

Japanese URSI Commission H (Waves in Plasmas)
Activity Report
November 2016 - March 2017

[1] Status of projects related with plasma wave observation

1. BepiColombo/MMO

<http://global.jaxa.jp/projects/sat/bepi/>
http://www.stp.isas.jaxa.jp/mercury/p_mmo.html

BepiColombo is a Mercury exploration project jointly planned by JAXA and the European Space Agency (ESA), planned for launch in 2018 and arrival at Mercury in 2025. It consists of two orbiters; the Mercury Planetary Orbiter (MPO) and the Mercury Magnetosphere Orbiter (MMO). JAXA is responsible for development of the MMO.

MMO is at ESA/ESTEC (European Space Research and Technology Centre, Netherlands) from April 2015. For the plasma wave, Plasma Wave Investigation (PI: Y. Kasaba [Tohoku Univ.]) is aboard this spacecraft. PWI will first observe electric field, plasma waves, and radio waves around Mercury, which were not covered by past spacecraft.

After the ESA manufacturing of MPO and Cruise units, the final FM test including the MMO was reactivated from January 2017. PWI science team is now shifting to prepare the telemetry data pipelines and operation planning for the real science execution which will be realized in 2020s.

<Meeting> MMO Science Working Group Meeting (ISAS, Sep. 2016)

2. JUICE

<http://sci.esa.int/juice/>

JUICE (JUper ICy moons Explorer) is the L-class mission of ESA, planned for launch in 2022 and arrival at Jupiter in 2030s. It will spend at least three years making detailed observations of the Jovian system including Ganymede, Callisto and Europa, and finally be on the orbit around Ganymede. For the plasma wave, Radio and Plasma Wave Investigation (PI: J.-E. Wahlund [IRF Uppsala, Sweden]) is aboard this spacecraft and covers the information of the exospheres, surfaces, and conducting subsurface oceans of icy satellites and their interactions with surrounding Jovian magnetosphere. From Japan, High Frequency part (Preamp and Receiver) will be supplied (Co-PI: Y. Kasaba [Tohoku Univ.]), and provide the highly resolved information of Jovian radiation emitted from Jupiter and Ganymede by the first 3-axis E-field measurement. For the access to the conductive subsurface ocean, RPWI will first observe cold plasma and electric fields, in order to separate the global conductivity and current from the ionospheres. As a byproduct, reflected Jovian radio emission can be expected from the boundary of crust (ice) and subsurface ocean (conductive water).

In 2016, RPWI EM2 (EM) was in the development phase.

3. The ERG project

<http://ergsc.isee.nagoya-u.ac.jp/index.shtml.en>
<https://ergsc.isee.nagoya-u.ac.jp/mw/>

The ERG (Exploration of energization and Radiation in Geospace) project is a mission to study acceleration and loss mechanisms of relativistic electrons around the Earth. To achieve comprehensive observations of plasma/particles, fields, and waves, the Plasma Wave Experiment (PWE, PI: Y. Kasahara [Kanazawa Univ.]) is installed onboard the ERG satellite to measure electric field in the frequency range from DC to 10 MHz, and magnetic field in the frequency range from a few Hz to 100 kHz. Besides the PWE, the Software-Wave Particle Interaction Analyzer (SWPIA) (PI: H. Kojima, [Kyoto. Univ.]) is equipped onboard the ERG to realize direct measurements of interactions between energetic electrons and whistler-mode chorus in the Earth's

inner magnetosphere.

The satellite was shipped to the launch site at Uchinoura Space Center, Kagoshima in the beginning of October, 2016 and was launched on 20 Dec 2016. The satellite was nicknamed “ARASE”. The extension of WPT-S and MAST was successfully performed and the onboard instruments are now under the initial check out phase. Full scientific observations will start from end of March 2017.

4. HpFP protocol

<http://hfpf.nict.go.jp/>

Due to rapid increase of network bandwidth, applications and systems working in long fat network (LFN) play more important roles. For effective development of them, precise measurements of network conditions are significant. Transmission Control Protocol (TCP) is the most commonly used protocol, but is essentially unable to achieve high throughput in LFNs with packet losses. For this reason, it is hard for conventional network measurement tools to show the maximum or available bandwidth in LFN, especially in high packet loss environments. To overcome this issue, we introduce a novel data transfer protocol on TCP/IP transport layer, namely high-performance and flexible protocol (HpFP). For high-precision pace control and retransmission control, the HpFP intermittently monitors network conditions such as packet loss and latency. We develop an application via the HpFP, named hperf, which measures end-to-end throughput as well as status of packet loss and latency in LFNs. We carry out experiments to examine the abilities of the hperf in high-throughput data transfer and measurement of network qualities in terms of packet loss and latency. The hperf achieves almost wire-rate throughput, 10 Gbps, on the international link between Japan and the USA with even 0.5% packet loss ratio (PLR). The measurements of packet loss and latency show good correspondence with the conventional methods via iperf and ping. These results are verified in our laboratory experiments on 10 Gbps link using a network simulator as well. We conclude that the HpFP has significant potential for a variety of network applications and the hperf is a good network quality measurement tool in LFNs, compared to the conventional TCPs.

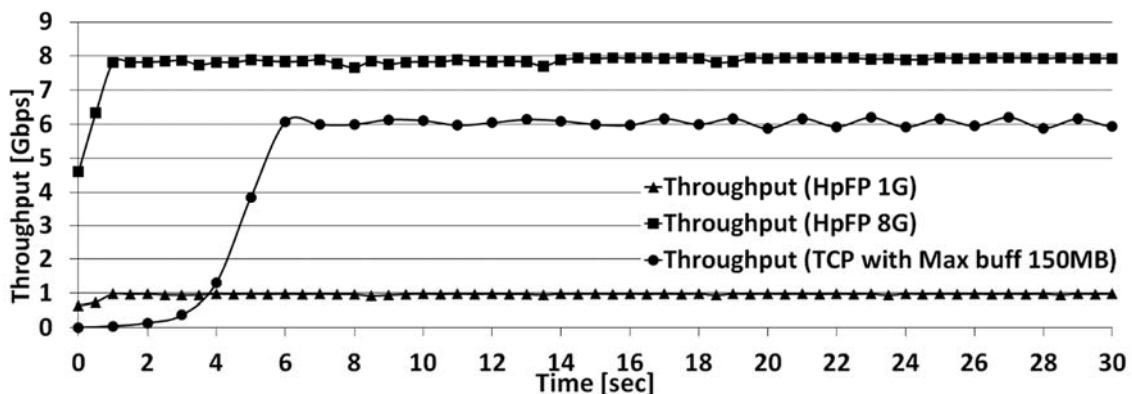


Figure Laboratory experiment result of HpFP and TCP on a LNF

5. Iceland - Syowa conjugate observation

A new VLF instrument has been installed at Husafell observatory in Iceland in September, 2016. Unique conjugate observations of auroral phenomena including the measurements of ULF and VLF waves have been carried out between Iceland and Syowa Station, Antarctica since 1983 by the National Institute of Polar Research in Japan in collaboration with University of Iceland.

6. Hisaki spacecraft

http://global.jaxa.jp/projects/sat/sprint_a/

Hisaki satellite with the EUV spectrometer (Extreme Ultraviolet Spectroscope for Exospheric Dynamics: EXCEED) is the UV/EUV space telescope dedicated to planetary sciences.

Hisaki has provided continuous observations of Jovian system in UV aurora total flux and EUV Io torus plasma distributions and plasma diagnostics, which connected the solar wind information and ground-based radio (Decameter [aurora] - VHF [radiation belt]) and IR (aurora and airglows) observations. From July 2016, NASA Juno orbiter started the observation around Jupiter. Hisaki's priority is on the support observation for this mission.

7. GEOTAIL

GEOTAIL spacecraft has been operated since 1992. The Plasma Wave Instrument (PWI) is continuously collecting the high resolution waveform data as well as the spectrum data. The color 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 make the color spectrum plots in flexible time scales in the NICT web page <http://geotail.nict.go.jp/>. Geotail is presently under review for extending its operation for 3 more years in JAXA.

[2] Recent Meetings

1. BepiColombo Hermean Environment Working Group Meeting & BepiColombo Science Working Team Meeting, Tokyo, Japan, 7-10 November, 2016.
http://sprg.isas.jaxa.jp/researchTeam/spacePlasma/symposiumH28/BepiColombo_swt2016.html
2. The 8th ERG Science Working Meeting and Data Processing School, Nagoya, Japan, 15-16 November, 2016.
<https://ergsc.isee.nagoya-u.ac.jp/documents/science201611/>
Tutorial Talk: Y. Kasahara, "Data Processing on Plasma Wave Experiment (PWE) on board ERG".
3. SGEPS Fall Meeting, Fukuoka, Japan, 20-23 November, 2016.
<http://www.icswse.kyushu-u.ac.jp/sgepss2016/>
4. **Symposium on Waves in Space Plasma** (The 332nd Symposium in Sustainable Humanosphere), Uji, Kyoto, 2-3 December, 2016.
The symposium was held in cooperation with Japanese URSI-H commission and subcommittee on plasma wave in SGEPS (Society of Geomagnetism and Earth, Planetary and Space Sciences).
5. High Energy Astrophysics Workshop 2016, Sagamihara, 30 November - 2. December, 2016.
<http://th.nao.ac.jp/MEMBER/inouety/HE2016/HE2016.htm>
6. American Geophysical Union Fall Meeting, San Francisco, 12-16 December, 2016.
<http://fallmeeting.agu.org/2016/>
7. Symposium on Planetary Science 2017, Sendai, Japan, 20-22 February, 2017.
http://pparc.gp.tohoku.ac.jp/collegium/pdf/SPS2017_program.pdf
8. Symposium on Plasma in the Inner Heliosphere, Solar-Terrestrial Environment and Cosmic Ray Modulation, Nagoya, Japan, 2-4 March, 2017.
<http://www.isee.nagoya-u.ac.jp/meetings/meeting-20190301.html>
9. The 9th ERG Science Working Meeting and Data Processing School, Nagoya, Japan, 1-2 March, 2017.
<https://ergsc.isee.nagoya-u.ac.jp/documents/science201703/>
The workshop was held in cooperation with Japanese URSI-H commission.

[3] Future Meetings

1. European Geosciences Union (EGU) General Assembly 2017, Vienna, Austria, 23-28 April, 2017.
<http://www.egu2017.eu/>
2. Japan Geoscience Union - American Geophysical Union Joint Meeting 2017, Chiba, Japan, 20-

25 May, 2017.

http://www.jpгу.org/meeting_e2017/

3. Asia Oceania Geosciences Society (AOGS) 14th Annual Meeting, Singapore, 6-11 August, 2017.
<http://www.asiaoceania.org/aogs2017/>
4. The 3rd COSPAR Symposium: Small satellites for space research, Jeju, Korea, 18-22 September, 2017.
<http://www.cospars2017.org/>

[4] Recently Published Papers

Goto, Y., K. Uda, Y. Kasahara, and K. Hashimoto, Calibration Method of Wave Polarization Data Obtained by KAGUYA/WFC, Radio Science, doi: 10.1002/2015RS005927, 51(9), 1579-1586, 2016.

- ✓ A calibration method for wave polarization data obtained by waveform capture (WFC) on the KAGUYA spacecraft is introduced.
- ✓ As a result, the polarization data are calibrated with a sufficient accuracy.

Imajo, S., A. Yoshikawa, T. Uozumi, S. Ohtani, A. Nakamizo, S. Demberel, and B. M. Shevtsov, Solar terminator effects on middle- to low-latitude Pi2 pulsations, Earth, Planets and Space, doi: 10.1186/s40623-016-0514-1, 68(1), 137, 2016.

- ✓ To clarify the effect of the dawn and dusk terminators on Pi2 pulsations, we statistically analyzed the longitudinal phase and amplitude structures of Pi2 pulsations at middle- to low-latitude stations around both the dawn and dusk terminators. Some features of the D component Pi2s depended on the location of the terminator rather than the local time.

Kalaei, M. J. and Y. Katoh, Study of a condition for the mode conversion from purely perpendicular electrostatic waves to electromagnetic waves, Phys. Plasmas, 23, 072119, doi: 10.1063/1.4958945, 2016.

- ✓ We study a condition required for mode conversion of electrostatic waves propagating purely perpendicular to the ambient magnetic field, by numerically solving the full dispersion relation.
- ✓ Numerical calculation revealed that the angle between the boundary surface and the magnetic field vector should be within a specific range in mode conversion processes in inhomogeneous plasma, which imply that the angle between the magnetic field and the density gradient plays an important role in the conversion process.

Kalaei, M. J. and Y. Katoh, The role of deviation of magnetic field direction on the beaming angle: Extending of beaming angle theory, J. Atmos. Solar Terrestrial Phys., 142, 35-42, doi: 10.1016/j.jastp.2016.02.021, 2016.

- ✓ The effect of the angle between the magnetic field and gradient density on beaming angle of mode conversion process was investigated, which cause the deviation from estimation proposed by Jones [1988].
- ✓ The calculated beaming angle in this study was consistent with continuum radiation events, which are observed by CRESS and IMAGE, and analyzed by Hashimoto et al. [2006].

Kasaba, Y., H. Misawa, F. Tsuchiya, Y. Kasahara, T. Imachi, T. Kimura, Y. Katoh, A. Kumamoto, H. Kojima, S. Yagitani, M. Ozaki, K. Ishisaka, C. Tao, Y. Miyoshi, T. Abe, B. Cecconi, M.W. Morooka, J.-E. Wahlund, and JUICE-RPWI Japan team, Back to Jupiter, with renovated point of view and focus on icy moons - Toward the Flight of Radio and Plasma Wave Instruments -, Japanese Soc. Planet. Sci., 25, 3, 96-107, 2016.

- ✓ Development of RPWI (Radio Plasma Wave Instruments) onboard Jupiter Explorer JUICE are now performed as next step of European and Japanese radio and plasma wave receivers onboard Cassini, Kaguya, ERG, and BepiColumbo.
- ✓ Observation of DC electric fields, AC electromagnetic fields, their directions and polarizations, passive subsurface radar and wave-particle interaction analyzer by advanced onboard software are planned in order to clarify the structures and dynamics of Jovian magnetosphere and to probe the ionosphere, ice crust and subsurface ocean of the icy moons.

Katoh, Y. and Y. Omura, Electron hybrid code simulation of whistler-mode chorus generation

with real parameters in the Earth's inner magnetosphere, *Earth Planets Space*, 68:192, doi:10.1186/s40623-016-0568-0, 2016.

- ✓ We carry out a self-consistent simulation of the generation process of whistler-mode chorus by a spatially one-dimensional electron hybrid code, by assuming the magnetic field inhomogeneity corresponding to $L = 4$ of the dipole field.
- ✓ Spectral fine structures found in simulation results were similar with the observation by the Cluster spacecraft (Santolik et al., 2003; Santolik, 2008).
- ✓ The gap at half the gyrofrequency was not found in simulation results. That implies oblique propagation of the waves with respect to magnetic field, which can not be treated in one-dimensional simulations, are essential for forming the half gyrofrequency gap.

Katoh, Y., Y. Omura, Y. Miyake, H. Usui, H. Nakashima, and K. Fukazawa, *Electron hybrid code simulations with OhHelp load balancer for the study of relativistic electron acceleration in planetary magnetospheres, Proceedings of JSST 2016.*

- ✓ A spatially one-dimensional electron hybrid code domain-decomposed by OhHelp, a library for PIC simulation with achieving both dynamic load balancing and scalability, has been developed for the study of the generation process of whistler-mode chorus emissions and relativistic electron acceleration in the Earth's inner magnetosphere.
- ✓ We evaluated the efficiency and scalability of the developed code tested on the system A (Cray XE6) of Academic Center for Computing and Media Studies, Kyoto University.

Khasanah, N., C. W. Peng, C. H. Chen, T. Y. Huang, N. Bolouki, T. Moritaka, Y. Hara, H. Shimogawara, T. Sano, Y. Sakawa, Y. Sato, K. Tomita, K. Uchino, S. Matsukiyo, Y. Shoji, S. Tomita, S. Tomiya, R. Yamazaki, M. Koenig, and Y. Kuramitsu, *Spatial and temporal plasma evolutions of magnetic reconnection in laser produced plasmas, High Energy Density Physics, (in press), 2017.*

- ✓ Magnetic reconnection is experimentally investigated in laser produced plasmas.

Kitahara, M. and Y. Katoh, *Method for direct detection of pitch angle scattering of energetic electrons caused by whistler-mode chorus emissions, J. Geophys. Res. Space Physics*, 121, doi:10.1002/2015JA021902, 2016.

- ✓ We propose a new method to detect pitch angle scattering caused by plasma waves.
- ✓ We evaluate the feasibility of the proposed method using the simulation data.
- ✓ The proposed method enables us to identify the location where pitch angle scattering occurs. It can be applied to the results of space-based observations by the forthcoming ERG satellite.

Kuramitsu, Y., A. Mizuta, Y. Sakawa, H. Tanji, T. Ide, T. Sano, M. Koenig, A. Ravasio, A. Pelka, H. Takabe, N. Woolsey, T. Moritaka, S. Matsukiyo, Y. Matsumoto, and N. Ohnishi, *Time Evolution of Kelvin-Helmholtz Vortices Associated with Collisionless Shocks in Laser-produced Plasmas, The Astrophysical Journal*, 828, 93, 2016.

- ✓ Experimental results on Kelvin-Helmholtz (KH) instability and the associated vortices in laser-produced plasmas are reported.

Nosé, M., K. Keika, C. A. Kletzing, H. E. Spence, C. W. Smith, R. J. MacDowall, G. D. Reeves, B. A. Larsen, and D. G. Mitchell, *Van Allen Probes observations of magnetic field dipolarization and its associated O⁺ flux variations in the inner magnetosphere at $L < 6.6$, J. Geophys. Res. Space Physics*, 121, doi:10.1002/2016JA022549, 2016.

- ✓ Magnetic field dipolarization is commonly observed in the inner magnetosphere at $L = 4.5 - 6.6$. It is accompanied by strong magnetic fluctuations that have a dominant frequency close to the O⁺ gyrofrequency.

Ozaki, M., S. Yagitani, H. Kojima, K. Takahashi, H. Koji, T. Zushi and Y. Tokunaga, *Development of an ASIC preamplifier for electromagnetic sensor probes for monitoring space electromagnetic environments, Earth, Planets and Space*, doi:10.1186/s40623-016-0470-9, 68(1), 2016.

- ✓ A preamplifier for the 3-axis loop antenna of an electromagnetic sensor probe has been developed by using ASIC technology with a 0.25- μm CMOS process.

Ozaki, M., K. Shiokawa, Y. Miyoshi, R. Kataoka, S. Yagitani, T. Inoue, Y. Ebihara, C.-W Jun, R. Nomura, K. Sakaguchi, Y. Otsuka, M. Shoji, I. Schofield, M. Connors and V. K. Jordanova, *Fast modulations of pulsating proton aurora related to subpacket structures of Pc1 geomagnetic*

pulsations at subauroral latitudes, *Geophys. Res. Lett.*, **43**, 7859-7866, doi:10.1002/2016GL070008, 2016.

- ✓ Fast (a few tens of seconds) modulation of pulsating proton aurora was observed.

Santosa, H., and Y. Hobara, One day prediction of nighttime VLF amplitudes using nonlinear autoregression and neural network modeling, *Radio Sci.*, doi: 10.1002/2016RS006022, 52, 132–145, 2017.

- ✓ Nighttime VLF amplitude of NPM-CHF path is predicted by using NARX NN model.
- ✓ The model is built based on input variables of stratospheric temperature, cosmic rays flux, totalcolumn ozone, Dst index, and Kp index.
- ✓ Prediction quality: Pearson correlation is 0.94 and root-mean-square error is 1.98 dB.

Sato, Y., A. Kumamoto, Y. Katoh, A. Shinbori, A. Kadokura, and Y. Ogawa, Simultaneous ground- and satellite-based observation of MF/HF auroral radio emissions, *J. Geophys. Res. Space Physics*, **121, 4530-4541, doi:10.1002/2015JA022101, 2016.**

- ✓ First simultaneous space/ground-based observation of >1 MHz auroral radio emissions.
- ✓ Frequency differences corroborated different source altitudes across the F peak.
- ✓ Space- and ground-level detections did not always accompany one another, which were explained as spacecraft could detect THR from wider regions while auroral radio emissions generated in the bottomside F region were masked by ionospheric absorption and screening in the D/E regions associated with ionization which resulted from auroral electrons and solar UV radiation

Shimizu, C., M. Sato, Y. Hongo, F. Tsuchiya, and Y. Takahashi, Relation between charge amounts of lightning discharges derived from ELF waveform data and severe weather, *IEEJ Transactions*, doi:10.1541/ieejfms.136.252, 2016.

- ✓ We analyzed lightning current waveforms measured by a Rogowski coil installed at Mt. Oigami and ELF waveforms measured at Onagawa observatory.
- ✓ Based on comparison between the ELF and the current waveforms, empirical equations for conversion from the magnetic field intensities into the current intensities and charge amount were obtained.
- ✓ Using ELF waveform at Kuju station in Kyushu and the Japan Lightning Detection Network (JLDN) lightning data, we newly found a clear feature showing that the time variation of charge amounts drastically changed just before the downburst onset in the Kanto Plain.

Suarjaya, IMAD, Y. Kasahara, and Y. Goto, Automatic Detection of Omega Signals Captured by the Poynting Flux Analyzer (PFX) On Board the Akebono Satellite, *International Journal of Advanced Computer Science and Applications*, doi: 10.14569/IJACSA.2016.071009, 7(10), 67-74, 2016.

- ✓ An automatic detection method of Omega signals measured by the PFX receiver on board the Akebono satellite was introduced.
- ✓ The detected signals are valuable for studying the propagation characteristics of VLF waves in the ionosphere and plasmashpere.

Watanabe, H., Kurosawa, T., Kimura, E., Mizuhara, T., Murata, Ken. T., and Tatebe, O., A File Transfer Tool by UDT Multiple Streams for A Distributed File System (in Japanese), *The IEICE Transactions of Information and Systems (Japanese Edition)*, vol. J99-D(5), 514-525, doi: 10.14923/transinfj.2015AIP0009, 2016.

- ✓ In this paper, a multi-stream file transfer tool based on the UDT (UDP-based Data Transfer) protocol. We implement and experiment the performance of the tool on the international LFN (Long-Fat Network) to achieve 7 Gbps in throughput using 12 sessions.

Win Zaw Hein, Y. Goto, and Y. Kasahara, Estimation Method of Ionospheric TEC Distribution using Single Frequency Measurements of GPS Signals, *International Journal of Advanced Computer Science and Applications*, doi: 10.14569/IJACSA.2016.071201, 7(12), 1-6, 2016.

- ✓ An estimation method of TEC distribution map from single frequency GPS measurements was developed.
- ✓ The method makes it possible to expand ionospheric TEC observation networks easily.