Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

PCG14-01 Room:202 Time:May 23 09:00-09:30

Sprint-B/ERG satellite project

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The ERG (Energization and Radiation in Geospace) is a geospace exploration mission in Japan for the solar maximum and subsequent declining phase of solar cycle 24. The mission is especially focusing on the relativistic electron acceleration mechanism in the context of the cross-energy coupling via wave-particle interactions as well as the dynamics of space storms. The interplay among different plasma/particle populations of the inner magnetosphere; plasmasphere, ring current/plasma sheet, and radiation belts is a key to understand the energetic particle accelerations. The cross-regional coupling such as magnetosphere-ionosphere via FAC and the potential electric fields causes the spontaneous variations of the ambient fields.

The ERG project consists of the satellite observation team, the ground-based observation team, and integrated-data analysis/simulation team, as well as the science working team and the project science team. The SPRINT-B/ERG satellite of ISAS/JAXA will be launched into inner magnetosphere in FY2014-2015. The comprehensive instruments for plasma/particles, field and waves are installed in the SPRING-B/ERG satellite to elucidate the electron acceleration processes. The newly developed system will directly measure the flow of the Poynting flux between particles and waves in the wave-particle interactions. In this talk, we will present the current status of the ERG project and possible collaborations with other geospace satellite missions.

Keywords: Small Science Satellite, Geospace Exploration

PCG14-02 Room:202 Time:May 23 09:30-10:00

Development of a Low-Energy Electron Instrument LEP-e for the ERG Mission

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Plasma and Space Science Center (PSSC) at National Cheng Kung University in Taiwan is now developing a low-energy electron instrument for Japan's radiation belts observation mission ERG (Energization and Radiation in Geospace). The instrument consists of an electrostatic energy analyzer with multi-channel plates (MCP) and electronics. The energy analyzer is of the top-hat type, and measures radiation belt electrons from approximately 10 eV to 20 keV. The analyzer's design was studied by numerical particle tracing simulations to achieve good electron measurement performance. The challenge in this development is how to suppress effects due to harsh background radiations in the inner magnetosphere. As a measure against radiation, the analyzer employs 6-mm aluminum shields to reduce radiation penetration to the MCP. Based on GEANT4 radiation simulations with the AE-8/AP-8 radiation model, ~1000 counts/sec of the radiation noise can be received by the MCP. To reduce the radiation effects, a channel is placed for measuring the background noise counts. In the presentation, the electron observation performance and the radiation effects will be discussed.

Keywords: Top-Hat Analyzer, Electron Energy Spectrum, Electron Pitch Angle Distribution, radiation belt

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PCG14-03 Room:202 Time:May 23 10:00-10:15

Performance tests of medium-energy ion mass spectrometer developed for SPRINT-B (ERG)

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We have been developing a medium-energy ion analyser for the radiation belt mission SPRINT-B (ERG). This instrument is comprised of an electrostatic analyser, time-of-flight (TOF) mass spectrometer, and solid state detectors, hence it can measure energy, mass and charge state of 10-180 keV/q ions. It provides the significant information of flux and pitch angle distribution of ring current core components, which is essential for the understanding of the radiation belt dynamics. One of the important issues for particle measurements in the inner magnetosphere is the mitigation of the background noise caused by the radiation belt particles. When the penetrating high-energy electrons (greater than MeV) and protons (greater than 10 MeV) hit detectors in the TOF unit, they produce spurious signals. Secondary particles (electrons and gamma rays) also cause a significant background. Therefore we have designed a TOF unit that is especially suitable for the radiation belt observations in terms of the small detection areas (note that the background count rate is less for the smaller detector areas). Through experiments in a laboratory we have confirmed expected performance on TOF profiles expected from numerical simulations.

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PCG14-04 Room:202 Time:May 23 10:15-10:30

Development of 0.01-25keV/q ion mass spectrometer for inner magnetospheric reserach

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Measurements of plasma partciles with energies lower than 100keV is not easy in the terrestrial magnetosphere, since fluxes of high-energy particles are large. High-energy particles can penetrate through, or kick out the secondary particles when they hit materials. This means they can be detected by a detector inside an instrument without any analysis, namely, noise. We are developping an ion energy-mass spectrometer with energy range of 0.01-25keV/q for terrestrical inner magnetosphere. In order to reduce the noise generated by the high-energy particles, we apply a time-of-flight (TOF) technique. In addition, we try to minimize size of the detector.

We will discuss how an instrument in the current design can survive under severe environment like terrestrial inner magnetosphere.

Keywords: plasma particle instrument, terrestrial inner magnetosphere, ERG

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PCG14-05 Room:202 Time:May 23 10:45-11:15

The ESA-led JUpiter ICy moon Explorer mission: a sophisticated instrumentation in an intense radiation environment

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The JUICE (Jupiter ICy moon Explorer) mission is one of the three candidates for the first ESA Cosmic Vision 2015/2025 L-class mission slot, with a foreseen launch in 2022. The final selection will be known in April 2012. JUICE will carry out an in-depth study of the Jovian system and its four largest satellites, with particular emphasis on Ganymede and Europa. It will conduct unprecedented detailed studies of Jupiter and its magnetosphere, the diversity of the Galilean satellites, the physical characteristics, composition and geology of their surfaces. A model payload of 11 instruments addressing most of JUICE science goals has been studied for the spacecraft. The studied model payload consists of a remote sensing package, a geophysical package, and an in situ package. We will first review the mission science objectives and enabling instrumentation. We will then make use of the charged particle package in order to illustrate some of the main mission challenges related to the intense radiation environment of Jupiter.

Keywords: Jupiter, instrumentation, mission, radiation, particle package

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PCG14-06 Room:202 Time:May 23 11:15-11:30

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 Nov. 2011. While CDR for ESA BepiColombo project is expected to be held on July 2012.

Electrical Interface Check (EIC)/ Mechanical Interface Check (MIC) for MMO has been completed in Jan. 2012. Environmental test and final calibration for each instrument will be performed before the Flight Model (FM) AIV. MMO stand alone FM AIV is scheduled from June 2012. MMO Mechanical Test Model(MTM) has been transported to ESA/ESTEC on Nov. 2011 and wait for the stack (MCS) level mechanical test which will be held on this year.

6th BepiColombo science working team (SWT) meeting, which discusses science related matters, was held on Sep. 2011. In this paper, we will report the latest information of MMO project status.

Keywords: Mercury, Planetary Exploration, International Collaboration

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PCG14-07 Room:202 Time:May 23 11:30-11:45

Space Experiment on Interaction between High Power Microwave and Ionospheric Plasma for Solar Power Satellite

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The Space Solar Power System (SSPS) which converts solar energy into electricity in space, and transmits energy using microwave from space to the ground is a promising candidate for a clean and sustainable energy system. The first solar power satellite (SPS) concept was proposed by Dr. P.E.Glaser in 1968. R & D activities on the SPS have been carried out in US, Japan and Europe. Some key technologies require space experiments in order to realize the SPS. Especially, Wireless power transmission (WPT) is inherent technology of the SPS, and WPT demonstrations on the ground and in space have been performed in Japan. Two rocket experiments, MINIX in 1983 and ISY-METS in 1993 were performed by Kyoto University and ISAS in order to study nonlinear interactions of the high power microwave in the space plasma environment and to demonstrate microwave power transmission. However higher-accuracy evaluation of the effect of the microwave against the ionospheric region is required because the experiments of the sounding rocket are limited in time and mass resources. Microwaves interact with ionospheric plasma. Plasma density gradient and its variation will results the phase shift of the microwave and degradation of the accuracy of the microwave beam pointing. Also, injection of the high power microwave into plasma will cause a change in plasma distribution of ionospheric region or a plasma hole that will affect on communications. There are some interaction mechanism between ionospheric plasma and high power microwave. Plasma heating by the microwave will cause a decreasing of the plasma density and thermal self focusing of the microwave beam. Several potential non-linear interactions between ionosphere and microwave have been identified. These include parametric instability excitation, electron thermal runaway in the lower ionosphere and thermal self-focusing of the microwave beam by the ponderomotive force. Microwave power density around ionospheric region is designed around several hundred W/m2 for the future commercial base SPS. These effects should be confirmed by the space experiments. We are considering a space experiment on the WPT from space to the ground and on the interaction between high power microwave and ionospheric plasma using a small scientific satellite. The total microwave power radiated from the power transmission panel is 0.95 kW for a single antenna panel configuration. This level of microwave power injection will generate a power density above 1000 W/m2 within 50 m, and 100 W/m2 within 100 m in the ionosphere. Effects of interaction between high power microwaves and plasma in ionosphere can be measured. We plan to measure the electron temperature, the electron density and excited waves under the microwave irradiated conditions using plasma probes, wave receiver or some observation equipments. We would like to discuss the on-board instrumentations for the plasma and waves measurement in ionosphere.

Keywords: Solar Power Satellite, Microwave, WPT, plasma, ionosphere

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PCG14-08 Room:202 Time:May 23 11:45-12:00

Development of High Resolution Magnetometers for Space Plasma Study at SPDL

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Space plasma has the unique property of being highly collisionless and thus conducting. As a result, the magnetic field is highly perturbed due to the complex motion of charged particles. Measurement of high resolution magnetic field is very important for providing information on the physics of small spatial and temporal scales of collective plasma which cannot be achieved by particle instruments. Satellite Payload Development Laboratory (SPDL) at National Central University was founded in 2002 with the goal of developing high resolution space instruments for in-situ exploration and study of magnetspheric and collisionless space plasma by space science major students. In this talk we present the achievement and recent progress on the development of high resolution magnetometers by the efforts of SPDL members.

Keywords: Magnetometer, Space Plasma

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PCG14-09 Room:202 Time:May 23 13:45-14:15

Tiny magnetic field measurement system onboard satellites by using an ASIC chip

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Scientific instruments for space applications are required to reduce their resource requirements, such as volume, mass and power while at the same time achieving at least the same performance as conventional instruments. So it is important that especially the instrument front ends and readout units undergo miniaturization.

A front-end ASIC (Application Specific Integrated Circuit) for magnetic field sensors based on the fluxgate principle (Magnetometer Front-end ASIC, MFA) has been developed that reduces the required power for the active readout electronics by a factor of 10 as well as the area needed on a printed circuit board by a factor of 3-4 compared to magnetic field instruments e.g. aboard Venus Express (ESA).

The concept of the MFA is based on a combination of the readout electronics of a conventional fluxgate magnetometer with the control loop of a delta-sigma modulator in order to get an optimized signal-to-noise ratio with a reasonable oversampling factor. The analog part of the MFA contains altogether four 2-2 cascaded sigma-delta modulators. Three of those modulators are having the fluxgate sensor in their control loops for a direct analog-to-digital conversion of the sensor output. The fourth modulator is unmodified and connected to the output of an eight-to-one multiplexer for housekeeping measurements (e.g. temperatures of MFA and fluxgate sensor). The single-bit outputs of the cascaded modulators are processed by a digital tuning logic for generating a fourth-order noise shaped and digitized output signal. The digital part includes primary (128Hz output) and secondary decimation filter stages (2, 4, 8, to 128Hz output) as well as a serial synchronous interface (data are transmitted with 24 bit resolution). The chip area (0.35um CMOS from austriamicrosystems) is about 20mm^2 and the total power consumption is 60mW (drive power for the fluxgate sensor is not included).

The achieved performance and radiation robustness can be summarized with THD $>$ 95dB, SNDR in field mode $>$ 85dB, offset stability $<$ 10pT/degC and $<$ 0.2nT/100h and TID $>$ 300krad. A first space magnetometer equipped with the MFA will fly aboard a 4-satellite NASA mission called Magnetospheric Multiscale (launch in 2014).

Keywords: Magnetometer, Miniaturization, Fluxgate, Magnetic Field

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PCG14-10 Room:202 Time:May 23 14:15-14:30

Development of Miniaturized Plasma Wave Receiver using analog ASIC

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Since space is filled with collisionless plasmas, kinetic energies of plasma particles are exchanged via electric and magnetic fields, so-called plasma waves. The plasma waves have been observed a number of scientific spacecraft with plasma wave receivers. The plasma wave receivers are classified into two types, spectrum receivers, and waveform receivers. The spectrum receivers provide an overview of physical processes in which the plasma waves are excited, grown, and dissipated. The waveform receivers give not only amplitude but also phase of the plasma waves. Phase information between the plasma waves and plasma particle is essential in wave-particle interactions. It is important for understanding physical processes to combine both kinds of data of spectra and waveforms. Since the plasma waves have various intensities in wide-band frequency range, from DC to tens of MHz, the onboard instruments for the plasma wave observation are required to have low noise, high sensitivity, and wide dynamic range in wide-band. The required performances lead to increase the weight budget of the analog part of the instrument since discrete electronics devices and integrated circuits are usually used to implement the instruments. We have developed dedicated chip which can drastically decrease weight budget of the plasma wave instruments for multi-point observation and deep space exploration missions. It is also significant that manufacturing a number of instruments with the same performance becomes easy. In this paper, we demonstrate the miniaturized plasma wave receiver using ASIC (Application Specific Integrated Circuit) technology. The ASIC is a LSI (Large Scale Integrated circuit) for a particular purpose, is commonly developed for a consumer electronics products. For the spectrum receiver, we develop a double super heterodyne receiver, so-called ”Sweep Frequency Analyzer (SFA).” This SFA is improved in the time resolution with keeping good frequency resolution by combining the analog frequency conversion and FFT. The SFA consists of an amplifier, a frequency synthesizer, mixers and band-pass filters. These component circuits are fabricated in chips and their performances are tested. The waveform receiver generally consists of the band-limiting filter, the amplifier, the anti-aliasing filter, and the A/D converter. The developed chip contains these circuits except for the A/D converter, and has six-channel to observe full components of the electric and magnetic fields waves. The chip is connected to A/D converters, a clock generator, and power circuits on the PCB. The sampling frequency is 400 kHz, and the dynamic range of the A/D conversion is 14 bits. The total dimension of the PCB containing waveform receiver chip is 50 mm by 90 mm, similar size of a business-card. By the development of the dedicated chip, the weight per channel of the waveform receiver declines to a tenth of the NOZOMI LFA, which was the onboard instrument of the pas Japanese scientific spacecraft.

Keywords: Plasma Wave, Downsizing, Integrated Circuit, ASIC, Sweep Frequency Analyzer, Waveform Capture

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PCG14-11 Room:202 Time:May 23 14:30-14:45

LED mini lidar for Planetary Exploration

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Dust exists universally in space. Especially, it plays an important role in discussing the evolutions of solid bodies. For instance, it is considered that dusts exist on the surfaces of and around the asteroids, and the existence reflects the surface evolution. Although it is considered that dusts on the asteroid surfaces are horizontally transported by the electric fields formed with electrification by the sunlight, and a similar transport mechanism may also occur on the lunar surface, details are unclear. The hypervelocity dust particles can be detected with conventional dust monitors utilizing the phenomenon like the impact ionization, while levitating dusts are hardly detected with the original place observation. Hence, we are studying a lidar for the observation of levitating dusts that have low velocities. Normally, pulse laser for light transmission source are used, however, we consider using light emitting diode (LED) for it. The benefit of LED is easy handling, for instance, it is strong against serge, and the driver's composition is simple. Hence, the entire lidar instrument can be miniaturized by using LED, LED mini lidar. Lidar was a part of the meteorological observation station onboard to Mars lander Phoenix. LED mini lidar can be utilized for such a mission. Moreover, because LED light has a lot of diversities of the wavelength of luminescence, for instance, it is relatively easy to probe a certain particular atmospheric constituent by using as difference absorption lidar. In this paper, we describe our study on LED mini lidar for planetary exploration.

Keywords: LED, LIDAR, Planetary Exploration, compact, dust observation

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PCG14-12 Room:202 Time:May 23 14:45-15:00

The Development of the Miniaturized Antenna Impedance Measurement System using ASIC

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Space is filled with plasmas. Since space plasmas are essentially collisionless, plasma wave is one of the most essential physical quantities in the solar terrestrial physics. There are two kinds of plasma wave receivers, the sweep frequency analyzer and the waveform capture. While the sweep frequency analyzer provides plasma wave spectra, the waveform capture provides waveforms of plasma waves with wave phase information. Electric field sensors in plasmas show different features from in vacuum. Since plasma is a dispersive medium, the antenna impedances are various complex numbers in the frequency domain. Consequently, in order to calibrate the observed plasma wave data we have to measure not only the antenna impedances but also the transfer functions of plasma wave receiver's circuits precisely. The impedances of the electric field antennas are affected by surrounding plasma density and temperature. However, these states of plasmas change from moment to moment. Thus, we precisely should measure the antenna impedances onboard spacecraft and convert the observed waveform data into the calibrated data. On the contrary, we can obtain the plasma density and temperature from the antenna impedances.

Various systems for measuring the antenna impedance were proposed. A synchronous detection method is used on the Bepi-Colombo Mercury Magnetospheric Orbiter (MMO), which will be launched in 2014. MMO has the onboard digital synthesizer, as a signal source. The synthesized waveforms are fed to the preamplifiers of electric field sensors through a fixed resistor after the D/A conversion.

We can obtain a transfer function of the circuit by applying the synchronous detection method using output waveform, and digitalized signal source. This system is also useful to check the behavior of the waveform capture receiver. The size of this system is same as an A5 board. In recent years, Application Specific Integrated Circuit (ASIC) is in attention which is a technique to integrate large scale and complicated circuits. Lots of ASICs have been applied to high energy astrophysics, though there are few applications in the solar terrestrial physics.

In this paper, we present our attempt to miniaturize the antennas impedances measurement system and Waveform Capture. We design 8bits segment D/A converter synchronized with waveform captures. We improve input logic of the D/A converter to generate a very weak signal accurately.

Keywords: Miniaturized satellite, Plasma wave reciever, Analogue ASIC

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PCG14-13 Room:202 Time:May 23 15:00-15:15

Flight verification and performance of a discrete MCP anode with ASIC

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Recently, time resolution of the low energy charged particle measurement is becoming higher and higher. There exist several development items to realize high time resolution measurements including development of a charged particle detector. Most of the recent satellite-borne instrumentation for low energy charged particle (eV/q - 10s keV/q) measurement adopts top-hat type electrostatic analyzers [Carlson et al., 1983, Young et al., 1988]. Since the top-hat type electrostatic analyzers have wide field of view of 360deg. with uniform transmission characteristics, they are suitable for low energy charged particle measurement by spin-stabilized spacecraft. Using top ?hat type electrostatic analyzers, one dimensional circular position sensing is necessary in order to determine the incident particle direction. For this purpose, a detector with MCP (Micro Channel Plate) and anode that collects the multiplied charged particles has been widely used. There are several types of one-dimensional circular position sensing anode. For the high time resolution measurements, the anode has to measure high enough count rates in order to keep good statistics for short sampling time. The most appropriate anode for the high time resolution measurements is discrete anode where different anodes are used for different positions and each anode has its own amplifiers. Although discrete anode has been widely used, the problem is that the required power and the size of the electronics circuit become unacceptably large for the satellite borne instruments when the higher position sensing resolution is necessary. In order to solve this problem, an MCP anode with ASIC has been developed [Saito M. et al., AIP Conf. Proc. 1144, 48 (2009), DOI:10.1063/1.3169303]. In order to use the anode for sounding rockets and satellites, it should be lightweight and low power consumption. The anode should survive the vibration / shock during the launch, wide temperature variation and radiation. We have decided to adopt the anode configuration that discrete anode is formed on 1mm ceramic substrate, and the bare ASIC chip is installed on the backside of the ceramic. It has been turned out that the S/N performance is very good since the amplifier is very near to the anode. Whole ceramic substrate except discrete anode pattern that collect electrons is parylene coated in order to protect the ASIC and the bonding wires from humidity and (metal) dusts. So far, we have performed radiation test including total dose and single event latch up, thermal cycle test between -40deg. and 85deg. It is found that the anode can detect count rate of 25MHz/channel. The anode has been successfully flight verified by two Norwegian sounding rocket experiments ICI-2 and ICI-3 (Launched from Ny Alesund, Svalbard, Norway in Dec. 2008 and 2011). In the near future, this anode will be used for detecting low energy ions with Mercury Ion Analyzer (MIA) on BepiColombo/MMO. The ASIC chip and its implementation will be widely used for the future missions that require lightweight low power consumption, high time resolution charged particle measurements.

Keywords: charged particle, detector, ASIC, MCP anode

PCG14-14 Room:202 Time:May 23 15:30-15:45

Development of small-sized radio sensor for future Jovian mission

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Future Jovian mission is now planned for 2020s. One of its major objectives is the investigation of electromagnetic system connected and drived by Jupiter. Under the international collaborations, we have started the development for the small-sized radio sensor for this mission from 2011. We succeeded to establish the base technical elements for (1) light-weight rigid antenna with simple and reliable extension capability and (2) small-sized radiation-hard preamp with the highest sensitivity.

In any missions related to plasmas, electric field from DC to several 10s MHz has contributed to the remote-sensing and in-situ studies of dynamics and energetic interactions in the electromagnetic system, associated with remote optical measurements and in-situ particle and magnetic field sensors.

For the Jovian project, Euro-USA-Japan joint team is formed for the plasma and radio wave studies. Especially in Jupiter, it is important as a remote sensing tool for the direct measurement of Jovian radio source regions distributing around the Jovian system, i.e., polar region, radiation belts, Io torus system, and several satellites with thin atmospheres like Io, Europa, Ganymede, and Calisto. We are involved for this topic, based on the Plasma Wave Investigation (PWI) aboard the BepiColombo/MMO, and started the small-sized radio sensor package with antenna and preamp within the tightest resource limitations.

In 2011, we investigated base technologies for (1) a 3-axial antenna with 2m length, extracting at the Earth orbit and can be kept along the long travel to the orbit around Galilean satellites, and (2) a 3-axial preamp covering 10 kHz - 50 MHz with highest sensitivity, enough radiation tolerance in Jovian environment (the hardest in the solar system), within the mass limit less than 200g, and

For the former, we established the simple extension mechanism based on the self-extracting thin metal element, which is based on the combination of the SCOPE Z-axis antenna (STEM-type extension mechanism but with a complex motor system) and the sounding rocket antenna (self-extraction antenna but limited within 1m extension length). For the latter, under the collaboration with the IRF Uppsala (Sweden) team, we established the key parts of the radiation-hard analogue custom IC technologies, in which the most difficult part was a relay in the package with high-impedance, small-sized, and high-reliability enough. In parallel, we also tested the high-sensitivity preamp BBM under the radiation hard condition, and proved that even in 200 krad the degradation of the noise level is only the twice, without critical linearity and sensitivity damages. In 2012, we will proceed to the next phase.

These small but reliable extension mechanism and electronics are not so much expensive. Therefore, we consider to apply them to sounding rocket experiments. It can be also adopted to any space and planetary missions in which the resource is very tight.

Keywords: electric field, plasma wave, radio wave, antenna, sensor, Jupiter

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Means to avoid the contamination effect of Langmuir probe measurement for ionosphere studies

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Some scientists are still not aware of the serious effect of electrode contamination in Langmuir probe experiments in space, or they do not take any action for that even though they are aware of the seriousness. We stress here that one should pay extra small attention to the electrode contamination to get accurate and reliable parameters, by which the long time effort for sounding rocket/satellite mission does not end in vain. In this paper we describe two main features of voltage-current characteristic curves associated with contaminated Langmuir probe, which are predicted from equivalent circuit model which we proposed in 1970's. We then show that that fast sweep DC Langmuir probe can give reliable result in steady state regime. The first sweep probe can also give a reliable result in transient situation such as the passing through plasma bubble in the ionosphere where electron density suddenly changes, after the several sweep cycle of the probe voltage. This fact is first confirmed through Laboratory experiment.

Keywords: Ionosphere, Surface contamination, Langmuir Probe