Introduction to the THOR mission

*Yasuhito Narita[1], Andris Vaivads[2], Alessandro Retino[3], Yuri Khotyaintsev[2], Jan Soucek[4], Philippe Escoubet[5], Francesco Valentini[6], Christopher H. K. Chen[7], Andrew Fazakerley[8], Benoit Lavraud [9,10], Federica Marcucci[11], Rami Vainio[12], Martin Gehler[5], Arno Wielders[5], Jens Romstedt[5]

1. Space Research Institute, Austrian Academy of Sciences, Austria, 2. Swedish Institute of Space Physics Uppsala, Sweden, 3. Laboratoire de Physique des Plasmas, France, 4. Insittute of Atmospheric Physics, Czech Academy of Sciences, Czech Republic, 5. ESA/European Space Research and Technology Centre (ESTEC), The Netherlands, 6. Calabria University, Italy, 7. Imperial College London, UK, 8. Mullard Space Science Laboratory (MSSL), UK, 9. University of Toulouse, L'Institut de Recherche en Antrophsique et Planetologie, France, 10. Centre national de la recherche scientifique (CNRS), L'Institut de Recherche en Antrophsique et Planetologie (IRAP), France, 11. Instituto Nazionale di Astrofisica (INAF), Italy, 12. University of Turku, Finland

Fundamental plasma processes at kinetic scales such as wave-particle and wave-wave interactions play an important role in the heliosphere and various astrophysical systems. Turbulence Heating ObserveR (THOR) is the first mission under a study for ESA M4 candidate ever flown in space dedicated to understanding the heating process in collisionless plasma turbulence. THOR explores the kinetic plasma processes that determine the fundamental behavior of the majority of baryonic matter in the universe. THOR aims to find answers to the fundamental questions on the turbulent plasma processes by achieving the highest-resolution in the particle and electromagnetic field measurements in the solar wind and the regions around Earth's bow shock. Toward the launch in 2026, the spacecraft design, the instrument design, the orbit plan, and the analysis tools are presented on the THOR mission.

Keywords: plasma turbulence, spacecraft mission, solar wind, bow shock

Two-fluid tearing mode instability in cylindrical geometry

Two-fluid tearing mode instability in cylindrical geometry

*Ito Atsushi[1]、Ramos J. J.[2]
*Atsushi Ito[1], J. J. Ramos[2]

1. National Institute for Fusion Science、2. Plasma Science and Fusion Center, MIT
1. National Institute for Fusion Science, 2. Plasma Science and Fusion Center, MIT

The two-fluid tearing mode instability in a plasma cylinder of finite aspect ratio is investigated. An analytic dispersion relation for a force-free equilibrium with constant density and temperature in the cylindrical geometry for general ion skin depths, the characteristic length of the two-fluid effect, has been derived by extending the theory for the slab geometry [1]. The dispersion relation shows the continuous dependence of the growth rate and the real frequency on the ion skin depth d_i ranging from single MHD limit ($d_i << L$) to electron MHD ($d_i >> L$). Analytic representations of dispersion relations that cover a wide range of parameters are useful to carry out benchmark tests of extended-MHD simulation codes [2]. It is found that the real frequency appears due to the combination of the two-fluid and curvature effects. The scaling law for the real frequency in the regions of small and large skin depth as well as for the growth rate is also found. The numerical analysis shows good agreement with analytical dispersion relation and inner solutions of eigenfunctions for a wide range of the ion skin depth and resistivity.

[1] E. Ahedo and J.J. Ramos, Plasma Phys. Control. Fusion 51, 055018 (2009).
[2] C.R. Sovinec, J.R. King and the NIMROD Team, J. Comp. Phys. 229, 5803 (2010).

キーワード：tearing instabiliry、two-fluid MHD、force-free equilibrium
Keywords: tearing instabiliry, two-fluid MHD, force-free equilibrium

Flare Productivity in Different Magnetic Types of Active Regions

*Ya-Hui Yang[1], Min-Shiu Hsieh[2], Hsiu-Shan Yu[3], P. F. Chen[4]

1. Institute of Space Science, National Central University, Taiwan, 2. Geophysical Institute, University of Alaska Fairbanks, USA, 3. Center for Astrophysics and Space Sciences, University of California San Diego, USA, 4. School of Astronomy and Space Science, Nanjing University, China

It is believed that intense flares preferentially originate from the large-size active regions (ARs) with strong magnetic fields and complex magnetic configurations. Based on two datasets of daily sunspot and flare information as well as the GOES soft X-ray measurements and HMI vector magnetograms, we investigate the dependence of flare activity on the AR properties and clarifies the influence of AR magnetic parameters on the flare productivity. We find that flare behaviors are quite different in the short- and long-lived complex ARs and the ARs with more complex magnetic configurations are likely to host more impulsive and intense flares. Moreover, our results demonstrate that the total source field strength on the photosphere has a good correlation with the flare activity in complex ARs. Intense flares tend to occur at the regions of strong source field in combination with an intermediate field-weighted shear angle, which implies that the magnetic free energy provided by a complex AR could be high enough to trigger a flare eruption even with a moderate magnetic shear on the photosphere. We thus suggest that the magnetic free energy represented by the source field rather than the photospheric magnetic complexity is a better quantity to characterize the flare productivity of an AR, especially for the occurrence of intense flares.

Keywords: solar flare, active region

シース領域の南北磁場成分とコロナ磁場の関係
Relationship between north-south component of magnetic field in sheath regions and coronal magnetic fields

*西村 信彦[1]、徳丸 宗利[1]、藤木 謙一[1]、林 啓志[2,1]、袴田 和幸[3]
*Nobuhiko Nishimura[1], Munetoshi Tokumaru[1], Ken'ichi Fujiki[1], Keishi Hayashi[2,1], Kazuyuki Hakamada[3]

1. 名古屋大学宇宙地球環境研究所、2. 中国科学院国家宇宙科学センター、3. 中部大学
1. Institute for Space Earth Environmental Research, Nagoya University, 2. National Space Science Center, Chinese Academy of Sciences, 3. Chubu University

Southward interplanetary magnetic field (IMF) is a crucial factor that causes geomagnetic storms. A majority of geomagnetic storms is associated with magnetic clouds (MCs) or sheath regions, since a large southward component of IMF is likely to occur in these regions. Therefore, it is important to understand north-south (NS) component of IMF associated with MCs and sheath regions for space weather forecast. MCs are studied by many researchers using flux rope models. However, the origin of IMF at sheath regions is poorly investigated and it is still not clear how IMF in sheath regions is related to coronal magnetic fields. We investigate the relationship between the NS component of IMF in sheath regions and coronal magnetic fields. Here, we assume that coronal magnetic fields around prominence eruption sites move outward and are then convected into the interplanetary space to be observed at the Earth during the passage of sheath regions. In this study, we calculate coronal magnetic fields from the Kitt Peak/NSO photospheric magnetic field data using the PFSS model [Hakamada, 1998] and extrapolate these fields radially outward to 1AU at background solar wind velocity. The background solar wind velocity is given from interplanetary scintillation observations at ISEE via the tomographic analysis. The coronal magnetic fields are projected to 1AU using the background solar wind velocity data and the 1D-HD solar wind model developed by K.Hayashi. We examine whether the sign of the NS component (in RTN coordinates) of the projected coronal magnetic field agrees with that of the field observed by ACE spacecraft prior to MC arrival at the Earth. We make the comparison three hours before the MC start time (pre MC time) and at the MC start time (MC time) for five MC events during 2006–2007. As a result, we find that the sign of NS component of the magnetic field extracted from 1.1 solar radius (R_s) or 1.2 R_s agrees with ACE observation at the MC time for all MC events analyzed here. The same result is obtained from the analysis that uses UCSD time-dependent tomography [Jackson et al., 2013] for solar wind model (this result was reported at the JPGU 2016). The result indicates that the coronal magnetic field at low height erupts and the field is observed at the MC time. We also determine the solar sources of the MCs and those of the projected coronal magnetic fields. We find that the sign of NS component at the source of projected coronal magnetic field agrees better with that of NS field observed at the Earth at the MC time than the source of MC. This result indicates that the IMF observed at the sheath comes from the source region of the background solar wind, not from the source region of MC.

キーワード：コロナ磁場、磁気雲、宇宙天気、太陽風
Keywords: coronal magnetic field, magnetic cloud, space weather, solar wind

Occurrence characteristics of Type-III solar radio bursts in the solar quiet period

松本 紗歩[1]、*三澤 浩昭[1]、土屋 史紀[1]、増田 智[2]、小原 隆博[1]
Saho Matsumoto[1], *Hiroaki Misawa[1], Fuminori Tsuchiya[1], Satoshi Masuda[2], Takahiro Obara[1]

1. 東北大学大学院理学研究科惑星プラズマ・大気研究センター、2. 名古屋大学宇宙地球環境研究所
1. Planetary Plasma and Atmospheric Research Center, Graduate School of Science, Tohoku University, 2. Institute for Space-Earth Environmental Research, Nagoya University

Type III bursts are impulsive radio bursts generated in association with solar flare. A characteristic spectral nature of Type III burst is its first negative frequency drift, which is considered to reflect energetic electrons moving upwards from the sun along an open magnetic field line generated by the magnetic reconnection process near the sun. On the other hand, it is also considered that simultaneously generated downward energetic electrons move into the dense chromosphere and make thermalized plasma, which enhances soft X-ray emissions (SXR) and is recognized as occurrence of flare. Thus, it is expected that solar flares in SXR have a tight relation with Type III bursts. However, there seems to be no small number of examples of Type III bursts which occur in weak or no SXR flare event.

We have derived characteristics of Type III bursts appeared in the solar quiet period and have compared them with SXR variations to investigate their mutual relation. For this purpose, we have analyzed dozens of Type III bursts appeared after 2014 using the database of the meter-wave range solar radio telescope in Tohoku University (IPRT/AMATERAS). For estimating SXR variations we have used the database of GOES SXR. As the result, it is indicated that the correlation between energy of Type III burst and corresponding variation of SXR is low actually, and Type III bursts with similar intensity appeared in a few orders of SXR variations. Then, we have also investigated expected solar surface phenomena corresponding to each Type III burst for revealing causalities of the low correlation. We referred to the RHESSI flare list and surveyed solar surface phenomena using the SDO/AIA image data. It is suggested that Type III bursts with very weak or no variation in SXR were related to compact solar surface phenomena such as EUV spot or jet. This result implies a possibility that a causality of the low correlation is due to the height or scale size of magnetic reconnection region which affects SXR intensity.

In the presentation we will introduce results of the statistical and event analyses of Type III bursts in the solar quiet period precisely and discuss expected causalities of the low correlation.

Acknowledgements: We thank the GOES, RHESSI and SDO teams for providing the solar data.

キーワード：太陽、III型バースト、フレア
Keywords: sun, type III burst, flare

かぐやが観測した磁場と月面の磁場を3D表示するソフトの開発
Software for virtual 3-dimensional display of Kaguya in-situ observation of magnetic field and the magnetic anomalies on the moon

高寺 寿門[1]、*中川 朋子[1]、綱川 秀夫[2]
Hisato Takatera[1], *Tomoko Nakagawa[1], Hideo Tsunakawa[2]

1. 東北工業大学工学部情報通信工学科、2. 東京工業大学大学院理工学研究科地球惑星科学専攻
1. Information and Communication Engineering, Tohoku Institute of Technology, 2. Department of Earth and Planetary Sciences, Tokyo Institute of Technology

かぐや衛星によって月周回軌道上で観測される多様な磁場変動は、太陽風と月面及び月の固有磁場との相互作用を反映している。それぞれの変動の発生メカニズムの解明には、月に対する衛星の位置だけでなく、衛星と月面間の磁力線のつながりや固有磁場との位置関係を考慮する必要があるが、太陽風、月面、太陽風磁場、月固有磁場の位置関係を２元的な表示で把握するのは困難である。そのため、これらを３次元的に表示し、見やすい角度から吟味できる表示ソフトウェアを開発した。

本ソフトウェアで表示するデータは、衛星かぐやに搭載された月磁場観測装置LMAGで観測された磁場3成分の１秒平均値、およびかぐやの月磁場観測に基づいてSVM法によって得られた高度0kmおよび月面上空30kmの月面上磁場である。月面上空0kmは60.6km間隔、月面上空30kmは151.6km間隔で推定したデータを使用する。ソフトウェア開発では3次元コンピュータグラフィックスのためのライブラリOpenGLを使用する。開発環境はMicrosoft Visual studio 2013で、言語はC言語を使用し、動作環境はOS:Winsows 8 64 bit、CPU:Intel Core i5である。

本ソフトウェアによって、かぐやの位置における磁場ベクトルとともに月面の磁場を３次元的に表示し、かぐやが観測したデータが月面の磁場の影響を受けているかどうかを把握することが容易になった。月面の磁場は色による強度表示のほか、ベクトルによる表示も選べるようにした。ユーザが入力した日付と時刻からデータを読み続けることによって月周回のアニメーションの再生や一時停止も可能であり、視点を自由に移動させることでイベントごとに見やすい方向からの画像を得ることが可能となった。

キーワード：かぐや、磁場観測装置、３次元表示、固有磁場、磁気異常、太陽風
Keywords: Kaguya, MAP/LMAG, 3D display, crustal magnetic field, magnetic anomaly, Solar wind

「ひさき」衛星による惑星間空間のヘリウム分布光学観測
Optical observation of neutral helium distribution in interplanetary space by Hisaki

*山崎 敦[1]、村上 豪[1]、吉岡 和夫[2]、木村 智樹[3]、土屋 史紀[4]、鍵谷 将人[4]、坂野井 健[4]、寺田 直樹[5]、笠羽 康正[5]、吉川 一朗[6]、ひさき（SPRINT-A） プロジェクトチーム
*Atsushi Yamazaki[1], Go Murakami[1], Kazuo Yoshioka[2], Tomoki Kimura[3], Fuminori Tsuchiya[4], Masato Kagitani[4], Takeshi Sakanoi[4], Naoki Terada[5], Yasumasa Kasaba[5], Ichiro Yoshikawa[6], Hisaki (SPRINT-A) Project team

1. 宇宙航空研究開発機構　宇宙科学研究所、2. 東京大学大学院理学系研究科地球惑星科学専攻、3. 国立研究開発法人理化学研究所仁科加速器研究センター、4. 東北大学大学院理学研究科惑星プラズマ・大気研究センター、5. 東北大学大学院理学研究科、6. 東京大学
1. Institute of Space and Astronautical Science / Japan Aerospace Exploration Agency, 2. Department of Earth & Planetary Science, Graduate School of Science, The University of Tokyo, 3. Nishina-Center for Accelerator Based Science, RIKEN, 4. Planetary Plasma and Atmospheric Research Center, Graduate School of Science, Tohoku University, 5. Graduate School of Science, Tohoku University, 6. The University of Tokyo

The Hisaki (SPRINT-A) satellite has a main scientific topic of the planetary continuous observation for a long term, but carried out the non-planet observation at the time when no planet during a good observation opportunity phase exists. One case of those is observation of helium atom resonance scattering from the interplanetary space.
The interstellar wind flows into the heliosphere over the heliopause by the relative velocity of the heliosphere and the interstellar medium. The helium atom can travel into about 0.5Au from the neighboring of the sun without ionizing because of its high ionization energy. The travelling orbit is bent by sun gravity and forms a high density region on the downwind side. It is called helium cone. The distribution of helium atoms in the helium cone can estimate the speed and direction of the interstellar wind, and the density and the temperature of the helium atom in interstellar space. Such a study was carried out from the 1970s.
Recently the study of interstellar space is one of interesting topics owing to the IBEX satellite observation results. Frisch (2013) shows that the interstellar wind direction gradually changes for this several decades. However, it is shown that the direction is stable from the re-analysis of the IBEX observation (Mebius et al., 2015) and the hydrogen scattering emission distribution observed by SOHO/SWAN (Koutroumpa et al., 2017).
The Hisaki satellite carried out the optical observation of the resonance scattering from helium corn. It is a different method from the IBEX and SOHO observations and it is important to confirm the interplanetary helium distribution continuously. In 2015 and 2016 seasons, Hisaki observed the helium cone including a ecliptic longitude with the maximum density of the helium. In this presentation, the helium cone observation results are reported and it is discussed whether the change of the wind direction or not.

キーワード：ひさき衛星、極端紫外分光観測、星間風・星間ガス、惑星間空間中性ヘリウム
Keywords: HISAKI satellite, EUV spectral observation, Interstellar wind and gas, Interplanetary neutral helium

