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

PCG14-P01 Room:Convention Hall Time:May 23 17:15-18:30

Development of the ASIC for fluxgate magnetometers onboard space exploration satellites

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Fluxgate magnetometers have many advantages, good accuracy, small-size, lightweight, and low-power consumption. Therefore they have been most often used for space science missions to measure the earth, planetary and interplanetary magnetic fields. Recently it is required to further reduce the resources of the scientific instruments for space missions keeping the high performance levels of conventional instruments.

To realize a miniaturized and low-power fluxgate magnetometer, an analog Application Specific Integrated Circuit(ASIC 0.5 micrometer process) for the signal processing has been developed. Our newly designed magnetometer consists of the analog ASIC part and the digital processing part. The digital processing part was already developed and realized by sounding rocket experiments(S-310-38 and S-310-40).

In our presentation, we focus on the results of the ASIC design. The ASIC contains two channels and the single channel contains an amplifier and a band-pass filter. The gain of the amplifier is variable (2, 3, ... ,10 times) by the external signals given to the ASIC. The band-pass filter is the second-order Butterworth filter and the center frequency is adjusted to 22 kHz, the frequency of the pickup signal of the fluxgate magnetometer. The dimension of the ASIC is 5 mm by 5 mm. The performance and the temperature dependence of the designed circuit were evaluated by the circuit simulator. The power consumption is about 5 mW(5.0 V, 1 mA). The output dynamic range is 0.24 F.S.(corresponding to 1.2 V). The frequency characteristic of the band-pass filter satisfies the requirement. The noise density in the output signal is less than 600 $nV/Hz^{1/2}$ @ 1 Hz(corresponding to 2 $pT/Hz^{1/2}$) in the temperature range between -30 degrees C and 50 degrees C. The simulation results indicated that the overall performance of the designed ASIC satisfies the requirements.

Keywords: fluxgate magnetometer, ASIC, digital-type, amplifier, band-pass filter

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Statistical evaluation of the fluctuation of the WPIA analysis

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”Wave-Particle Interaction Analyzer (WPIA)” is a new type instrument proposed by Fukuhara et al. (Earth Planets Space, 2009) for the measurement of interactions between plasma waves and energetic electrons directly and quantitatively in space plasmas. In the WPIA, we use the wave vector and each velocity vector of plasma particles respectively measured by wave and particle instruments onboard a spacecraft. One of the methods of the WPIA measurement is the evaluation of the summation of qE dot v, corresponding to the Joule heat, where E, v and q are the electric field, the velocity and charge of plasma particles, respectively. The WPIA has a capability of the direct measurement of the phase relation between waves and particles which cannot be obtained by conventional particle measurements and data processing. The WPIA will be installed in the ERG satellite (Energization and Radiation in Geospace). In the ERG mission, one of the prime target is resonant interactions of energetic electrons and whistler-mode chorus emissions. In this study, we discuss about the feasibility and capability of the method of WPIA measurement based on the results of WPIA analysis of the simulations of whistler-mode chorus emissions.

Keywords: Wave-Particle Interaction Analyzer (WPIA), wave-particle interaction, whistler-mode chorus emission, radiation belts, ERG

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PCG14-P03 Room:Convention Hall Time:May 23 17:15-18:30

Development of white-noise-applied impedance probe for high resolution electron density measurements in the ionosphere

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Impedance probe is an instrument for electron number density measurements by using frequency dependence of the capacitance of the probe antenna extended into the space plasma. Due to its high accuracy and independency from probe shapes and plasma conditions, it has been installed on numerous sounding rockets and provided vertical profiles of electron number density in the ionosphere. The spatial resolution of the current impedance probe system, 100 m, is determined by the sweep period of frequency of the local signal applied to the AC bridge. On the other hand, the spatial scale of the field aligned irregularity (FAI) in the ionosphere, which has been observed by the radars on the ground, is several meters. Therefore, those phenomena can not be observed by the current impedance probe system. In order to solve the problem, we are now planning the development of a new impedance probe system which uses white noise instead of the swept-frequency signal. The results of preliminary plasma chamber experiment and development plan will be shown in the presentation.

Keywords: Impedance probe, Electron number density, Field aligned instability (FAI)

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PCG14-P04 Room:Convention Hall Time:May 23 17:15-18:30

Development of Electron Temperature and Density Probe(TeNeP)

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To prepare for the near future satellite missions, we propose to develop a new instrument ? the Electron Temperature and Density Probe (TeNeP) and conduct its test and calibration in the Space Plasma Operation Chamber (SPOC, 2m in diameter and 3m in length) of the Plasma and Space Science Center, National Cheng Kung University (PSSC/NCKU). PSSC/NCKU has completed the development and test of an Electron Temperature Probe (ETP) to measure the electron temperature and an Impedance Probe (IP) to measure the electron density for deployment in the observation in the ionosphere. Because the ETP and the IP make use of the same electrodes and similar electronics, we develop a new Electron Temperature and Density Probe (TeNeP)by combining the design and function of the Electron Temperature Probe and the Impedance Probe. The TeNeP can measure the electron temperature and electron density successively in the satellite altitude below 3000 km.

Keywords: Small satellite, Ionosphere, Electron density, Electron temperature

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Reciprocal contamination between electrons, protons and alphas in the radiation belts: Akebono RDM and Geant4 simulation

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The Japanese semi-polar orbiting satellite Akebono (EXOS-D), launched in February 1989, has observed the space environment at altitudes of several thousands km. The radiation monitor (RDM) onboard Akebono gives data of energetic particles in the Earth's radiation belt for twice solar cycles. The data from RDM are for electrons in three energy channels of $>$ 2.5, 0.95-2.5, 0.3-0.95 MeV, protons in three energy channels of 30-38, 15-30, 6.4-15 MeV, and alpha particles in one energy channel of 15-45 MeV [Takagi et al., IEEE 1993]. These energy ranges are however based on information of about 20 years ago so that the data seem to include some errors. In addition, these data include contamination of electrons and protons reciprocally. Actuary it is noticed that the electron data are contaminated by the solar protons but unknown quantitative amount of the contamination. Therefore we need data calibration in order to correct the energy ranges and to remove data contamination.

We examine the RDM instrument using the Geant4 simulation. Geant4 gives information of trajectories of incident and secondary particles whose are interacted with materials. It is confirmed from the results that electrons showed extremely complex trajectories caused by material interactions in the instrument. Some electrons are scattered in the shading material (Al) and the primary detector element (Si) before arriving the main detector elements of the instrument. Our simulation moreover confirms that signals of proton incidence appear in the electron and alpha channels. The results of the simulation successfully show reciprocal contaminations that electron contaminates onto the proton channels and proton contaminates onto the electron and alpha channels of the RDM detector.

It has been known that the solar protons enter the magnetosphere at high latitudes. Actuary the RDM instrument detects the solar flare particles often at high L values of $>$ 8. We compare the RDM data modified by Geant4 with the solar flare particle data provided by the OMNI web database. It is found from the investigation of the solar energetic particle events from 1989 to 1999 that the solar helium of a few ten MeV can enter to the inner magnetosphere of L ˜ 3 during the geomagnetic storms. In the inner radiation belt (L $<$ 2), the electron data are significantly contaminated by protons $>$ 40 MeV.

Keywords: radiation belts, high energy particles, particle detector, Geant4, solar energetic particles

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Atmospheric Neutral Analyzer for neutral mass composition and velocity measurement in the upper atmosphere

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Atmospheric Neutral Analyzer for neutral mass composition and velocity measurement in the upper atmosphere

Manabu Shimoyama, Andrew W. Yau, Masafumi Hirahara

In order to understand the variability of the ionosphere-thermosphere system, in-situ measurements of the composition and density of the neutral atmosphere and the detailed velocity distribution of individual species are required. However, most conventional types of instruments for neutral atmosphere lack the simultaneous capability of measuring neutral atmospheric velocity and resolving neutral mass.

We are designing the Atmospheric Neutral Analyzer (ANA) instrument to measure neutral composition and velocity distribution simultaneously in the thermosphere. It is designed to measure the detailed, mass-resolved 2 dimensional velocity distribution of thermospheric neutral species, and to derive the corresponding density, mass composition, velocity and temperature from the measured distribution.

The ANA is comprised of 4 sections; Entrance Aperture (EA), Ion Accelerator (IA), Radio-Frequency Ion Mass Analyser (MA) and Imaging Particle Detector (PD). The EA consists of a planar aperture slit and deflection electrode, and functions as an incident-particle selector and collimator. A small fraction of the neutral particles is ionized by electron beam. The IA acts as a particle energy selector by accelerating the ionized particles. The RF acts as an ion velocity selector. The RF voltage is applied to grids and selectively accelerate ions of matching speed. As a result, ions with a particular mass-per-charge are selected. The PD, which is comprised of a retarding grid, micro-channel plate and charge coupled device, acts as a detector of the selected ions and a two dimensional velocity imager.

We present the concept and the detailed design of the ANA.

Keywords: wind measurement, temperature measurement, mass analysis, thermosphre-ionosphere coupling

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PCG14-P07 Room:Convention Hall Time:May 23 17:15-18:30

Spaceborne multi-turn time-of-flight mass spectrometer for isotope analysis

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In situ low-energy ion measurement in terrestrial or planetary plasma environment has been done with a variety of ion analyzers. Detailed studies of plasma characteristics demand not only energy analysis but also mass analysis. When measuring a variety of ions originating from planetary atmospheres, we need to be able to measure the ion composition with high mass resolution. As we achieve the measurements of the ion composition by mass analyzers around planetary environment, higher mass resolution is needed in order to distinguish heavy species and isotopes. For the future isotope measurements around moons, planets and asteroids, we are developing a high-mass-resolution mass analyzer. One of our scientific objects is to measure the Martian atmospheric escape and evolution. Although mass resolution (m/dm) of 100 is generally needed for the isotope analysis of planetary particles, the Martian atmospheric escape and evolution science requires m/dm>3,000 to discriminate N2 from CO.

ISAS particle measurement group has developed a time-of-flight(TOF) ion mass analyzer with mass resolution of about 20 for KAGUYA, which succeeded in measuring ions originating from the lunar exosphere and surface. It is also preparing a TOF mass analyzer with mass resolution of 40 for the BepiColombo mission. Multi-turn TOF mass spectrometers(MULTUM), where ions are stored in a fixed orbit within electrostatic sectors and allowed to propagate the same orbit numerous times, have been developed by Osaka Univ. mass spectrometry group. One of the MULTUM series achieves the mass resolution over 30000 with the size of 20cm x 20cm. Our isotope analyzer in development for the future planetary mission employs the MULTUM system. We will show the spaceborne MULTUM analyzer and report the development schedule.

Keywords: mass analysis, isotope analysis, MULTUM

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Numerical model and calibration experiment on the sensor characteristics of MIA/MMO

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The Mercury Ion Analyzer (MIA) is one of the plasma instruments on board the Mercury Magnetospheric Orbitor (MMO). and measures the three dimensional velocity distribution of low-energy ions (5 eV to 30 keV) by using a top-hat electrostatic analyzer for half a spin period (2 sec). By combining both the mechanical and electrostatic sensitivity controls, MIA has a wide dynamic range of count rates for proton flux expected around Mercury, in the the solar wind between 0.3 and 0.5 AU from the sun and in the plasma sheet of Mercury's magnetopshere. In this presentation, we discuss the sensor characteristics from both model calculations and calibration experiment of the flight model.

Keywords: MMO, Mercury, solar wind

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The evaluation of the contamination on the EUV reflectance for the SPRINT-A/EXCEED mission

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An Earth-orbiting small satellite 'EXtreme ultraviolet spectrosCope for ExosphEric Dynamics' (EXCEED) which will be launched in 2013 is now under development. EXCEED will observe the atmosphere and plasmas around various planets in our solar system. The optical instrument consists of entrance mirror, grating and microchannel plates. For this mission, it is essential that the detection efficiency must be very high in order to detect the faint signals from targets.

In extreme ultraviolet spectral range, the mirror reflectivity is easily degraded by the molecular contamination. Therefore, it is very important to evaluate the effects of the contamination on the mirror.

In this study, we prepared the mirrors contaminated by some materials that would be used in EXCEED instrument. Then, we have compared the reflectivities of those mirrors for EUV for both before and after contamination. In this presentation, we report those results.

Keywords: contamination, extreme ultraviolet

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Airglow observation mission with a visible spectrometer IMAP/VISI on ISS: Current status for the launch

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The ISS-IMAP mission is one of the Japanese Experiment Module (JEM) 2nd stage plan which will be launched in the summer of 2012 onto the International Space Station (ISS) with HTV (Konotori) We completed the development and manufacturing of a visible imaging spectrometer instrument (VISI) for this mission. VISI will measure to measure three nightglow emissions; O (630 nm, altitude 250 km), OH Meinel band (730 nm, altitude 87km), and O2 (0-0) atmospheric band (762 nm, altitude 95 km) with the two field-o-views which enable us to make a stereoscopic measurement of the airglows looking forward (+45 deg.) and backward (-45 deg.) to subtract contaminations from clouds and ground structures. We designed a bright (F/0.9), wide-angle (field-of-view 90 degrees) objective lens. VISI have a two-line-slit on the first focal plane to perform the stereoscopic measurement. Each slit, i.e., field-of-view, is faced perpendicular to the orbital plane, and its width is about 550 km mapping to an altitude of 100 km. We will obtain a continuous line-scanning image for all emissions line from + 51 deg to -51 deg. in geographic latitude by the successive exposure cycle with a time interval of 1 - several sec.

We carried out so far the optical test including the adjustment of focus and alignment, intensity calibration, function check, vibration and vacuum thermal tests. We also performed the system integration test on the Multi-mission Consolidated Equipment (MCE). In this February, MCE will be mounted on the H-IIB rocket at the Tanegashima Space Center of JAXA. We present the development of VISI, and the current status for the launch in this summer.

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Ultra-high resolution observations of planetary atmospheres using Mid-Infrared LAser Heterodyne Instrument (MILAHI)

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We have developed a ultra-high spectral resolution spectrometer, called Mid-Infrared LAser Heterodyne Instrument (MILAHI). It is for the applications to astronomy and planetary atmospheric science in 7-11 um wavelength at a spectral resolution resolution of up to 10^{7-8} and a bandwidth of 1GHz. We just finish the development phase of this project.

High-resolution spectroscopy in the mid-infrared regime is a versatile tool for studies of planetary atmospheres. With the highest possible spectral resolution provided by heterodyne techniques, fully resolved molecular features enables us to retrieve many physical parameters from single lines migrated in strong absorption of terrestrial atmospheric molecule bands. Because many key species in the planetary atmosphere are also abundant in the terrestrial atmosphere, high-resolution directly leads to less ambiguity. It also allows us to measure slow wind velocities with the order of 10-100m/s directly.

The heterodyne spectroscopy has been developed by our group from 1980s, in order to detect minor constituents in the terrestrial atmosphere [Taguchi et al., 1990]. The renovation with a wide-band detector, the quantum-cascade (QC) lasers and CO_2 gas laser allows us to apply this instrument to tiny planetary atmosphere.

Our performance achieved the proper level for this target. (1) System noise: At 10.3 um, we achieved 3000 K (NEP of 2.24 $W/Hz^{1/2}$ at 3MHz resolution). It leads to a minimal detectable brightness temperature difference of 37mK within 10min at 1.5 MHz bandwidth, corresponds to a minimum flux difference of 0.48 ergs/(scm2cm-1Sr) for extended source. (2) Spectral resolution: It can be achieved to be 20 MHz with a feedback using gas-cell absorption spectra.

The telluric CO_2 and O_3 absorption spectra had been obtained from the sunlight background in the lab at Sendai. On January in 2012, our equipment was mounted on the Higashi-Hiroshima 1.5m telescope, and succeeded to detect the telluric O_3 spectra obtained from moonlight. We also aimed Venus and standard stars. Unfortunately, the final success was prevented by bad weathers, but the S/N gained by these target told us that we should get the Venus and Mars spectrum with this design.

Now, we try to refine the emission spectra of the QC lasers, which provide us very wide tuneability (5cm^{-1}, and 20cm^{-1}) to operate the heterodyne system.

Although a telescope dedicated to this instrument does not exist yet, we expect to attach it to the PLANETS telescope at the top of Mt. Haleakala at Hawaii, which is now in development by PPARC / Tohoku Univ. with IfA / Univ. Hawaii (USA), Kiepenheuer Inst. f. Sonnen. (Germany), Univ. Nac. Aut. de Mexico, Univ. Turku (Finland), Harlingten Inovative Optics Co. (USA), Stan Truitt Breckenridge Astronomycal Ltd (USA), and collaborators. Its first light is, if all things are going well, in 2014.

Keywords: spectroscopy, infrared, planetary atmospheres, high spectral resolution, heterodyne, laser

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PZT sensor with current-to-voltage converting amplifier for dust observation

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This paper describes the concept of a dust monitor with a large detection area but less resource consumption using lead zirconate titanate (PZT) ceramics, and the possibility is experimentally demonstrated. PZT sensors, which are traditional devices for in-situ observation of hypervelocity dust particles, have been used for momentum measurement. The hypervelocity impact signals of PZT sensors are typically read by charge-sensitive amplifiers. Instead, we suggested the use of a current-to-voltage converting amplifier for interpreting the impact signal of a PZT sensor to determine the size of a dust particle down to 0.5 um in radius. If a sufficient number of such PZT sensors cover the interspaces of instruments on interplanetary-space-cruising spacecraft, datasets of dust impacts can be obtained with higher statistical precision than that of previous observations. Such observations can provide insights into unresolved science problems in interplanetary dust research.

Keywords: cosmic dust observation, piezoelectric PZT, current to voltage conversion amplifier