Introduction to the THOR mission

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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

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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.

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Keywords: tearing instabiliry, two-fluid MHD, force-free equilibrium

Flare Productivity in Different Magnetic Types of Active Regions

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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

Relationship between north-south component of magnetic field in sheath regions and coronal magnetic fields

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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.

Keywords: coronal magnetic field, magnetic cloud, space weather, solar wind

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

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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.

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Keywords: sun, type III burst, flare

Software for virtual 3-dimensional display of Kaguya in-situ observation of magnetic field and the magnetic anomalies on the moon

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A variety of magnetic fluctuations were found by Kaguya in its orbit around the moon. They manifest the interaction between the solar wind and the lunar surface or the lunar crustal magnetic field. To understand the generation mechanisms of those phenomena, it is crucial to examine the relative potion of the spacecraft with respect to the moon in the solar wind and the magnetic anomaly on the surface, as well as the magnetic connection between the spacecraft and the moon.
In order to make it easier to realize the 3-dimentional configuration, we have developed computer software which enables a virtual 3-dimensional display of magnetic field vectors observed by Kaguya on the position of the spacecraft, together with the lunar magnetic field displayed on the moon. The data used are the 1-s averages of the Kaguya/LMAG magnetometer and SVM data (Tsunakawa et al., 2015, JGR Planet).

Keywords: Kaguya, MAP/LMAG, 3D display, crustal magnetic field, magnetic anomaly, Solar wind

Optical observation of neutral helium distribution in interplanetary space by Hisaki

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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.

Keywords: HISAKI satellite, EUV spectral observation, Interstellar wind and gas, Interplanetary neutral helium

