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

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

Effects of finite electrode area ratio on Langmuir probe measurement

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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

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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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PCG11-P04 Room:Poster Time:April 28 18:15-19:30

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 ~2.2×10^{-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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PCG11-P05 Room:Poster Time:April 28 18:15-19:30

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

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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

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

Verification of engineering models of medium energy particle analysers for ERG

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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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PCG11-P07 Room:Poster Time:April 28 18:15-19:30

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 453e$_{rms}$ to 320e$_{rms}$.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 200e$_{rms}$). 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 90e$_{rms}$).

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 2.3μm 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