Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)


PCG11-01 Room:421 Time:April 28 10:00-10:15

# Problems of DC Probe Measurement onBoard Mini/Microsatellite

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DC Langmuir probe is one of the key instruments to study ionosphere by satellite. It needs a counter electrode whose conductive surface are is at least 1000 times larger than that of surface area of the electrode. This requirement is usually fulfilled for large satellites which have been launched so far for ionosphere study. Now we are jumping into an era to use tiny satellites. Then we will encounter serious problems for DC Langmuir probe measurements. Conductive surface area of the satellite becomes much less than 1000 times, or even equal to the surface area of electrode. As a result, measurement of electron density becomes unreliable, because potential of the electrode with respect to the satellite (counter electrode) cannot reach ambient plasma potential where electron density is calculated. For the worst case, DC Langmuir probe is in double probe region, where the maximum current is controlled by ion current. An electronics needs to measure low current. although to measure the low current is not impossible with low frequency response. Another more serious problem is contamination of electrode as well satellite surface. To avoid the effect of contamination, probe bias of DC Langmuir probe need to be swept with about 10 Hz. These two factors make it possible to use DC Langmuir probe, because to measure low current with high frequency is not possible. We review problems which raises for the ionosphere measurement by small satellite, and propose one solution to avoid these problems to accomplish accurate measurements. The data which have been used here are the contribution of three students, G. S. Jiang, W. H. Chen, and Y. W. Hsu, Plasma and Space Science Center, National Cheng Kung University,Taiwan.

Keywords: microsatellite, Dc Langmuir probe, surface area, contamination

PCG11-02 Room:421 Time:April 28 10:15-10:30

# Canadian Instrument Participation in Japanese Space Science Mission: A Retrospective Look

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Canada has participated in a number of Japanese space science satellite and sounding rocket missions by contributing scientific instruments and participating in related science investigations since the 1980s, including the Akebono (EXOS-D) and Nozomi (Planet-B) satellite and the SS520-2, S520-23, and S520-26 sounding rocket missions. We review the experience of this participation, including the resulting scientific benefits and the lessons learned.

Keywords: space instrument, space plasma, satellite

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PCG11-03 Room:421 Time:April 28 11:00-11:15

# Development of Miniaturized Plasma Wave Receiver using ASIC

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Plasma waves are an important physical phenomenon for understanding the electromagnetic environments in space. The plasma wave receiver is roughly divided into two types: a waveform receiver and a spectrum analyzer. Spectrum analyzer provides the frequency spectrums with low noises and high frequency resolution. On the other hand, waveform receiver provides the waveform. Though the waveform has more noise than the spectrum provided by the spectrum analyzer, only the waveform has phase information of a plasma wave. Thus it play a complementary role. However, these plasma wave receivers occupy a large amount of space because of its analog circuits, so a late scientific satellite has only a kind of plasma wave receiver. We have developed miniaturized waveform capture (WFC), a kind of waveform receiver, and sweep frequency analyzer (SFA), a kind of spectrum analyzer, using ASIC (Application Specific Integrated Circuit). We realized 6ch WFC in a chip of 5 mm x 5 mm. We execute experiment expose this chip to radiation. We find that though radiation influence WFC component, especially switched capacitor filter, our WFC fit for the space radiation environment. The SFA has fine frequency resolution, but its time resolution is poor. We propose a new kind of SFA combined with FFT. It has an improved time resolution without losing time resolution. We have developed analog circuits in the new SFA using ASIC technology. Furthermore, we propose the multipoint plasma wave observation system that consisted of some sensor probes using these miniaturized plasma wave receiver. We plan the sounding rocket experiment for performance test of this sensor probe.

PCG11-04 Room:421 Time:April 28 11:15-11:30

# Development of a wide-field X-ray imaging spectrometer for solar system exploration

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We present our development of a wide-field X-ray imaging spectrometer for solar system exploration. In the past decade or so, various types of X-ray emission have been discovered in the solar system (Bhardwaj et al., 2007, Planet. Space, Sci., Ezoe et al., 2011, Adv. Space, Res.). These X-rays are often associated with energetic particles in planetary magnetosphere and neutrals in planetary atmosphere and cometary coma. Therefore, X-ray observations of solar system objects will lead to better understanding of solar system environments and astrophysical phenomena.

For this purpose, we are developing a wide-field X-ray imaging spectrometer for future exploration missions such as GEO-X (Ezoe et al. 2014, Space Sci. Symposium) and JMO (Sasaki et al. 2011, EPSC-DPS). This instrument is composed of an ultra light-weight X-ray telescope and a low-power radiation-hard semiconductor pixel sensor. The telescope covers a wide field of view of ˜4 deg in diameter in 0.3–2 keV with the angular resolution of $<$5 arcmin. It uses sidewalls of etched holes through thin 4-inch silicon wafers for X-ray mirrors (Ezoe et al., 2010, Mircosys. Tehc.). The detector covers a wide area of ˜20 x 20 mmˆ2 with a ˜300 x 300 umˆ2 pixel. It is an active pixel sensor developed by MPE and PNsensor (Strueder et al., 2010, SPIE). Compared to X-ray CCDs, this type is more radiation hard and allows higher frame time less than 1 ms. This instrument can satisfy stringent resource constraints in the exploration missions. The mass, size, and power are estimated to be ˜10 kg, ˜30 cm cubic, and ˜10 W, respectively. Multiple units of this instrument are considered for GEO-X to achieve a wider field of view, while one unit will meet science requirements of JMO. In this presentation, we will describe design, fabrication, and performance of the instrument components and future prospects.

Keywords: X-ray, imaging spectroscopy, Earth's magnetosphere, Jupiter, Mars

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PCG11-05 Room:421 Time:April 28 11:30-11:45

# ENA Imaging On board the DESTINY Mission

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Energetic Neutral Atom (ENA) imaging is a technique that enables remote imaging of space plasma and neutral clouds. Several current space-borne missions including Cassini, IMAGE, TWINS, Chandrayaan-1, IBEX, and several future missions such as JUICE make use of ENA imaging to investigate magnetospheric plasma acceleration and evolution; structure and acceleration mechanisms in the boundary between the heliosphere and the interstellar medium; and surface and atmosphere interactions (terrestrial upper atmosphere, terrestrial moon, the Galilean moons, and Titan).

Demonstration and Experiment for Space Technology and INterplanetary voYage (DESTINY; See Kawakatsu et al., this conference) is an innovative technology demonstration mission that is being proposed to JAXA with a low-thrust increase of the apogee of an equatorial orbit, followed by a lunar swing-by, and finally an insertion in to a halo orbit around the Sun-Earth L2 point. This trajectory provides a historical opportunity to perform ENA imaging of the two following compelling targets.

- **The terrestrial magnetosphere:** the equatorial vantage point will offer the first compound view of how ions flow out from the polar ionospheres, , plasma stagnation at the sub-solar magnetopause, ion energization in the plasmasheet out to about 20 $R_E$ and the subsequent heating and earthward transport that forms the terrestrial ring current.

- **The boundary between the heliosphere and the interstellar medium:** the NASA/IBEX and Cassini missions have revealed a global pattern and possibly dynamics that are believed to originate from ions charge exchanging in the heliosheath. A multitude of compelling science questions have arisen from the combined analysis of these two data sets that have demonstrated that ENA imaging is perhaps the only tool capable of remotely probing the global structure and acceleration processes in this important region.

The key to observing these targets in a new light that goes beyond previous missions is the ability to image with high angular and energy resolution, with a wide field of view (FOV) that can image large portions of the regions simultaneously. In this presentation we discuss a concept of an ENA camera to perform imaging from DESTINY. The ENA camera design is capable of imaging ENAs in the $\leq$1keV - 100 keV range with an angular resolution down to 2 degrees and an energy resolution down to 20%. The current design has a FOV of 120x90 degrees, which dramatically increases the duty cycle over single-telescope detectors on spinning platforms.

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PCG11-06 Room:421 Time:April 28 11:45-12:00

# A compact, broad-beam, low-energy, LED-based, UV photoelectron source for the calibration of plasma analysers.

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Electrostatic electron analyser instruments are used to make in-situ measurements of space plasmas and are typically designed to detect electrons with energies from a few eV to a few tens of keV. To make optimal use of such instruments, a complete calibration is performed in a laboratory vacuum chamber before flight. An electron source and a moveable stage are used so that the instrument response can be characterised at every relevant electron energy and beam direction. For an ideal calibration, the source should be a uniform, collimated electron beam of controllable energy and flux, which is sufficiently broad in diameter to cover the entrance aperture of the electron analyser instrument being tested.

Various sources are used for such purposes, including radioactive beta-emitters and thermionic emission guns — although the former have fixed flux and are broad-band in energy, and the latter are expensive and produce only a narrow beam with limited energy ranges and limited dynamical control. To produce a broad, uniform, highly-controllable, long-lifetime, monoenergetic beam, UV photoelectron sources are generally preferable. These consist of a UV light source which illuminates a photocathode causing it to release photoelectrons. These electrons, which are released with negligible kinetic energy, are accelerated toward a high transmission grid by an electric field. The source can thus be as wide as the grid and the photocathode, as spatially uniform as the light that falls on the photocathode, and as collimated and monoenergetic as the photocathode and grid are flat and parallel (and thus the E field uniform). The electron flux can be adjusted by adjusting the UV lamp intensity, and the electron energy can be varied by adjusting the strength of the grid-photocathode E-field.

Traditionally the UV photons are created using gas discharge lamps (e.g. mercury, xenon, deuterium), however these typically have poor dynamical control, can create large amounts of background light and are bulky and inefficient. In recent years however, advances in solid-state technologies have enabled increasingly powerful, efficient and affordable LEDs of various UV wavelengths. Accordingly this has enabled compact, low-power, UV-stimulated electron sources that can have intensities that vary between 10 to $10^{-9}$ electrons $cm^{-2}$ $s^{-1}$.

To meet the requirements for calibrating the electron analysers for the SCOPE (cross Scale COupling in Plasma universE) mission, a 9cm beam diameter, UV photoelectron source of this nature has been built and is being tested. Weighing approximately 1.5kg (excluding power supplies) and consisting of rugged, low cost components it can be mounted inside the vacuum chamber with great flexibility, including on a motorised translation stage.

The SCOPE mission requires several FESA (Fast Electron energy Spectrum Analyser) instruments for 10eV to 30keV electrons and several EISA (Electron Ion Spectrum Analyser) instruments for 10eV to 20keV electrons and ions. The first duty of the new electron source is the testing of prototype developments for the EISA instrument: namely measuring the electron transmission properties of carbon foil and assessing the secondary electron emission performance of candidate dynode materials

Keywords: Electron energy analyzer, Plasma spectrometer, Particle source, Ultra-violet photoelectron, Calibration, UV LED

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PCG11-07 Room:421 Time:April 28 12:00-12:15

# Characterization of Exoplanets with High Contrast Instruments

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Small exoplanets in the habitable zone (HZ) have been recently discovered by Kepler spacecraft and by ground-based radial velocity surveys. Now one of most interesting issues in this field is how to characterize them. In this presentation, I review our approaches to develop the instruments of direct imaging for the Thirty Meter Telescope (TMT) and other ground-based telescopes. These instruments aim to detect exoplanets in the HZ around late-type stars. I show that the search for the oxygen 1.27 micron bands as a biomarker is promising with the ground-based direct imaging (Kawahara+12 ApJ). I also show that the combination of extreme adaptive optics and coronaraphs for the direct imaging is also valuable for other characterization of exoplanets, for instance, for detection of exoplanetary molecules in close-in planets.

Keywords: exoplanets, terrestrial planets, direct imaging, biomarker

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PCG11-08 Room:421 Time:April 28 12:15-12:30

# Development of geocoronal Hydrogen Lyman Alpha Imaging CAmera (LAICA)

SATO, Masaki[1*] ; KAMEDA, Shingo[1] ; YOSHIKAWA, Ichiro[2] ; TAGUCHI, Makoto[1] ; FUNASE, Ryu[2] ; KAWAKATSU, Yasuhiro[3]

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Hydrogen and helium atoms are the main constituents of the outermost region of the earth's atmosphere. These atoms resonantly scatter solar ultraviolet radiation causing an ultraviolet glow in this region, called geocorona. Hydrogen Lyman alpha radiation (121.567 nm) is the brightest. To date, various observations of the geocorona have been made. The geocorona comprises three main particle populations: ballistic, escaping, and satellite. Escaping particles are present at all altitudes, and they become particularly dominant at higher altitudes. In previous observations, the geocorona was identified to extend to an altitude of about 20$R_E$. The geocoronal distribution reveals asymmetries from day to night, dawn to dusk, and north to south. Recently, abrupt temporary increases (from 6% to 17%) in the total number of hydrogen atoms in the spherical shell from a geocentric distance of 3$R_E$ to 8$R_E$ have been recorded during several observed geomagnetic storms.

Past exploration of the geocorona has mainly been obtained from earth orbiters. Therefore, several low altitude (~8$R_E$) observations have been made. On the other hand, in order to obtain the geocoronal distribution at high altitude, it is necessary to observe the geocorona from the outside in. However, there have been very few such observations (only Mariner 5, Apollo 16, and Nozomi). Among them, only Apollo 16 obtained an image. However, the observational FOV was about 10$R_E$.

In this study, we are developing a LAICA (geocoronal hydrogen Lyman Alpha Imaging CAmera) which will go onboard the very small deep space explorer PROCYON that will escape the earth and navigate interplanetary space. From such an explorer, our equipment can perform wide FOV (more than 25$R_E$) imaging of the geocoronal distribution. The first observation will be conducted one week after the launch for a period of one or two weeks. Subsequently, observations will continue for about three months. These observations will be conducted in higher temporal resolutions than that obtained from earth orbiters. The prototype of the LAICA has now been manufactured for testing and verification. And the flight model will have been completed by May. This presentation will show the development status.

Keywords: geocorona, Lyman alpha line, exosphere, earth's atmosphere

PCG11-P01 Room:Poster Time:April 28 18:15-19:30

# Effects of finite electrode area ratio on Langmuir probe measurement

CHEN, Wen-hao[1*] ; JIANG, Guo-hsiang[1] ; HSU, Yu-wei[1] ; FANG, Hui-kuan[3] ; OYAMA, Koichiro[2] ; CHENG, Chio[2]

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Langmuir probe(LP) is a widely used instrument for measuring electron density and temperature on satellites and rockets. Recently pico- and nano- satellites have become more popular, when the surface area of satellite is similar to the probe, the effects on LP measurement due to limited satellite surface area need to be considered, and these effects may cause LP measurement inaccurate. We have investigated the effect of satellite surface area, satellite and probe contamination and LP sweeping frequency in laboratory. Also we have found that the satellite and probe voltage will decrease when a large quantity of electrons are attracted by probe voltage and the contamination effect of satellite surface becomes major.

In summary, a solution to these problems is suggested.

Keywords: Langmuir probe, finite electrode area ratio, electrode surface contamination, pico/nano-satellite, electron temperature, electron density

PCG11-P02 Room:Poster Time:April 28 18:15-19:30

# Development of Electron Temperature and Density Probe (TeNeP) for Nano- and Micro-satellites -II

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The nano/micro-satellite becomes popular for the study of near earth environment. To measure the electron temperature ($T_e$) and electron density ($N_e$) in the ionosphere, we have developed the Electron Temperature and Density Probe (TeNeP). The TeNeP measures $T_e$ and $N_e$ based on principles of electron temperature probe (ETP) and planar impedance probe (IP). By combining systems of ETP and IP, $T_e$ and $N_e$ can be measured by one single probe. The TeNeP system has advantages not only as being small, light weighted and low power consumption that fulfills the needs of instruments onboard nano/micro-satellites. It also overcomes problems associated with electrode surface contamination and satellite/probe surface area ratio for DC Langmuir probes.

Keywords: Electron Temperature and Density Probe, nano/micro-satellite, Electron Temperature, Electron Density, electrode surface contamination, satellite/probe area ratio

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PCG11-P03 Room:Poster Time:April 28 18:15-19:30

# Development of the small probe system to measure plasma wave for the sounding rocket experiment

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Plasma filling the space is very rarefied. Ions and electrons in space plasma don't exchange their kinetic energy through their collision but through plasma waves. Hence observing plasma wave is essential for measuring space electromagnetic environment. We propose the multipoint plasma wave observation system that consisted of some sensor probes.

The present paper shows the achievements in designing the small sensor probe system which is dedicated to the sounding rocket experiment. The experiment is performance test of the small sensor probe which measures the standard wave in outer space. The necessary components for the small sensor probe are Li-Ion battery, wireless LAN device, plasma wave receiver, A/D converter, and CPU. All of them should be installed in the cubic body with an edge of 10 cm. Therefore, we chose one-chip microcomputers as wireless LAN device, A/D converter, and CPU. The wave receiver is miniaturized by designing the analog ASIC (Application Specific Integrated Circuit).

The wave receiver has the function of observing electromagnetic waves in the frequency up to 100 kHz and we want to take three-axis data at the same time. So, we should design A/D converter which has three simultaneous sampling and sampling frequency over 200 kHz to fulfill the sampling theorem.

We also designed other necessary systems, such as attitude sensor and wireless communication system with the sounding rocket.

Keywords: Space plasma, Plasama wave, Small sensor probe, Sounding rocket

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# Plasma properties of the space plasma operation chamber at NCKU in Taiwan

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The space plasma operation chamber (SPOC), a research facility designed to calibrate and test satellite/rocket-borne instruments and study space plasma processes, is constructed at NCKU in 2009. It is a cylindrical chamber of 2m in diameter and 3m in length. Plasma is produced by two back-diffusion type sources installed at the center of both chamber sides. The sources produce ions of controllable drifting energy from a few ten to several hundred eV and density up to $10^6$ $cm^{-3}$. These ions are neutralized by thermal electrons emitted from Nickel cathodes, and collide with neutral molecules in the chamber of pressure ˜$2.2\times10^{-4}$ Torr, and a plasma environment with ion temperature ˜300K and electron temperature ˜1000-3000K is formed in the chamber. This paper presents measurement results of a retarding potential analyzer (RPA), an electron temperature and density probe (TeNeP) and a Langmuir probe installed on the 2-axis moving system in SPOC. The thermal and beam component ion energy distributions at different distances from the ion source and the electron temperature/density spatial distributions in the SPOC will be presented. The collision process of ions with neutral molecules will also be discussed.

Keywords: Plasma properties, space plasma operation chamber, back-diffusion plasma source, retarding potential analyzer, electron temperature and density probe, Langmuir probe

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# Construction of a calibration system for developing space-borne particle analyzers

ITO, Fumihiro[1*] ; HIRAHARA, Masafumi[1] ; SHIMOYAMA, Manabu[1] ; HAYASHI, Ayuko[1] ; ISHIGURO, Keisuke[1] ; KOGISO, Shun[1]

[1]Solar-Terrestrial Environment Laboratory, Nagoya University

To study physical phenomena in the terrestrial/planetary ionosphere and magnetosphere, it is essential to consider effects of ionized particles and neutral particles which influence each other. For detailed investigations, in-situ observations by spacecraft are required. So we have been developing space-borne particle analyzers for planetary atmospheres with new technologies. As developing these analyzers, it is necessary to construct an appropriate calibration system for them.

For the calibration, we set the analyzer in a vacuum chamber, and irradiate an ion beam towards it, and investigate its response. We have already been constructing a calibration system (ion beam line) which can irradiate an ion beam of which energy per charge range is from 10keV/charge to 150keV/charge. It is necessary, however, for the system to irradiate a suprathermal ion beam of several tens eV/charge. Particularly the system provides the other species of atomic ion beams: $H^+$, $He^+$, $O^+$, $N^+$, $Ar^+$, over the energy per charge range from 10eV/charge to 10keV/charge in addition to the other species of molecular ions like ${N_2}^+$, ${O_2}^+$, ${CO_2}^+$. We have been constructed a new beam line which can irradiate an ion beam of which energy per charge range is from 10eV/charge to 10keV/charge. Eventually, we will construct a calibration system which can control each beam line integratedly. In this paper, we report the development of the suprathermal ion beam line.

The suprathermal ion beam line is mainly composed of six parts: (a) ion source, (b) electromagnetic ion mass spectrometer, (c) beam expander, (d) main acceleration, (e) vacuum chamber, (f) multi-axial turntable. In the ion source, introduced gases form a gas cylinder are ionized by thermal electrons emitted from filaments. The ionized particles are initially accelerated and discriminated by the electromagnetic ion mass spectrometer. The discriminated ion beam is expanded by electrostatic 2D raster scanning, and is parallelized through the deceleration and acceleration in the beam expander. The ion beam is accelerated or decelerated for the specific energy in the main acceleration. The analyzer is set on the turntable in the chamber. Incident angles of the beam are controlled by changing the elevation and azimuth of the turntable system. We can control the beam property to change parameters: (1) thermal electrons flux and its acceleration voltage, (2) pre-acceleration voltage for ionized particles, (3) strength of the magnetic field of the electromagnet, (4) raster scanning and parallelized electric field for enlarging the beam cross-section uniformly, (5) main acceleration/deceleration voltage, (6) elevation and azimuth of the turntable system. We have also been developing a system which can control them centrally and remotely by using a computer. As interfaces, we use wireless LAN, RS-232, and USB and make programs with LabVIEW. We have added a monitoring and alert system for multipoint vacuum components.

So far, we have constructed the system expect for the turntable system and can irradiate a specific energy beam which is expanded and parallelized sufficiently. We set up a MCP measurement system to measure the beam intensity and cross-section profile. We will present the updated status of calibration system and the beam properties in this paper.

Keywords: calibration system, ion beam line, suprathermal ion beam, particles analyzer, magnetic ion mass spectrometer, remote control

PCG11-P06 Room:Poster Time:April 28 18:15-19:30

# Verification of engineering models of medium energy particle analysers for ERG

KASAHARA, Satoshi[1*] ; ASAMURA, Kazushi[1] ; MITANI, Takefumi[1] ; TAKASHIMA, Takeshi[1] ; HIRAHARA, Masafumi[2] ; SHIMOYAMA, Manabu[2] ; YOKOTA, Shoichiro[1]

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ERG (Exploration of energization and Radiation in Geospace) is a geospace exploration spacecraft, which is planned to be launched in FY2015. The mission goal is to understand the radiation belt dynamics especially during space storms. The key of this mission is the observations of electrons and ions in medium-energy range (10-200 keV), since these particles excite various electromagnetic waves (e.g., EMIC waves, magnetosonic waves, and whistler waves), which are believed to play significant roles in the relativistic electron acceleration and loss. Engineering models (EMs) of medium energy electron analyser and ion mass spectrometer have been developed and their performances and tolerances are tested. We report the results of these verification tests on EMs.

Keywords: Geospace exploration spacecraft ERG, medium energy ion, medium energy electron

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# The results in the initial operation of the Neutral Mass and Velocity Spectrometer (NMS) onboard the CASSIOPE satellite

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We report on the results in the initial operation of the Neutral Mass and Velocity Spectrometer (NMS) instrument that is one of the Enhanced Polar Outflow Probe (e-POP) mission payloads onboard the CASSIOPE satellite. The scientific objective of the e-POP mission is to explore the escape of plasma from the polar ionosphere and the escape of neutral particles from the upper atmosphere and their interactions. The NMS instrument is expected to contribute toward a quantitative understanding of occurrence morphology of neutral particles with non-thermal velocity distributions. Therefore, NMS was developed based on a new principle, which is different from previous satellite-borne neutral mass spectrometers. The NMS instrument has an entrance aperture for incoming neutral particles is perpendicular to the ram direction of the satellite in order to take in neutral particles using the satellite velocity of 7-8 km/s. The NMS instrument consists of three parts: an ionization part, a detection part, and data processing part. The ionization part has an electrostatic thermionic electron gun to ionize the neutral particles by the electron beam. In the detection part, the ionized neutral particles are perpendicularly accelerated by the electric field for the Time of Flight (TOF) mass spectrometry, and the two-dimensional positions are detected with a Microchannel Plate (MCP) and a resistive anode. The two-dimensional position detection provides the relative velocities of neutral particles with a certain mass and the original velocity distribution is derived by subtracting the satellite velocity from the relative velocities.

In the initial operation of the satellite, though the NMS instrument had nothing wrong in the status, it was found that charged particles a few orders of magnitude more than expected were detected if the electron gun was off. At present, we suppose this can be caused by the incident neutral particles ionized by collisions with internal surfaces of the instrument. The influence of the collision in the velocity distribution measurement and the results of the analysis in the routine operation are discussed in this paper.

Keywords: neutral mass spectrometer, atmospheric escape, non-thermal velocity distribution

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# Development and evaluation of the drive system of InSb imager mounted on infrared cameras for Jovian aurora

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In Tohoku University, infrared observation system is being developed for self-owned 60cm telescope. The purpose of this research is to develop a driving system of a Focal Plane Array (FPA) mounted on both an infrared camera and Echelle spectrometer and to evaluate observation possibility for various specific objects by establishing a method to determine adequate operating conditions based on detailed evaluation and analysis of a FPA.

First, from the previous researches, we estimated the required S/N to reveal the variation of some specific Jovian objects. In the case of H3+ aurora, the required S/N and the limit imaging time are 15 and 15s, respectively. For H2 aurora, they are 5 and 1200s. For equatorial temperature field, they are 5 and 7200s. Based on these, we showed the noise indicator, is composed of an upper limit of read noise and leakage current of FPA to realize the required S/N, considering the emission from a telescope and terrestrial atmosphere, and object.

Next, based on the driving mechanism of the FPA: CRC463(Raytheon) used in this research, we revealed that adequate bias is under -3.0V:Vdet, and over -4.0V :Vdduc. In this condition, Full Well(FW) is increased from 0.02V to 0.4V when bias(Vdet-Vdduc) is set at 0.6V, and we succeeded in the imaging of halogen lamp. And, we made improvements as follows.1. Increasing of conductivity of thermal path in the IR camera. This successfully decreased the temperature near FPA from 45K to 20K, resulting in the decrease of both the leakage current from 17,145e/s to 200e/s and the read noise from 453$e_{rms}$ to 320$e_{rms}$.2. Verifying the specific problem on CRC463, and we suggested new driving sequence based on frame to frame control. This resulted in the decrease in the read noise (to 200$e_{rms}$). This made it possible to precisely evaluate the performance of this system.3. Improving bias circuit in FPA driving system. The noise in output was reduced, resulting in the decrease of read noise (to 90$e_{rms}$).

Thanks to the above, it became possible to evaluate the performance parameters of FPA by Photon Transfer Curve method. As the result, in the case of 0.6V bias, DSNU and PRNU were evaluated as 38 ‰ and 16 ‰, respectively. In addition, leakage current, FW and system gain were 200e/s, 133,000e, and 10.9e/DN. We confirmed that the quantum efficiency is 0.85. We also evaluated the NEDT. With a 2.3$\mu$m filter and incident flux of 400K of blackbody, the NEDT reaches 45mK, is the equivalent performance compared to the third generation FPAs. As well, the performance parameters of our system other than the leakage current are equivalent to those of the NASA's IRTF system using the same FPA.

And, we evaluated the bias dependences on FW, leakage current and system gain. Using the results, we established the method to determine the adequate bias setting to realize the maximum S/N for specific object. As a result, following estimations were obtained. Using this FPA driving system, H3+ aurora can be observed at the maximum S/N=30 when the bias and exposure time are set at 0.5V and 15s. In the case of H2 aurora, the maximum S/N is 3.14 after binning, when the bias and imaging time are 0.4V and 1200s, respectively. Obtained S/N is below the requirement. It is needed to decrease leakage current under 81e/s. The case of temperature field, the maximum S/N is 52.7 with accumulating 28times, when total imaging time is 7200s, and the bias is set at 0.4V. To decrease accumulating times, bias should be set at 0.9V. If the leakage current will be under 100e/s, the S/N will be over 40 with an accumulation.

In summary, we developed FPA driving system for IR observation instrument mounted on telescope of Tohoku University for planetary observation. We evaluated the performance in detail, and developed the method to determine the adequate bias conditions for each observational object. Decreasing the leakage current is the remaining issue since it is two orders of magnitude larger than the FPA ' s specification.

Keywords: Focal plane array drive system, IR telescope of Tohoku Univ., long-term observation for planet, NASA IRTF

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# A study for candidate scientific instruments for DESTINY

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DESTINY (Demonstration and Experiment of Space Technology for Interplanetary Voyage) aims to demonstrate new technologies of high energy orbit insertion, large scale ion engine, ultra light-mass solar panel, etc., which will be useful for deep-space mission by Epsilon launch vehicles. DESTINY has possibility to equip scientific mission instruments when system design makes the margin of the resource. DESTINY can conduct scientific observations for a half to one year on the Halo orbit of solar-terrestrial Lagrange 2 (L2) point. If conditions permit, DESTINY will leave L2 Halo orbit, and transfer to the next destination. Potential scientific topics include in-situ observation and remote sensing from L2 for, such as, plasma, energetic particles, and the magnetosphere in the plasma sheet of terrestrial magnetosphere. It 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. It is also valuable to observe ultra-violet and X-ray emission from planetary phenomena. The mass allocated for the instruments is, however, currently estimated as in the range of between a few and ten kilograms. DESTINY will play roles as pilot experiments for these full-scale observations.

Keywords: Epsilon Rocket, DESTINY, Lagrange point

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

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

The baseline mission consists of two spacecraft, i.e. the Mercury Planetary Orbiter (MPO) and the Mercury Magnetospheric Orbiter (MMO). JAXA is responsible for the development and operation of MMO, while ESA is responsible for the development and operation of MPO as well as the launch, transport, and the insertion of two spacecraft into their dedicated orbits.

MMO is designed as a spin-stabilized spacecraft to be placed in a 400 km x 12000 km polar orbit. The spacecraft will accommodate instruments mostly dedicated to the study of the magnetic field, waves, and particles near Mercury. While MPO is designed as a 3-axis stabilized spacecraft to be placed in a 400km x 1500 km polar orbit. Both spacecraft will be in same orbital plane.

Critical Design Review(CDR) for MMO project is completed in November 2011 while ESA Spacecraft CDR is completed in Novemver 2013. MMO stand alone FM AIV is started from September 2012 and expected to be finished on this autumn. MMO FM will be transported to ESA/ESTEC to attend stack level (MCS) final AIV. BepiColombo is expected to be launched in 2016 summer.

10th BepiColombo science working team (SWT) meeting, which discusses science related matters, was held on September 2013 at Lapland. In this paper, we will report the latest information of BepiColommbo MMO project status.

Keywords: Mercury, Planetary Exploration, International Collaboration

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# Magnetic Cleanliness of BepiColombo MMO

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In the terrestrial planets, Earth and Mercury has the intrinsic dipole magnetic field. The Mercury magnetic moment is relatively smaller than that of Earth; the magnetic field intensity on the Mercury surface is about 1 percent of that on the earth surface. Therefore the Mercury magnetospheric condition is significantly affected by the variation in the solar wind, and varies with the short period. The magnetic field around Mercury and its nature has been studied by MESSENGER which was launched by NASA and arrived at Mercury in 2011. However, because the magnetic field around Mercury is summation of the intrinsic and external origin, and MESSENGER always has the perigee in the north hemisphere, the Mercury intrinsic magnetic moment has not been determined accurately. BepiColombo is planed to be launched in 2016 and arrive at Mercury in January 2024. It consists of two satellites, MMO built by JAXA, and MPO by ESA, which will observe together the magnetic field around Mercury. BepiColombo has advantages to determine the accurate magnetic moment, which is one of the major scientific target of the BepiColombo project. The orbit shape is not biased, and the measurement at two locations enables to separate the intrinsic field and the external contribution. For the accurate measurement of the magnetic field, it is very important to suppress the magnetic noise generated by the components installed on the satellite. In the phase of the development of the satellite, the design of the every component was examined not to cause the magnetic noise which would degrade the magnetic field measurement. During the manufacturing period, components were controlled not to be magnetized. The means of the magnetic cleanliness of MMO and the result of the system EMC test, where the magnetic moment of MMO was measured, are reported.

Keywords: Mercury, magnetic field