Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

PCG10-01 Room:102A Time:May 24 09:00-09:20

Requirements for Observation Equipment Development on Small Satellite from Bus Side

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1: Introduction

Artificial satellites are getting larger and larger every year and reached to several tons. This induces satellite high cost, long term development and high reliability requirements and large satellite development stalled. In this situation small satellite which weighs 1 to 100kg become conspicuous in astronautics. Especially, Japan is leading 1kg nano-satellite class in the world since we have developed and verify them first in the world. Mission at first stage was simple satellite bus performance check. Now there are technical demonstrations and high-level science observation missions similar to large satellites are taken place. This time, requirements from satellite side to observation equipment developers are reported.

2: Nano-satellite specifications

In this paper, nano-satellite means 1-50kg, 10-50 cm cubic size and it generates 1-50W power. (Common large satellite is several meter size.) Nano-satellite can provide 30 to 50 % resource for mission side.

In Japan, university one laboratory is a major player for nano-satellite development. And this means students are main force.

As referred in the above, usually nano-satellite has a single mission because of limited resources. And that means observers can use the satellite exclusively.

3: Requests for observation equipment developers

3-1: Interface and use of resources

Nano-satellite developers are not bureaucratic. Interface can be determined based on discussion between bus and mission side and it can be changed it is needed.

3-2: Information and motivation

For precise interface draw up, both sides should exchange design and development information each other. Since we work in a different area, we will start from understanding of terms of other side. Announcement of observation purpose, method and achievements are strongly welcome, it help to raise motivation. Main members of bus side are students, they are curious in science. When the explanation is enough, bus side will start to develop observation equipment part. This helps further mutual understanding and union of organization and knowledge speeds up.

3-4: Development strategy

Ambition for precise observation deserves to be acclaimed. There is performance limit for nano-satellite. Future plan should be considered. Successive small satellite project or combination use of large satellite (high low mix) will be easy rather than on extremely high specification satellite.

3-5: Redundancy

Since nano-satellite bus has little redundancy, too much careful design in mission side is useless.

3-6: Launch delay

Small satellites are often launched as a piggy-back of large satellite. So launch will postpone in many cases by irresistible force. Prepare for launch delay on ahead.

3-7: Ground test

The equipment tests are difficult since it will be used in vacuum and zero-gravity environment. But we can't fix them after the satellite in on the orbit. Verification for validation must be done before the launch no matter how hard it is.

4: Conclusion

Requirements for mission side from bus side are described in this paper. In recent years, many universities star satellite projects. You can contact UNISEC (University Space Engineering Consortium) for introducing satellite projects.

Keywords: nano-satellite

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PCG10-02 Room:102A Time:May 24 09:20-09:35

Compact Instrument to measure Te and Ne for Pico /Nano satellite

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An instrument has been developed for Pico/nano satellite to measure electron density and electron temperature simultaneously. Electron temperature probe(ETP) which has been developed about 40 years ago is modified. ETP has been accommodated in Japanes 5 scientific satellites (TAIYO, HINOTORI, OZORA, KYOKKO, and AKEBONO), and 3 foreign satellites(Korea, Brazil, and Russia). ETP was also installed in more than 50 Japanese sounding rockets including Showa base, West Gemany, Brazil, and Russia. Its performance is well established. In ETP, 30KHz sine wave oscillator which has been used so far is replaced by an oscillator which generates 200Khz-7Mhz sweep frequency signal.

Keywords: Pico.Nanosatellte, Topside ionopshere, Electron density, Electron temperature

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PCG10-03 Room:102A Time:May 24 09:35-09:50

Detecting Electrons and Ions with a Single Detector in Miniaturised Low Energy Particle Analysers

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Electrostatic energy analysers for eV to low keV particles typically analyse either electrons or positive ions. Instruments that do study both usually use separate detectors. Using a single detector for both electrons and ions potentially enables more compact instruments with reduced spacecraft resource requirements.

CATS (Cylindrical And Tiny Spectrometer) is one such approach to this challenge. It is a prototype highly miniaturised instrument that uses a concentric cylindrical geometry to measure multiple energies of electron and ion simultaneously. It has been demonstrated experimentally with 0.5-8 keV electrons using an ion-implanted CCD for a detector. It is being adapted for use in PoleCATS: a student-led experiment on the REXUS (Rocket EXperiments for University Students) European sounding rocket programme. The current geometry has ~7% energy resolution and ~7 degree by ~3 degree angular resolutions. Conceptually the design can be adjusted to tune the instrument parameters for a range of applications.

An alternative approach to the challenge is to adapt a conventional top hat geometry instrument so that it can sample alternately electrons and ions in continuous positive to negative inner hemisphere electrode voltage sweeps. While, unlike CATS, the electron and ion measurements would not be made simultaneously, the elegant focussing properties of the powerful and well-understood top hat geometry are preserved and existing, well-evolved instrument designs can be leveraged. By placing suitable dynodes (secondary electron emitters) at the exit of the analyser it is intended that a single MCP can be used to study electrons and ions over a wide range of energies. Initial simulations and development work on this project will be discussed.

Keywords: plasma analyser, miniaturised instrumentation, direct detection of low energy electrons with a CCD, SIMION simulations, low energy electron and ion spectrometer, CATS Cylindrical And Tiny Spectrometer

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PCG10-04 Room:102A Time:May 24 09:50-10:10

The Fast Auroral Imager Experiment to Investigate the Dynamics of Nighttime Optical Aurora

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The Fast Auroral Imager (FAI) consists of two CCD cameras: one to measure the 630 nm emission of atomic oxygen in aurora and enhanced night airglow; and the other to observe the prompt auroral emissions in the 650 to 1100 nm range. Good optical throughput (etendue) will be realized through the combination of fast lens systems (f/0.8) with CCDs of high quantum efficiency. Both cameras have a common 27 degrees field-of-view, to provide circular images of about 650 km diameter from apogee at 1500 km.

In the nadir viewing mode, the near infrared camera will provide multiple images per second at a spatial resolution of a few kilometres, for studies of dynamic phenomena such as substorm onset, vortices and multiple narrow arcs, and for monitoring the auroral context for the complementary *in situ* measurements onboard. The 630-nm camera will produce images once per minute with an exposure time of 0.5 sec, which is compatible with the radiative lifetime of the $O(^1D)$ atom in the atmosphere. Not only will this camera image auroral forms such as discrete arcs that are produced by soft electrons, it will also measure the locations of the auroral oval and polar cap boundaries. With on-chip pixel binning it will be possible to investigate weak emission phenomena such as polar arcs and patches, midlatitude SAR arcs and detached arcs, and enhanced airglow from artificial ionospheric heating. Overall, the FAI instrument represents a major advance in the application of new technology to the study of nighttime auroral phenomena.

Keywords: auroral imaging, nighttime optical aurora, night airglow, CASSIOPE/ePOP Mission, Fast Auroral Imager (FAI), discrete aurora

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PCG10-05 Room:102A Time:May 24 10:10-10:25

Observation plan of pulsating aurora with a monochromatic camera on a rocket experiment

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To understand the small-scale variation of pulsating aurora and its cross-scale coupling to large-scale feature, we plan a S520 sounding rocket experiment to carry out the high-time resolution wave-particle measurements as well as optical imaging. This rocket experiment is characterized by the simultaneous measurement among plasma particle in the wide energy range up to more than 200 keV, VLF and high-frequency plasma waves, magnetic field, electron temperatures and monochromatic auroral image at the N2 1st positive band. Ground-based instruments, such as EISCAT radar, optical imager, and SuperDARN radar, will join this experiment. The rocket will be launched into pulsating auroras from Andoya, Norway during a new moon period in winter of 2017 to achieve the conjugate measurement with the ERG satellite. The launch window is 01-06 MLT, and the apex altitude of rocket will be more than 300 km in altitude. The total mass, electric power and data rate are estimated to be 48 kg, 110 W, and 3.1 Mbps, respectively.

We are developing a monochromatic camera for this project. The auroral imaging data at the N2 1st positive band (670 nm) is useful since the time response of N2 emission to the precipitating electrons is prompt, and its emission intensity is proposal to the total energy flux of electrons that cause the pulsating aurora. The optical and electrical designing is still in progress. At the present design, the field-of-view (FOV) is 45 degrees covering the ontological to downward directions, time resolution is several frame-per-second, and spatial resolution is 1 to a few km. Using successive image data in the vicinity of pulsating auroral emission layer, we expect to estimate the thickness of emission layer. In addition, we will achieve simultaneous image-particle measurement using the data when the FOV of camera is pointed to the magnetic footprint threading the rocket during the apex period. In this presentation, we give the current status of optical and electrical design of monochromatic camera, its detailed specifications and operation plan.

Keywords: pulsating aurora, rocket, camera, optical, development, ERG

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PCG10-06 Room:102A Time:May 24 10:25-10:45

Discussions of Electrode Contamination Effects on a Retarding Potential Analyzer on-board Sounding Rocket

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Electrode contamination of a Langmuir probe in space is a serious problem even now although laboratory experimenters were aware of this problem for a long time. Surface contamination layer form extra capacitances and leads to a I-V curve distortion, which leads erroneous measurements, especially of electron temperature. Similar effects exist on electro-static analyzers, such as a retarding potential analyzer (RPA). Error caused by contaminations of a RPA is considered small for satellite experiments because satellite velocity is high (7 km/sec), and plasma density is low. While for sounding rocket experiments, error caused by contamination gets larger when we try to measure low ion temperature of 200-300K. We discussed several contamination effects on a RPA based on the experiments performed in a space plasma chamber. And development of a contamination-free RPA for rocket missions is also demonstrated.

Keywords: Retarding Potential Analyzer, Electrode Contamination, Sounding Rocket, Ion Temperature

Japan Geoscience Union Meeting 2013
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PCG10-07 Room:102A Time:May 24 11:00-11:20

Study of Space Storms using Next Generation Small Satellite of Korea

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Korea Advanced Institute of Science and Technology (KAIST) is developing its 8th satellite as the first of the Next Generation Small Satellite series. The satellite will be launched in early 2016 into a polar orbit with an altitude of ~700 km. While the main mission of the satellite is to test engineering payloads, scientific instruments were also selected for space science and astrophysical investigations. The scientific goal of the space science payloads is to understand the behavior of the radiation belt and the ionosphere during space storms. Two of the space science payloads, Medium Energy Particle Detector (MEPD) and High Energy Particle Detector (HEPD), will be operated in the polar region to observe precipitating and trapped energetic particles, in the energy range from ~40 keV to ~1 MeV. Electrostatic deflectors will be employed in these instruments to reduce the cross-contamination between electrons and protons. A Langmuir Probe (LP), a Retarding Potential Analyzer (RPA), and an Ion Drift Meter (IDM) will also be on board the satellite for the operation in the mid- and low-latitude regions by sharing the orbits with the infrared astrophysics mission. Instruments and their operation scenarios will be discussed.

Keywords: Space Storms, Next Generation Small Satellite

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PCG10-08 Room:102A Time:May 24 11:20-11:35

Seismo-Electromagnetic Research by Small Satellite Constellation

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Seismo-electromagnetic research by satellite observation started in Soviet Union in the 1980. After the collapse of USSR, France took over the initiative and its small satellite: DEMETER has already clarified, by statistical analysis of 9000 cases, that night-time attenuation of VLF range electromagnetic emission occurs 4 hours before earthquakes larger than M4.8 that would have required some 100 years for it by ground observation. Recently, satellite observation has followed in Ukraine, Italy, Taiwan, etc. and similar projects are being planned in China, Russia, UK, Mexico, Kazakhstan, India, Peru, South Korea and Iran.

The advantage of observation from space is that statistical research on the correlation between precursory phenomena and earthquakes is possible in a dramatically short-time compared with ground observation which is limited in the spatial coverage. Beyond this, the studies on the mechanism of observed phenomena will be facilitated by adoption of various instruments.

However, most existing and planned missions are single satellite or a few satellites, it is difficult to establish reliable ”time and space” ionospheric model which is indispensable for identification of precursory phenomena. Therefore, it is a logical conclusion that we should conduct comprehensive observations of space-time variations of ionosphere by satellite constellation with reliable instruments by international cooperation.

Keywords: Seismo-Electromagnetic, Small Satellite Constellation, Earthquake Precursor, Ionosphere

PCG10-09 Room:102A Time:May 24 11:35-11:50

The current status of EUV spectroscope, EXCEED on board the SPRINT-A

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EXCEED is the Extreme ultraviolet spectroscope on board the Japanese small scientific satellite, SPRINT-A. The mission will carry out spectroscopic and imaging observation of EUV (50-150 nm) emissions from tenuous plasmas around the planets (such as Venus, Mars, Mercury, and Jupiter) from the Earth orbit at the altitude of around 1000 km. It is essential for EUV observation to put on an observing site outside the Earth's atmosphere in order to avoid the absorption. In addition, because the emissions from the targets are very faint, the effective are should be as large as possible and needs long observation period. Since EXCEED is developed mainly for the planetary science, we can use the observation window as long as possible on the geometrical point of view. In this presentation, the specification and performance of the instrument according to the FM final calibration, and possible observation scenario are discussed.

Keywords: SPRINT-A, EUV, Jupiter, Escaping atmosphere, Io plasma torus, Spectroscopy

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PCG10-10 Room:102A Time:May 24 11:50-12:05

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 (NCKU) in Taiwan is now developing a low-energy electron instrument LEP-e for JAXA's radiation belts observation mission ERG (Energization and Radiation in Geospace). The LEP-e instrument measures electrons in the inner magnetosphere with energies from ~10eV to ~20keV to give key information on background plasmas, in which electron accelerations to a MeV range take place. The instrument is a tophat-type electostatic analyzer with multi-channel plates, similar to those on the NOZOMI and REIMEI missions. In the ERG mission, the keypoint of plasma instruments is to suppress effects due to background radiations. LEP-e employs 6mm-thick aluminum shields for the analyzer, and 5mm-thick shields for the electronics. In addition, LEP-e has a background noise channel, and an electron count is estimated by subtracting a noise count. In the presentation, instrument performance, estimated radiation effects and the current status of the development will be discussed.

Keywords: plasma analyzer, ERG mission

PCG10-11 Room:102A Time:May 24 12:05-12:20

Ionosphere Profiling Based on FORMOSAT-3/COSMIC Radio Occultation Experiment

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FORMOSAT-3/COSMIC (F3/C) is a Taiwan-US collaborative satellite mission for sounding Earth's atmosphere and ionosphere in recent years. The primary payload of each F3/C satellite is a GPS radio-occultation (RO) receiver, which measures the phase delay of radio waves from GPS satellites occulted by the Earth's atmosphere or ionosphere. By estimating the bending angles of radio wave trajectories, accurate and precise vertical profiles of the global troposphere, stratosphere and ionosphere are obtained. This presentation reveals data processing from F3/C RO phase measurements to ionospheric electron density profiles by means of single-difference excess phase estimation, bending angle estimation and ionosphere inversion technique. In addition, related RO experiments on board the next generation of F3/C, FORMOSAT-7, to be launched in 2016 and 2018, will be mentioned.

Keywords: FORMOSAT-3/COSMIC, radio occultation, ionospheric electron density, GPS