Commission H (Waves in Plasmas) Activity Report

March 11th, 2005

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Research Topics

<AKEBONO>

Based on the plasma wave data by AKEBONO spacecraft more than one solar cycle, the spatial and temporal **mapping of VLF wave activity** in the inner geospace has been elucidated (Kasahara et al., 2004). An example of such time variation of electric wave intensity during the geomagnetic storm time in the frequency range from 1kHz to 10kHz is shown in Figure 1. The plasma wave data obtained by the instruments PWS and VLF are available on request [for further information: http://www.stp.isas.jaxa.jp/akebono].

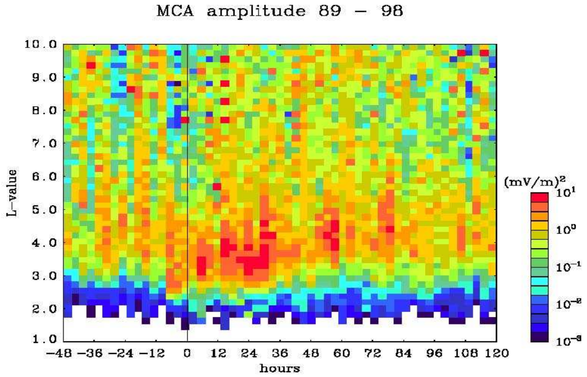


Figure: The vertical axis indicates the L-value of the observation point, and the horizontal axis indicates the relative time from the beginning time of the storm recovery (Kasahara et al., 2004).

Particle Acceleration by Plasma Wave

One of the hot topics in the **inner magnetosphere** physics is the **origin of relativistic electrons in the outer radiation belt**. One of the plausible mechanisms is **wave-particle resonant diffusion** by whistler mode chorus during recovery phase of the magnetic storm. Using Akebono VLF and RDM data, Hikishima, M. et al., presented the theoretical analysis and particle simulation results which indicate that the resonant electrons with initially large pitch-angle anisotropy are rapidly pitch-angle diffused by a generated whistler mode wave, and the subsequent anisotropy decreases and saturates the wave growth, (Computer experiment of cyclotron interaction for chorus generation, 2004 Asia-Pacific Radio Science Conference (AP-RASC 2004), pp.563-566, Qingdao, China, 2004).

<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 2005.The 24 hour plots of the observed wave spectrum data are opened in the PWI web site http://www.rish.kyoto-u.ac.jp/gtlpwi, and http://www.stp.isas.jaxa.jp/geotail.

ULF Waves in the Lunar Wake

GEOTAIL detected left-handed, circularly polarized ULF waves propagating along the background magnetic field when it was magnetically connected with the lunar wake. It is explained by polarity reversal of right-handed, sunward-propagating electron whistler waves, which were excited through the interaction with electron beams flowing in anti-sunward direction downstream of the lunar wake with energy of about 1 keV (Nakagawa et al., GEOTAIL observation of upstream ULF waves associated with lunar wake, Earth Planets Space, 569-580, 2003). The anti-sunward flow of electron beam was explained by filtering effect of the potential drop at the boundary of the lunar wake. After the passage through the electric field, the electrons obtain significant perpendicular component of velocity, which can account for the cyclotron resonance with sunward-propagating whistler mode waves detected by GEOTAIL (Nakagawa et al., Pitch angle diffusion of electrons at the boundary of the lunar wake, submitted to Earth Planets Space 2004).

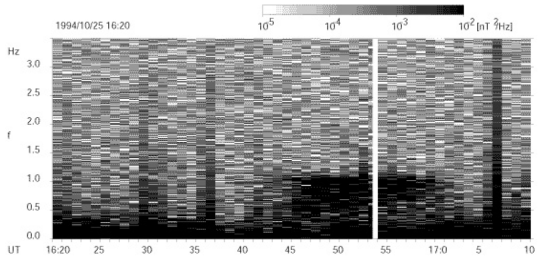


Figure: The dynamic spectrum of the IMF Bz component during the period from 16:20 to 17:10 on October 25, 1994. The wave activity associated with lunar wake was observed between 0.3 to 1.1 Hz during the period from 16:45 to 17:00.

MHD Waves in Solar Wind

Hada,T. et al. have developed a method to quantitatively evaluate phase coherence among waves included in time series data, by comparing structure functions of original data and its phase-shuffled/ phase-unified surrogates. Application of the method to magnetic field data obtained by Geotail spacecraft, it is revealed that the large amplitude MHD waves in the foreshock are phase correlated, and the correlation is stronger as the turbulence level is increased. Furthermore, the origin of the phase coherence is discussed using wavelet-filtering technique (T. Hada, D. Koga, E. Yamamoto, Phase coherence of MHD waves in the solar wind, Space Sci. Rev., 107, 463-466, 2003;
D. Koga, T. Hada, Phase coherence of foreshock MHD waves: wavelet analysis, Space Sci. Rev. 107, 495-498, 2003; D. Koga, Phase coherence among MHD waves in the earth's foreshock region, Doctoral thesis, Kyushu University, 2005.

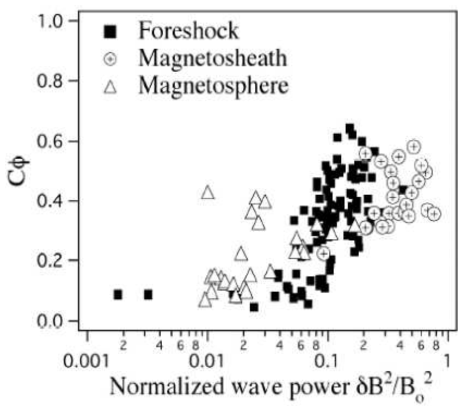
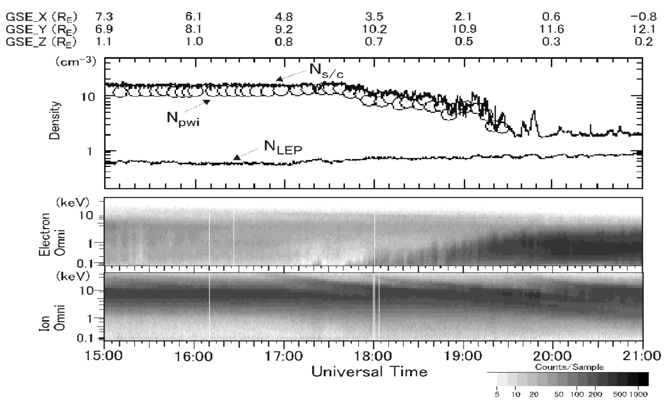


Figure: The phase coherence among waves from a given turbulence time series. The vertical axis is the 'phase coherence index', which indicates how strongly the wave phases are synchronized. It is positively correlated with the turbulence level, implying that the nonlinear interaction between the waves generate the phase coherence.

Plasma Measurements

An empirical formula correlating the Geotail spacecraft potential measured by the single probe and the electron number density as determined by the plasma wave observations in the solar wind and broader magnetosphere have been obtained. Using this formula and plasma particle measurements, the problem how much and how the low-energy plasma exist in



the magnetosphere is investigated.

The figure in the previous page shows the density profile and energy-time (*E-t*) spectrogram during the period from 15:00 UT to 21:00 UT, November 26, 1995. Top panel is the density profile. $N_{s/c}$ and N_{LEP} are shown as solid lone and N_{pwi} is shown as open circles. Middle and bottom panels are omni-directional *E-t* spectrogram of electrons and ions (K. Ishisaka, et al., Application of spacecraft potential to investigate the distribution of low-energy plasma in magnetosphere, COSPAR COLLOQUIA SERIES Vol.16, Frontiers in Magnetospheric Plasma Physics, pp.75-78, 2005).

Lobe Trapped Continuum Radiation

Lobe trapped continuum radiation (LTCR) has been observed onboard the Geotail spacecraft, at frequencies as low as 1 kHz in the distant geomagnetic tail region. By comparing the waveform observations of the LTCR with the 3-d ray-tracing analysis, the possible source regions of the LTCR is identified as the plasma sheet boundary layer away from the nominal tail axis and the low latitude boundary layer (H. Takano, et al., Lobe trapped continuum radiation generated in the distant magnetotail, COSPAR COLLOQUIA SERIES Vol.16, Frontiers in Magnetospheric Plasma Physics, pp.224-227, Elsevier, 2004).

Antenna in Space Plasma

The characteristics of dipole antenna or probe antenna, namely the **antenna impedance** and **effective length** have been studied using the AKEBONO and GEOTAIL observation data. The impedance of the wire dipole antennas onboard the Akebono satellite is estimated by using the electromagnetic field observations for Omega navigational signals. The estimated capacitance and resistance exhibit specific spin variation, which would be caused by the plasma sheath formation around the antenna wires depending on the angle between the antenna direction and the geomagnetic field line. The figure shown below indicates a dependence of antenna impedance to the angle on the geomagnetic field (R. Higashi et al., Estimation of impedance of wire antennas onboard the Akebono satellite, Proceedings of 2004 International Symposium on Antennas and Propagation (ISAP 2004), Vol.1, pp.269-272, Sendai (Japan), 2004). The effective lengths of two orthogonal sets of wire dipole antennas are estimated. The estimated effective length of each dipole is nearly the half of its tip-to-tip length of 60 m, which is consistent with the conventional assumption of the effective lengths of the dipole antennas (R. Higashi, et al., The characteristics of crossed wire antennas onboard the Akebono satellite, IEICE Trans. Commun, Vol.J88-B, No.2, pp.442-450, 2005.

Imachi,T. et al., have conducted a “**rheometry” experiment**, and found the frequency dependence of effective height for DC (static) and AC (wave) electric fields (Characteristics of electric wire antennas onboard scientific spacecraft, 2004 Asia-Pacific Radio Science Conference (AP-RASC 2004), pp.558-561, Qingdao ,China, 2004).

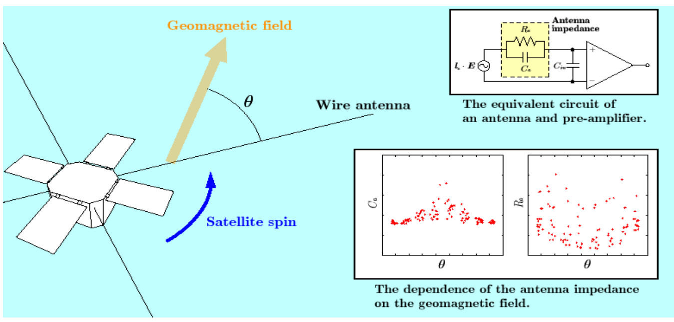
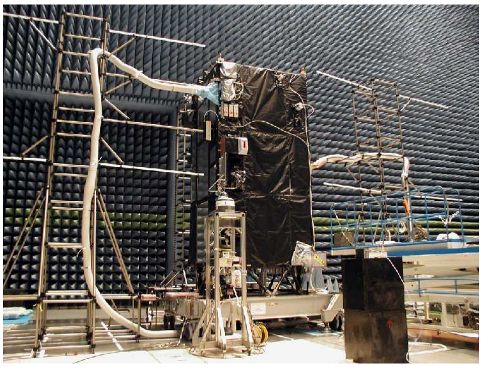


Figure: Experimental results showing the dependence of antenna impedance on the geomagnetic field (Higashi et al., 2004).

<SELENE>

Present state of SELENE spacecraft: Development of the onboard software was almost finished and the instrument is now in the final adjustment stage for the 2nd system function and EMC (ElectroMagnetic Compatibility) tests which are scheduled to start in March 2005. The Lunar Radar Sounder (LRS) experiment onboard the SELENE consists of three subsystems; SDR (sounder), NPW (natural plasma wave) and WFC (waveform capture).

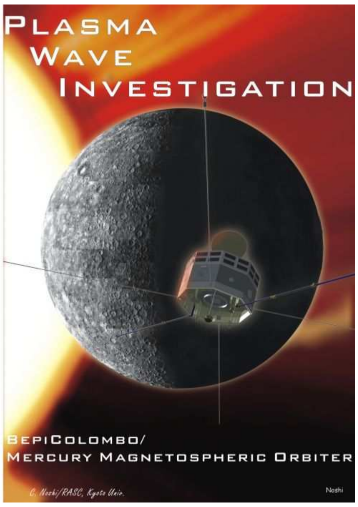


SDR will provide subsurface stratification and tectonic features in the shallow part (several km depth) of the lunar crust, by using an FM/CW radar technique in HF frequency range. NPW and WFC will observe natural plasma waves in the frequency range from 20kHz to 30MHz and from 100Hz to 1MHz, respectively.

The left picture shows the SELENE in the 1st EMC test at Tsukuba Space Center in March 2004.

<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 spacecrafts 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) in the response to the AO (Announce of Opportunity) for MMO. The Principal Investigator of PWI is Prof. Hiroshi Matsumoto in Kyoto University, Japan. After reviewing the PWI proposal, the MMO Payload Review Committee in JAXA selected the PWI for the science payload onboard MMO spacecraft. The MMO launch is scheduled in 2012.

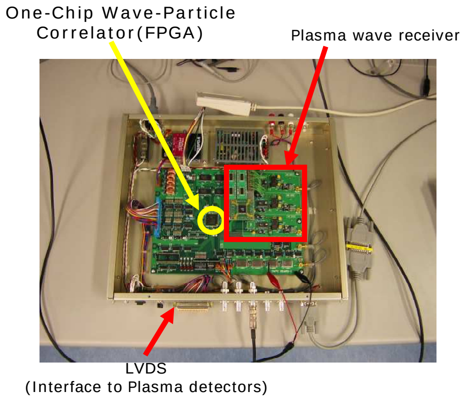


The PWI investigates plasma/radio waves and DC electric field in Mercury magnetosphere. It consists of two components of receivers, two sets of electric field sensors, two kinds of magnetic field sensors, and the antenna impedance measurement system. The PWI team has started the detailed design of each component and interface. The BepiColombo/MMO preliminary Requirement Review and first Science Working Team meeting was held on March 7 to 9 in ISAS/JAXA, Sagamihara, Japan.

<New Technology>

Development of Wave-Particle onboard Correlator

In the attempt of detecting wave-particle interaction processes based on spacecraft observation data, we always meet the difficulty in a data analysis stage. That is due to the big difference of time resolutions between wave data and plasma data. The breakthrough will be provided by the one-chip wave-particle correlator. It has the capability to calculate the correlation of wave and plasma measurement data onboard spacecraft with very high time resolution. All components of correlator circuits are constructed within a FPGA. We have been developing the engineering model of the **one-chip wave-particle correlator** and performing various function and efficiency tests (Report by H. Kojima, RISH).

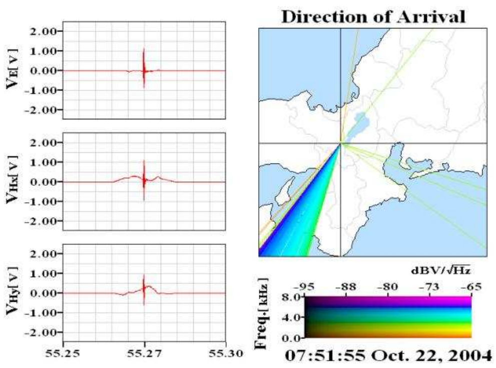


Development of Direction Finding System of Electromagnetic Pulses

Tsutsui M. et al (1994) have developed a new system for finding arrival directions of electromagnetic (EM) pulses which have frequency dispersion characteristics. The sensor system is composed of a vertical electric dipole antenna and orthogonally-arranged two horizontal search coils. This system is applicable for both space plasma waves, atmospheric and seismic-related radio emissions.

The application of the system to lightning pulses has shown that the system could accurately point to the locations of the lightning clouds and could chase their moving directions on real-time basis.

The figure shows the vertical electric field and orthogonal components of a horizontal magnetic field (from top to bottom at the left), and frequency-dependent arrival direction lines (a sector form) drawn from the detection site (right). The wide sector was formed due to frequency dispersion characteristics of a detected electromagnetic pulse.



Conferences and Meetings (November 2004 – February 2005)

1) Space Weather/Climate Symposium #5, STEL, Nagoya, November 24-26, 2004.
2) Symposium on Space Environment, JAXA, Tsukuba, November 25-26, 2004.
3) AGU Fall meeting: December 13-17, San Francisco, U.S.A., 2004.
4) Third International Symposium on the Arctic Research and eventh Ny-Alesund Scientific Seminar, Tokyo, Japan, February 22-24, 2005

Future Conferences and Meetings

1) International Workshop on Seismo Electromagnetics, Tokyo, Japan, 15-17 March, 2005.
2) Magnetospheric ULF Waves (Chapman), San Diego, CA, USA, March 21-25, 2005
3) 7th International School/Symposium for Space Simulations, Kyoto, Japan, March 26-31, 2005
4) ISSS-7, Kyoto, March 26-31, 2005 http://www.rish.kyoto-u.ac.jp/isss7/
5) International Workshop on Space Weather - On the Causes of Southward Interplanetary Magnetic Field (IMF), Tokyo, Japan, April 4, 2005.
6) 9th Spacecraft Charging Technology Conference, Tsukuba, April 4-8, 2005,
7) European Geosciences Union General Assembly , Vienna, Austria, April 24-29, 2005
8) Joint meeting for Earth and Planetary Science 2005, Chiba, Japan, May 22-26, 2005.
9) Spring AGU Meeting New Orleans, 23-27 May, 2005
10) AGU 2005 Joint Assembly, Louisiana, USA, May 23-27, 2005
11) Asia Oceania Geosciences Society's 2nd Annual Meeting (AOGS 2005), June 20-24, 2005, Singaporean (http://www.asiaoceania-conference.org/)
12) IAGA 2005 Scientific Assembly, Toulouse, France, 18-29 July, 2005
13) International Symposium on Antenna and Propagation (ISAP2005), Seoul, Korea, August 3-5, 2005
14) Cluster and Double Star Symposium: 5th Anniversary of Cluster in Space, ESA/ESTEC, Noordwijk, The Netherlands, 19-23 September 2005,