES was successful and contributed to measure precise spectral data, so that the load will be applied to multi frequency receiver.

The SMILES-2 mission will have a weight of about 200 kg. We estimate it is possible to reduce the weight of the system from that of JEM/SMILES, that is 476 kg. Besides the superconducting receiver, Schottky receivers will be installed in SMILES-2 to make the system reliable because expected lifetime of cryocooler is 3 years and we wish to prolong the mission life. An only Schottky receiver mission is also planned for a quick mission.

Keywords: middle atmosphere, limb observation, submillimeter wave, instrument development, future mission, SMILES

PCG31-14 Room:202 Time:May 28 15:15-15:30

Sensitivity study of chemical species for SMILES-2

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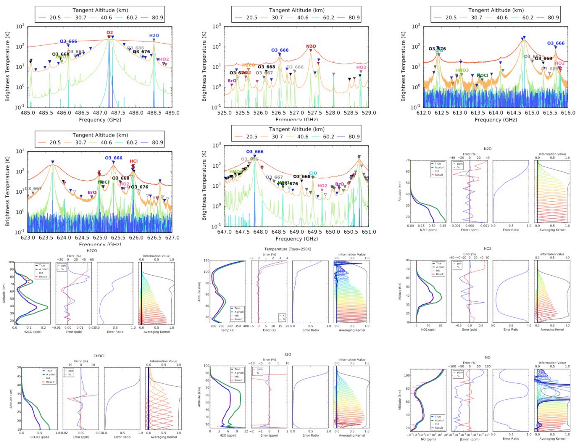
Superconducting Submillimeter-Wave Limb-emission Sounder (SMILES) was the first instrument to use 4K cooled SIS (Superconductor-Insulator-Superconductor) detection system for the observation of the atmosphere in the frequency regions 625 GHz (Bands A and B) and 650 GHz (Band C) [1]. It has demonstrated its high sensitivity (System Temperature, Tsys ~250K) for measuring stratospheric and mesospheric species, O3, HCl, ClO, HO2, HOCl, BrO, and O3 isotopes from Oct. 12, 2009 to Apr. 21, 2010 [2-5]. Since SMILES operation has terminated after only 6 months operation due to failure of sub-mm local oscillator (and later 4K cooler system), there exist strong scientific demand to develop successor of SMILES, the SMILES-2, which has optimized and enhanced frequency coverage to observe: (a) BrO and HOCl without interferences of stronger emission lines, (b) N2O, H2O, NO2, and CH3Cl not covered by the SMILES frequency regions, and (c) O2 line to measure temperature. This paper discusses possible SMILES-2 band selection considering limited instrument resources (number of SIS mixers and sub-mm local oscillator) and scientific requirements.

SMILES L2 system used strong O3 and HCl lines to retrieve temperature, which has sensitivity only up to 40-50 km. Temperature should be observed by SMILES-2 itself up to (or above) 100 km with a sensitivity of 1% (2-3K), since the temperature is the primary physical parameter to determine the dynamics and chemistry of the atmosphere and there is no global meteorological data set which is reliable above 60 km. SMILES-2 should have observation capability of H2O and N2O better than 5% precision, which are not observed by SMILES and are important tracers in the upper atmosphere. These are major sources of HOx and NOx. SMILES-2 should improve HOCl and BrO sensitivity by properly selecting observation frequency. SMILES BrO and HOCl observations have suffered severe interference from the near-by stronger lines. SMILES-2 should have original SMILES frequency coverage, and if possible it should add observation of other species retrieved in the Aura/MLS and Odin/SMR.

Instrument Altitude range: 10-120 km, 2.5 km vertical sampling. Frequency sampling: 4 GHz bandwidth, 500 kHz sampling interval, 1.3 MHz Gaussian (FWHM). Tsys = 150 K, Integration time $<$0.48 s.
(Band 1) 485-489 GHz: T, Wind, O2, H2O, O3, HO2, HNO3
(Band 2) 523-527 GHz: O3, 17OOO, 18OOO, O17OO, O18OO, BrO, NO2, H2CO, N2O, HO2
(Band 3) 612-616 GHz: HOCl, O3, HO2
(Band 4) 623-627 GHz: SMILES Bands A+B extended, O3, HCl, BrO, HNO3, HO2, N2O, HOCl, CH3CN, CH3Cl
(Band 5) 648-652 GHz: SMILES Band C extended, O3, 17OOO, O17OO, 18OOO, ClO, HO2, BrO, NO

[1] K. Kikuchi et al., Overview and early results of the Superconducting Submillimeter-Wave Limb-Emission Sounder (SMILES), J. Geophys. Res., 115, no. D23306, pp. 1-12, 2010.
[2] K. Imai et al., Validation of ozone data from the Superconducting Submillimeter-Wave Limb-Emission Sounder (SMILES), J. Geophys. Res., 118 (11), pp. 5750-5769, 2013.
[3] T. Sakazaki et al., Diurnal Ozone Variations in the Stratosphere Revealed in Observations From the Superconducting Submillimeter-Wave Limb-Emission Sounder (SMILES) on Board the International Space Station (ISS), J. Geophys. Res., 118 (7), pp. 2991-3006, 2013.
[4] A. K. Smith et al., Satellite observations of ozone in the upper mesosphere, J. Geophys. Res., 118 (11), pp. 5803-5821, 2013.
[5] R. A. Stachnik et al., Stratospheric BrO abundance measured by a balloon-borne submillimeterwave radiometer, Atmos. Chem. Phys., 13, pp. 3307 - 3319, 2013.

PCG31-14 Room:202 Time:May 28 15:15-15:30



PCG31-15 Room:202 Time:May 28 15:30-15:45

Mesospheric wind observation from Sub-millimeter limb sounding: Results from SMILES and simulation study for SMILES-2

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Wind observations in the middle atmosphere, i.e. stratosphere and mesosphere are sparse [1]. Observations have been obtained from ground-based active sensors (radar and lidar), and recently from passive infra-red and microwave spectrometers. Satellite observations were successfully conducted with instruments on-board the UARS and TIMED satellites but they mainly cover the mesosphere. Mesospheric winds have also been retrieved from AURA/MLS using the O2 line at 118 GHz. It was the first demonstration that good quality winds can be provided by a microwave limb sounder. More recently winds were measured between 30 and 80 km (with a theoretical lower limit of 20 km), by the Superconducting Submillimeter Wave Limb Emission Sounder (SMILES) onboard the Japanese Experiment Module on the International Space Station. The advantage of SMILES was its low measurement noise, about 5 to 10 times lower than concurrent systems such as Odin/SMR and AURA/MLS [2]. Such noise level was obtained with the use of two 4-K cooled SIS mixers. However, the instrument was not designed for wind observations and suffered from serious limitations due to the choice of the spectrometers (type, bandwidth, resolution) and of the spectral lines. Sensitivity studies [3,4] have shown that with a careful selection of these parameters, the line of sight wind velocity can be retrieved between 40 — 90 km with a precision of 2 m/s and a vertical resolution of about 5 km, even without the use of a SIS mixer.

Wind has been selected as one of the products for the study of the successor of JEM/SMILES, namely SMILES-2, whose the main target is the study of the dynamics and chemistry in the mesosphere. In this presentation we summarize the results obtained from JEM/SMILES and discuss the SMILES-2 potential for wind measurements.

References:

[1] P. Baron, D. P. Murtagh, J. Urban, H. Sagawa, S. Ochiai, Y. Kasai, K. Kikuchi, F. Khosrawi, H. Kornich, S. Mizobuchi, K. Sagi, and M. Yasui. Observation of horizontal winds in the middle-atmosphere between 30S and 55N during the northern winter 2009 — 2010. ACP, 13(13), 2013.

[2] K. Kikuchi, Nishibori, T., Ochiai, S., Ozeki, H., Irimajiri, Y., Kasai, Y., Koike, M., Manabe, T., Mizukoshi, K., Murayama, Y., Nagahama, T., Sano, T., Sato, R., Seta, M., Takahashi, C., Takayanagi, M., Masuko, H., Inatani, J., Suzuki, M., Shiotani, M. Overview and Early Results of the Superconducting Submillimeter-Wave Limb-Emission Sounder (SMILES), JGR Atmospheres, 2010

[3] P. Baron, D.P. Murtagh, J. Urban, H. Sagawa, P. Eriksson, S. Ochiai, Definition of an uncooled Sub-Millimeter/THz Limb sounder for measuring middle Atmospheric winds., Proc. In ESA Living Planet Symposium, 2013.

[4] N. Manago, H. Ozeki, and M. Suzuki. Band selection study for the SMILES-2, Proc. In 28 Taikiken symposium, 2014

Keywords: mesosphere, wind, SMILES, limb, microwave

PCG31-16 Room:202 Time:May 28 15:45-16:00

Initial performance verification of Atmospheric Neutral Analyzer for in-situ observations of planetary atmospheres

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The dynamics in the neutral upper atmosphere of the Earth and the other planets affect the environment of their ionospheres and the thermospheres. In-situ observations of the neutral atmospheres utilizing spacecraft are needed for understanding atmospheric circulations, heating, and dissipation. Neutral Mass Spectrometers for the terrestrial and planetary explorations have not had a capability to directly observe two-dimensional particle velocity distributions in the past. Therefore, detailed information on the interaction of the upper atmosphere with the solar wind and the dynamics of neutral particles have not been obtained so far.

We are newly developing a Bennett-type radio-frequency mass spectrometer, which is called Atmospheric Neutral Analyzer (ANA). The ANA is capable of observing 2-D velocity distributions, from which density, wind velocity and temperature are derived, for each component of neutral species. The ANA consists mainly of five sections: an entrance slit, an ionization section utilizing electron gun, a pre-acceleration section, a Radio Frequency (RF) stage for mass spectrometry, and a detection section which obtains 2-D velocity distributions in combination of MCP with 2-D position-sensitive device. We now concentrate on the development of the whole ion mass spectrometer after the ionization section.

In addition to the numerical design of the structure and the performance of the mass spectrometer by using SIMION 8.1, we newly had experiments to investigate the characteristics of the engineering model of the ANA except for the ionization section. We, here, used the suprathermal ion beamline of Ar^+ and $N_2{}^+$. For the calibration, we set the ANA in a vacuum chamber, and irradiated the ions with energies of several to a few tens of eV, in order to investigate its response. Because the spacecraft velocity is assumed to be 8 km/s, the energy of the irradiated ions must correspond to it. The energies of the Ar^+ and $N_2{}^+$ of 8 km/s are 13.3 and 9.3 eV/charge, respectively. We irradiated the Ar^+ and $N_2{}^+$ beams of 8 km/s, but the beam ions were not detected in the detection section. Instead, particles whose energies were approximately 17 eV (Ar^+) and 13 eV ($N_2{}^+$) were detected when the voltages of the ANA electrodes were of reference values for the 8 km/s cases of each species. We are now considering the possibility of fabrication errors in ANA. Besides, the irradiated Ar^+ whose energy was 17 eV was not detected when the parameter of the ANA electrodes were of reference values for the 13 eV cases of the $N_2{}^+$. And vice versa.

In the presentation, we will show the overall design of the ANA regarding the mass spectrometry and the characteristics investigated by the simulation and the beamline experiments.

Keywords: Planetary atmosphere, In-situ observation, Neutral mass spectrometer, Equipment development

PCG31-17 Room:202 Time:May 28 16:15-16:30

The design of the suprathermal ion mass spectrometer (STIMS)

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Ion escape processes are critical issues to solve atmospheric evolution of non-magnetized planets, e.g., Venus and Mars. Many studies about the ion escape have been conducted by both observational and theoretical methods. There is, however, a problem that qualities of in-situ observations have not been sufficient to identify the detailed suprathermal plasma dynamics, especially about molecular ions, around the non-magnetized planetary ionospheres. A suprathermal ion mass spectrometer (STIMS) has been designed for future in-situ observations of three dimensional velocity distributions for suprathermal ions around the planetary atmospheres.

The STIMS consists of (a.) an energy analyzer and (b.) a mass analyzer. A field of view of the STIMS is about 4 pi sr per a half spin of spin-stabilized spacecraft. A target energy range is from 0.1 to 300 eV, which corresponds to suprathermal energies, and a mass range is from 1 to 50 amu. An energy resolution, △E/E, is less than 5%, and a mass resolution, M/△M, is over 10.

(a.) An energy analysis of the STIMS is carried out in a top-hat type electrostatic analyzer, which deflects incident ions by 90 degrees and leads them to an entrance of the mass analyzer. Only ions that fly along a center radius of spherical electrodes are able to get to the mass analyzer.

(b.) The mass analyzer of the STIMS is mainly made up of a pre-acceleration section and a magnet section. The magnet section, which has a cylindrically symmetric structure, is divided into sixteen regions by permanent sector magnets. Firstly, in the pre-acceleration section, ions which got through the energy analyzer are accelerated or decelerated by an acceleration voltage E eV, whose magnitudes depend on mass number of the ions M amu. Secondly, the accelerated/decelerated ions experience Lorentz force in the magnet section, and reach a micro-channel plate (MCP), with semicircular trajectories. By sweeping magnitudes of the acceleration voltage E, only ions that conserve square root of product of their masses and kinetic energies, i.e., $\sqrt{ME}$, are able to reach the MCP.

As for observations of molecular ions, magnet type mass spectrometers have a great advantage that it is possible to detect the molecular ions without dissociations. However, this type of spectrometer has several disadvantages; (1) it is difficult to discriminate between noise signals and ion signals at the MCP because this type of spectrometer does not take signal coincidences; (2) this type of mass spectrometer tends to be heavier than other types of spectrometers due to installing magnets; (3) magnetic field of the magnets might cause undesirable effect on other observation instruments on spacecraft.

In this presentation, we will introduce design concepts and specifications of the STIMS.

Keywords: ion mass spectrometer, suprathermal ion, non-magnetized planet, planetary ionosphere

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PCG31-18 Room:202 Time:May 28 16:30-16:45

Space-terrestrial couplings and polar ionosphere/thermosphere dynamics studied by formation flight of compact satellites

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We have been discussing a possibility and feasibility of the future space exploration mission for studying the space-terrestrial couplings based on the space plasma dynamics. In this future mission, we are planning to elucidate the universal particle acceleration/heating and transport mechanisms by using the in-situ and remote-sensing observation techniques with a formation flight of multiple compact satellites. These plasma dynamics are caused mainly by the terrestrial ionosphere-magnetosphere coupling processes and also affect both mangetospheric plasma dynamics and upper atmospheric (ionospheric and thermospheric) phenomena in the Earth's polar regions. In past, our Reimei satellite, the first Japanese microsatellite focusing on the exploration of the fine-scale auroral dynamics, was launched in August, 2005. Reimei successfully obtained the in-situ observational data for the space plasmas but the imaging camera data for the auroras, the airglows, and the sprites. These Reimei results have been leading to several new satellite mission proposals in the world. We are now organizing a highly plausible mission based on our own experimental experiences obtained from Reimei and our data analysis achievements, for instance, in the ISAS Akebono mission and the NASA FAST mission. It is undoubtedly evident that highly accurate measurements of magnetic/electric fields and plasma waves should be realized in this future satellite missions in addition to the monochromatic auroral imaging camera with high-time/spatial resolutions and the energetic and suprathermal electron/ion analyzers with a high-time resolution. Thermal plasma instruments are also important for measuring the plasma circumstances. It should be noticed that the neutral particle instruments, which are now under development and modification in Japan, would significantly contribute to the quantitative researches of the polar ionospheric and thermospheric dynamics. Toward the realization of the new space exploration mission, we are making intensive efforts for defining the scientific mission strategy and the specifications of the science instruments. In the future mission planning, we are now considering the following features. 1: Changeable formation flight with multiple compact satellites, whose weights are roughly 100 kg, is essential for simultaneous multipoint observations of fine-scale auroral phenomena. 2: The precise three axial attitude control system should be applied for realizing the high-quality 2-D imaging of auroral emissions and the simultaneous measurements of the pitch-angle distributions of the auroral particles with top-hat type energy analyzers. 3: It is crucial to capture the ram direction of the satellite with the attitude control in order to measure the shifted velocity distributions of the core ions. 4: The electric/magnetic field instruments and the plasma wave instruments should be installed on the satellites for the integrated observations. Particularly, it is one of the most prominent features of this mission to perform wave-particle interaction analyses based on these comprehensive and integrated measurements of the plasma particles and waves, and the fields. 5: Neutral particle instruments for the velocity distribution measurements would make essential contributions from the farsighted viewpoint in the upper atmospheric dynamics beyond the space plasma regimes. 6: The sun-synchronous orbit at relatively low altitudes would be desirable both for bringing the observational advantages. In this presentation, we introduce the multi-sided scientific importance and several types of our exploration mission specification.

Keywords: space plasma, particle acceleration, space-terrestrial coupling, wave-particle interaction, integrated observation, formation flight

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PCG31-19 Room:202 Time:May 28 16:45-17:00

Study on miniaturization and accelertion of onboard digital signal processing module for plasma wave instruments

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Measuring plasma wave is one of important clues to understand space plasma physics, and it is necessary to implement intelligent signal data processing techniques into the plasma wave instruments. It is necessary to reduce the weight and size of the instruments to meet the requirements of future missions such as flying formation satellites and planetary exploration spacecraft. In the present study, we developed a FPGA board, which enables us to develop arbitrary digital signal processing applicable for the future missions.

Our FPGA board is designed to evaluate the performance of signal processing module, which is especially used for various kinds of real-time signal processing. The board consists of one CPU connected with a USB port, and two sets of FPGA and DDR2. One set of FPGA and DDR2 is equipped for storing input signal data and sending them to another one, which is used for the evaluation of real-time data processing module and storage of output data. The input and output data stored in the DDRs can be accessed from the onboard CPU, and we can easily control the CPU using Tera Term through a USB port. We also developed a general purpose module for evaluation of a proposed signal processing method. By using this module, a developer can integrate his/her own signal processing module on the FPGA board without any complicated wiring work for the peripheral circuits and evaluate the performance of his/her own module. Finally we implemented a sub-band compression module developed for real-time data compression of waveform measured by the plasma wave instruments. It was demonstrated that the designed module is compact and fast enough to realize real-time processing for 6 channels of waveform data.

Keywords: Waveform capture, Verilog-HDL, Plasma wave instruments, Signal processing

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PCG31-20 Room:202 Time:May 28 17:00-17:15

Miniaturization of plasma wave instruments and its perspective towards future space missions

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The miniaturization of onboard instruments is essential in executing space plasma observations using microsatellites. In particular, conventional plasma wave instruments have a large size of analogue circuits such as low noise amplifiers and various types of filters. In addition, onboard digital processing such as data compression and FFT calculation requires large budgets of mass and power in using CPU. However, the capability of the onboard CPU does not support the real time onboard processing of plasma wave observation data. We need to convert the processing using software into the processing using hardware such as FPGA and digital ASIC.

We have been attempting the miniaturization of plasma wave instruments using mixed signal ASIC technology. We have already succeeded in realizing six channels of waveform capture receiver inside the chip with the size of 5mm times 5mm. We also realized the preamp chip for magnetic sensors. Furthermore, this ASIC technology leads to the consolidation of the digital part and analogue part of plasma wave receivers. This means that the whole plasma wave receiver system will be installed inside a one chip. In the present paper, we will introduce our attempt of the miniaturization of plasma wave receiver using the ASIC and show you the perspective using the miniaturized plasma wave receiver.

Keywords: Plasma wave, ASIC

PCG31-21 Room:202 Time:May 28 17:15-17:30

Small Sensor Probe for Multiple Point Observation of Plasma Waves

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Recently, multi-spacecraft missions for observing space plasma phenomena have become the trend because multiple point observation is essential in overcoming the disadvantage of conventional one point observation. However, multi-spacecraft missions have a limit to the number of observation point and disposition of spacecraft because of the weight and the size. We propose a new system for multiple-point observation referred to as the monitor system for space electromagnetic environments (MSEE). The MSEE consists of small sensor probes that have a plasma wave receiver, a wireless communication module and electromagnetic sensors to measure electromagnetic waves and transfer observation data. The sensor probes are randomly distributed throughout the target area to observe plasma waves from multiple-point. Observation data are transferred to a central station, such as a satellite or a rocket through wireless communication.

We succeeded in designing and developing the prototype model of the MSEE sensor probe. The sensor probe includes the miniaturized plasma wave receiver, the microcontroller, the wireless communication module, and the battery in the 75 mm cubic housing. In addition, loop antennas, dipole antennas and actuators that are used for expanding dipole antennas are attached on the housing. The whole weight of the sensor probe is 692 g, and the total power consumption is 462 mW. We verified the total performance for electric field measurements, and we found that analog components had enough characteristics to measure electric fields, and the A/D conversion and the wireless transmission worked correctly.

Present sensor probe use miniaturized waveform capture (WFC) type of plasma wave receiver realized by Application Specific Integrated Circuit (ASIC). Although the waveform receiver can provide phase information of waves, it has disadvantages that it cannot measure continuously due to the limit of the telemetry capacity. Thus it is desirable to use both types of receivers in plasma wave observation. It requires spectrum type receivers for continuously observation. We proposed new spectrum type plasma wave receiver that overcome the disadvantage of conventional spectrum type receivers. New spectrum receiver copes with both high time resolution and high frequency resolution by combining analog circuits and digital signal processing. We succeeded in developing the analog circuit of the new spectrum receiver using ASIC.

In this presentation, we introduce the detail design and the performance of the prototype model of the sensor probe. We also introduce the new spectrum type receiver.

Keywords: plasma wave receiver, multiple-point observation, ASIC

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PCG31-22 Room:202 Time:May 28 17:30-17:45

Recent progress in developing search coil magnetometer using ASIC technology toward micro-satellite experiments

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Magnetic field components of plasma waves are essential for probing space plasma environments. Search coil magnetometers are commonly used in satellite experiments and well-adapted to the measurements in the frequency range from a few Hz to several tens of kHz. A search coil sensor is installed at the top of a few-meter long mast or boom to reduce a noise contamination from a satellite. Then a preamplifier could be installed inside the satellite due to thermal and radiation conditions in space. Such a preamplifier separated from a sensor has disadvantages for the signal-to-noise ratio and the system resource. Recently, application specific integrated circuits (ASICs) are one of key technologies for increasing demands of plasma wave observations using multiple micro satellites. In order to further reduce mass, volume, and power consumption of analog circuits in typical plasma wave instruments, we have developed a low noise ASIC preamplifier for search coil magnetometer. The preamplifier is an important analog component of plasma wave observation to determine the noise equivalent magnetic induction (NEMI). In this study, a current-sensitive preamplifier for search coil magnetometer was developed and fabricated on a 6-mm^2 silicon chip by using a standard 250 nm complementary metal-oxide semiconductor (CMOS) technology. A search coil sensor shows a maximum value of its impedance at the resonance frequency. The NEMI at the resonance frequency is determined by multiplying the sensor impedance by the current noise of preamplifier. Thus, the ASIC preamplifier using CMOS technology is more suitable for search coil magnetometer compared to a preamplifier using bipolar junction transistors, because MOS transistors show the very low current noise. The NEMI of developed ASIC preamplifier combined with a 100-mm-long search coil is 30 fT/$\sqrt{\text{Hz}}$ at 2 kHz with a power consumption of 15 mW. The radiation hardness assurance of the ASIC preamplifier is at least 100 krad total ionizing dose, which is equivalent to approximately the total amount for 10 year duration at the geostationary orbit. The temperature dependence of the gain of the ASIC preamplifier is 0.04 dB/deg C in the worst case. The ASIC preamplifier showing such sufficient NEMI, low power budget, and environmental tolerance in space can be installed in the close vicinity of the search coil sensor located at the top of a mast. Also the ASIC preamplifier can provide large mass saving. As an application, we have embedded a new ASIC preamplifier for 3-axis loop antennas into a palm-sized sensor probe as a monitor system for space electromagnetic environments. The sensor node includes the ASIC preamplifiers, an ASIC waveform receiver, a CPU, and a wireless communication module in the cubic body ($8 \times 8 \times 8$ cm).

In this presentation, we will report the present status of our ASIC preamplifier and also introduce some applications using the ASIC preamplifier for plasma wave observation.

Keywords: Search coil magnetometer, ASIC

PCG31-23 Room:202 Time:May 28 17:45-18:00

Evaluation of the effective measurement frequency for the digital fluxgate magnetometer installed in the S520-29 rocket

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The digital fluxgate magnetometer (DFG) is newly developed and installed in the S520-29 rocket launched on 17 August 2014. We expand the effective measurement frequency to higher frequencies by performing internal processes in the sensor and outputting the residual magnetic fields as the telemetry data. This is the new method that can be applied into the future rocket and satellite missions for higher-accuracy, downsized, and power-saving measurements.

The sun sensor is also installed in the S520-29 rocket and the direction to the sun from the rocket is accurately measured. By comparing the magnetic field in the direction to the sun observed by DFG to the one calculated by the model (e.g., IGRF), we investigate the magnetic field offset in the direction of the spin axis caused by DFG or the rocket, and also evaluate the stability of DFG measurement during the flight operation. In our presentation, we present how the new-type DFG improved its effective measurement frequency.