Commission H (Waves in Plasmas) Activity Report (final)

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Research Topics

<Akebono>

Akebono (EXOS-D) satellite has been observing electromagnetic waves in geomagnetized plasmas. It is necessary to know the antenna impedance of the VLF electric field antennas onboard Akebono to calibrate the electric field component data. Higashi et al. [2009] studied the fluctuation of the short-term antenna impedance, where statistical analysis on the capacitance component of the antenna impedance was performed. They analyzed data observed by Akebono from 1989 through 1995 and investigated the possible effects on the impedance of the strength of geomagnetic field and Akebono altitude and velocity (see Figure 1).

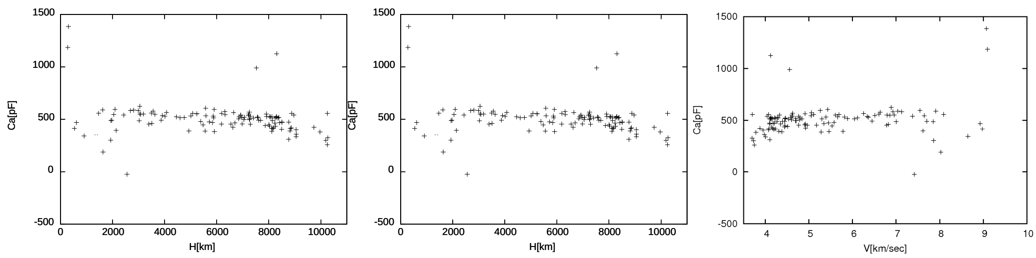

Figure 1: Dependence of the antenna capacitance on the geomagnetic field, Akebono altitude and velocity.

<GEOTAIL>

GEOTAIL spacecraft has been operated since 1992. The Plasma Wave Instrument (PWI) is continuously collecting spectrum data and high time-resolution waveform data. It is expected to be in a good condition at least until the next long eclipse in 2010. The 24 hour plots of the observed wave spectrum data have been opened in the PWI web site http://www.rish.kyoto-u.ac.jp/gtlpwi, and http://www.stp.isas.jaxa.jp/geotail. Furthermore, one can easily also access the PWI 2 hour plots with full time and frequency resolution through the above web page.

BepiColombo>

The BepiColombo is the science mission to Mercury. It is the first collaborative science mission between JAXA and ESA. The BepiColombo mission consists of two individual spacecraft called MPO (Mercury Planetary Orbiter) and MMO (Mercury Magnetospheric Orbiter). Scientists in Japan and Europe jointly proposed the plasma wave observation system called PWI (Plasma Wave Investigation). The proposal was successfully accepted and the development of the PWI component started. The MMO launch is scheduled in 2014. The Principal Investigator of the PWI is Prof. Yasumasa Kasaba of Tohoku University.

The PWI investigates plasma/radio waves and DC electric field in Mercury magnetosphere. It consists of two components of receivers, two sets of electric field sensors, two kinds of magnetic field sensors, and the antenna impedance measurement system.

The PWI consists of EWO, MEFISTO-E, SORBET, and AM2P receiver components as well as WPT-S, MEFISTO-S as electric field sensors and LF-SC and DB-SC as magnetic field sensors. The engineering models of these components have been performed and tested in Kyoto University in April, 2009. The test results show the good features except for non-serious problems. Furthermore, the thermal tests in the PWI level have been performed in October, 2009. All of the PWI components joined the tests and checked their function. The followed environment tests of the PWI such as the thermal-vacuum tests and vibration tests will be scheduled in November, 2009.

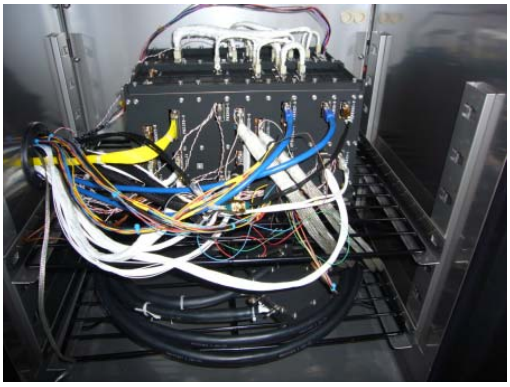

Photo 1: Thermal tests of the PME engineering model.

<Polar Region Experiments>

Ozaki et al [2009a] suggested a new remote sensing technique for enhanced electron density in the lower ionosphere. This technique is based on the difference in the ionospheric attenuation between VLF whistler mode waves (daytime chorus emissions) and 30 MHz CNA both observed on the ground. They found that the both correlation has information on the vertical profile of the enhanced electron density in the lower ionosphere caused by electron precipitation. This allows the study of the electron precipitation in the daytime.

< KAGUYA (SELENE)>

Measurements of Radio and Plasma Waves Using WFC/LRS Onboard KAGUYA

KAGUYA was launched on September, 14, 2007 in order to explore the surface distribution of elements and minerals, surface and subsurface structures of the moon, the gravitational field, the magnetic field, and energy particles originating from the moon, as well as from solar/interplanetary space (Kato et al., 2007). The Lunar Radar Sounder (LRS) is one of the scientific instruments onboard the KAGUYA main orbiter (Ono et al., 2008; 2009b). The LRS consists of two orthogonal 30 m tip-to-tip antennas and three subsystems; the sounder observation (SDR), the natural plasma wave receiver (NPW), and the waveform capture (WFC). A main objective of the SDR is to investigate the surface and subsurface structures of the moon using an HF radar technique (Ono et al., 2009a; 2009b), and the NPW and the WFC are designed to measure natural plasma waves around the moon and in interplanetary space originating from the sun, from the earth, and from other planets (Kasahara et al., 2009b; Kumamoto et al. 2009). The NPW covers the frequency range from 20 kHz to 30 MHz, and the WFC covers the lower frequency range from 100 Hz to 1 MHz. The operation of KAGUYA ended its scheduled nominal mission on October 31, 2008, and the mission was extended until KAGUYA was impacted to the south-east of near side of the moon on June 10, 2009.

Nominal data acquisition of the LRS was performed until the observation halt of LRS due to hardware trouble occurred on September 10, 2008 (Ono et al., 2009) and the operation of the LRS was suspended for ~5 months. Although passive measurements by the NPW and WFC in the nominal data rate mode of 176 kbps were tentatively recovered for ~30 hours around November 8, 2008, it was finally found that one of the FPGA on the DSP board for the SDR was functionally unstable. Because the DSP board was also responsible for the NPW operation, we had no choice but to abandon the SDR and NPW observation.

On the other hand, the operation of WFC was resumed on February 19, 2008 and the operation was continuously performed until KAGUYA was impacted to the south-east of near side of the moon on June 10, 2009.

When the operation of the WFC was resumed, KAGUYA spacecraft had already been descended to the 50 km altitude since February 1, 2009. KAGUYA was descended again to 10-30km in lower altitude (perilune) from April 16, 2009. As the telemetry rate was limited at 4 kbps, we firstly performed spectrum measurement of the WFC-H with PHASE mode from February 19, 2008 to May 26, 2009. During the last part of the extended mission from May 26, 2009 to the moment of the KAGUYA's impact to the moon on June 10, 2009, we also made a waveform observation using the WFC-L. The data rate of 2 kbps was assigned to one component (WFC-H-X) spectrum in FFT mode, and the rest of 2 kbps was assigned to waveform data from WFC-L-X below 12.5 kHz. The detailed data analysis obtained during the extended mission is now progressing and we expect many scientific outputs such as electron density profile around lunar wake (Kasahara et al., 2009a) and lunar ionosphere using low frequency wave reflection (Goto et al., 2009).

<ULF Waves>

Kataoka et al. (2009) applied the Hilbert-Huang Transform (HHT) to high-latitude search-coil ground-magnetometer data at an auroral expansion onset, which data was quite fluctuative (leading to no meaningful results when a regular FFT is applied) as in usual onsets. As a result, HHT could automatically extract Pi 1, Pi 2, and Pc 3. Thus, Kataoka et al. suggested that HHT is useful for understanding the onset mechanism of auroral substorms.

The AOGS (Asia Oceania Geoscience Society) 2009 meeting was held in Singapore on Aug. 11-15, 2009. The IAGA (International Association of Geomagnetism and Aeronomy) 2009 meeting was held in Sopron, Hungary on Aug. 23-30, 2009. The 126th SGEPSS (Society of Geomagnetism and Earth Planetary and Space Sciences) fall meeting was held in Kanazawa, Japan on Sep. 27-30, 2009. These meetings covered a wide area of geosciences, including ULF waves, thus wide varieties of papers were presented related to ULF waves.

<Ionospheric effects on Radio Wave Propagation>

Lightning-generated sferics observations

Koide et al. [2009] have been investigating the technique for estimating lightning current by using the sferic wave fields. In their technique, they have succeeded in obtaining information on the discharge duration of the return stroke that was impossible to know only from the conventional wave field observation. They have also found that it is possible to estimate the waveform of the return stroke current by using a nonlinear least-squares method applied to the wave field. Figure 2 shows the estimated current moment waveforms by using the direct waveforms of the observed sferic wave field. As a result, their method has shown that the error in the estimation of the current moment is less than 10 % for the horizontal distances of the lightning over 100 km. This current estimation technique is applied to the analysis of the natural VLF/LF harmonic waves observed in Antarctica, whose frequency spacing is determined by the lightning discharge duration [Ozaki et al., 2009b].

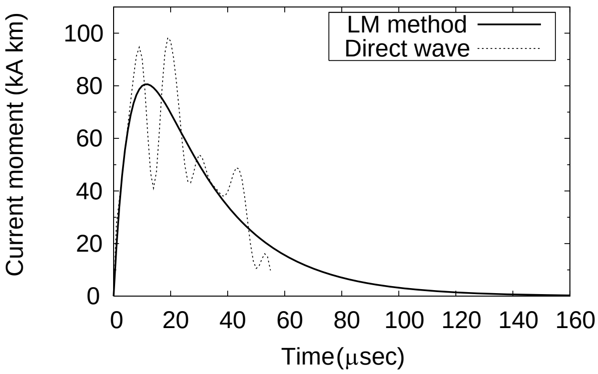

Figure 2: Estimated current moment waveforms (solid line) and the direct waveforms of the observed sferics (dotted line).

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1) IEEE MTT-S International Microwave Symposium 2009, Boston Massachusetts June 7-12, 2009
2) IEEE AP-S 2010, Toronto, Ontario, Canada July 10-17, 2010
3) International Symposium on Antenna Technology and Applied Electromagnetics (ANTEM) and the Canadian Radio Sciences Meeting (URSI/CNC), Banff, Canada July 27-30, 2009
4) AOGS (Asia Oceania Geosciences Society) 2009 Meeting, Singapore, Aug. 11-15, 2009.
5) IAGA (International Association of Geomagnetism and Aeronomy) 11th Scientific Assembly, Sopron, Hungary, Aug. 23-30, 2009.The 11th Scientific Assembly of IAGA, Hungary Aug. 23-30, 2009
6) 126th SGEPSS (Society of Geomagnetism and Earth, Planetary and Space Sciences) Fall Meeting, Kanazawa, Japan, Sep. 27-30, 2009.
7) 2009 AGU Fall Meeting, 14–18 December San Francisco, California, USA

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