Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

PEM05-01 Room:303 Time:May 20 14:15-14:30

space propulsion concepts using space environment

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Two types of space propulsion systems using space environment are discussed mainly in terms of orbit control capability.

1. Magnetic Sail in the Solar Wind Flow

Magnetic sail (Magneto-plasma sail) is an interplanetary space propulsion concept which produces the propulsive force due to the interaction between the artificial magnetic field around the spacecraft and the solar wind erupted from the Sun. The thrust can be approximated as continuous outward radial acceleration that is inversely proportional to the square of the radial distance from the sun.

A guidance scheme is proposed for orbital motion under continuous outward radial acceleration that varies in accordance to the solar wind intensity. The maximum attainable radial distance of the outbound trajectory is investigated, and a guidance scheme for achieving this target maximum distance is established under radial acceleration disturbances. The scheme not only provides a control law for continuous radial acceleration but also yields the amount and timing of impulsive maneuvers required to satisfy the guidance requirement at the terminal point.

2. Charged Satellite in the Earth Magnetic Field

The motion of a charged satellite subjected to the Earth's magnetic field is considered. The Lorentz force, which acts on a charged particle when it is moving through a magnetic field, provides a new concept of propellantless electromagnetic propulsion. A dynamic model of a charged satellite, including the effect of the Lorentz force in the vicinity of a circular or an elliptic orbit, is derived and its application to formation flying is considered. Analytical approximations for the relative motion in Earth orbit are obtained. The sequential quadratic programming method is applied to solve the orbital transfer problem. A strategy to reduce the charge amount using sequential quadratic programming is also developed.

Keywords: space peopulsion, space environment, orbital mechanics

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PEM05-02 Room:303 Time:May 20 14:30-14:45

The space weather research for deep space probes -Evaluation of solar energetic particles exposure on Akatsuki II-

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Space weather researches have become more and more important, according to the expansion of the ”humanosphere” to the space. On the other hand, current space weather researches are mainly for circumterrestrial space, not for the deep space probes that are located far from the earth. We aim to forecast and evaluate the radiation hazard to such space probes far from the earth by using the data taken by the Solar Terrestrial RElations Observatory (STEREO). STEREO provides the images of the part of the Sun that is invisible from the Earth, but only EUV images and coronagraph images are available. First, we examine the possibility of the evaluation of the radiation hazard by using EUV and coronagraph images. It is known that solar energetic particles (SEPs) flux is well correlated with the speed of coronal mass ejection (CME) measured by a coronagraph. We focused on two successive flare/CME events occurred on June 4th, 2011. It occurred in an active region that located on the invisible side of the Sun, and near the disk center as seen from Akatsuki (PLANET-C), the Venus Climate Orbiter that was orbiting the Sun at around 0.7AU. On June 5th, an abrupt decrease in the electric power of Akatsuki was observed, which may be attributed to the effect of SEPs associated with the flare/CME events. We measured the velocity of the two CMEs using the coronagraphic images from STEREO and found that the second CME was much faster (about 2200 km/s) than the first one (about 1000 km/s). Considering the time difference between the two events, it is likely that the second CME caught up the first one before they arrived at 0.7AU. The estimated arrival time is consistent with the timing of the power decrease of Akatsuki. According to a statistical study of CMEs and SEPs preformed by Gopalswamy et al (2004) SEP flux tends to become large if a preceding CME have been launched within 24 hours ahead of the onset time of the primary CME. Using the empirical relationship between the SEP flux and the CME velocity derived by Gopalswamy et al. (2004), we estimate the SEP flux of 10ˆ2-10ˆ4 cmˆ-2 sˆ-1 srˆ-1. We are also analyzing other large similar events that may potentiallyaffected Akatsuki. We will briefly report these events.We are also analyzing other large events that may potentially affected Akatsuki such as that occurred on January 23 2012.

Keywords: Solar flare, CME, SEP, Space weather

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PEM05-03 Room:303 Time:May 20 14:45-15:05

STEREO Views the Farside: CME and Solar Wind Research from STEREO Observations At large Separation Angles

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In the last two years, the STEREO spacecraft have reached opposition and have moved towards the farside of the sun. They are the first man-made probes to image the solar corona and heliosphere from such widely-separated viewing angles. At the same time, we are treated to continuous coverage of the full 360 degree corona during the maximum of solar activity, thanks to the support from AIA and LASCO observations. These unprecedented viewing conditions have opened up new research avenues, such as the study of the lifetime of active regions, the large-scale coupling in eruptive events, and the surprising extent of solar energetic particles in the inner heliosphere.

In this talk, I review the latest research on these areas and outline the future plans for the STEREO observations of the farside of the Sun. I will conclude with a discussion of the implications for Space Weather studies, including an operational Space Weather mission of interest to the Japanese space physics community—a mission to the L5 Lagrangian point.

Keywords: Space Weather, Coronal Mass Ejections, Solar Wind

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PEM05-04 Room:303 Time:May 20 15:05-15:20

Simulation Study of Solar Plasma Eruption by Interaction between Emerging Flux and Coronal Arcade Field

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Many kinds of eruptive phenomena, such as eruptive flares, solar filament eruptions and coronal mass ejections (CMEs) are seen in the solar atmosphere and sometimes have an crucial influence on the earth's magnetosphere.It is widely believed that these eruptive phenomena are caused by the same MHD mechanism by which magnetic energy stored in the corona is released. On the other hand, the detailed mechanism has not been clarified. Many observational studies reported the events which are triggered by the interaction between the newly emerging flux and the coronal arcade field. It is also suggested in these studies that reconnection has an important role in the triggering mechanism. In order to clarify the triggering mechanism by interaction between the emerging flux and the coronal arcade field and its parameter dependence, we perform 2.5-dimensional MHD simulation. The controlled parameters are the magnetic field strength, the location of the emerging flux relative to the arcade field, and the shear angle of the arcade field. As a result, two types of mechanisms are found and these are separated in a parameter space of the location of the emerging flux. One of them appears when the location of the emerging flux is around the polarity inversion line (PIL) of the arcade field and this mechanism depends on reconnection between the emerging flux and the arcade field, as pointed out by the observations. Another appears when the location of the emerging flux is far from the PIL and depends on reconnection in the arcade field above the PIL. We discuss how the interaction between the emerging flux and the arcade field causes eruptions and which kinds of conditions are required. Our results show the possibility to predict whether an eruption occurs or not by investigating the amount of flux of the emerging flux and the distribution of the ambient magnetic field.

Keywords: solar flare, solar filament eruption, coronal mass ejection

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PEM05-05 Room:303 Time:May 20 15:20-15:35

Observations from Hinode and SDO of a Twisting and Writhing Start to a Solar-filament-eruption Cascade

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We analyze data from SDO and Hinode of a solar eruption sequence of 1 June 2011 near 16:00 UT, with emphasis on the early evolution toward eruption. Ultimately, the sequence consisted of three emission bursts and two filament ejections. SDO/AIA 304 Ang images show absorbing-material strands initially in close proximity that over ~20 min form a twisted structure, presumably a flux rope with ~10^29 ergs of free energy that triggers the resulting evolution. A jump in the filament/flux rope's height (average velocity ~20 km/s) and the first burst of emission accompanies the flux-rope formation. After ~20 min more, the flux rope/filament kinks and writhes, followed by a semi-steady state where the flux rope/filament rises at (~5 km/s) for ~10 min. Then the writhed flux rope/filament again becomes MHD unstable and violently erupts, along with rapid (> 50 km/s) ejection of the filament and the second burst of emission. That ejection removed field that had been restraining a second filament, which subsequently erupts as the second filament ejection accompanied by the third (final) burst of emission. Magnetograms from SDO/HMI and Hinode/SOT, and other data, reveal several possible causes for initiating the flux-rope-building reconnection, but we are not able to say which is dominant. Our observations are consistent with tether-cutting reconnection initiating the first burst and the flux-rope formation, with MHD processes initiating the further dynamics. Both filament ejections are consistent with the standard model for solar eruptions. NASA supported this work through its Heliophysics program.

Keywords: Sun: CMEs, Sun: filaments, prominences, Sun: flares, Sun: UV radiation

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PEM05-06 Room:303 Time:May 20 15:35-15:54

The science of geomagnetically induced currents

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Geomagnetically induced currents (GIC) phenomenon impacting long conductor systems on the ground can be considered as the end link of chain of complex physical processes comprising the Sun-Earth system. In this paper I briefly review the current status of our understanding of the physics of GIC and novel applications enabled by the new understanding. More specifically, I will demonstrate how we can follow the chain of physical processes from the solar corona down to the upper mantle of the Earth and to GIC. Further, I will show how state-of-the-art models enable predictive modeling of the entire chain of complex processes.

The potential for severe societal consequences has been driving recent increasing interest in extreme GIC events. I will show how we have addressed the issue by generating 100-year GIC event scenarios. These scenarios are of substantial power grid industry interest and have been fed directly into further engineering analyses. I will review the results of our of 100-year geomagnetically induced current scenarios work and discuss some of the future directions in the field.

Keywords: space weather, geomagnetically induced currents, modeling, extreme events

PEM05-07 Room:303 Time:May 20 16:15-16:30

Global MHD simulation of the magnetospheric response to large and sudden enhancement of the solar wind dynamic pressure

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New global MHD simulation of the magnetosphere has been developed and is now available for somewhat extreme solar wind input parameters. We started to investigate interesting phenomena including super-large sudden commencement (super SC), geosynchronous magnetopause crossing (GMC), as well as the saturation of cross polar cap potential etc. Here we show the initial results on the response of the magnetosphere to large and sudden enhancement of the solar wind dynamic pressure, gradually increasing the dynamic pressure up to the extreme level of GMC. We discuss the fundamental mechanisms of transient response.

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PEM05-08 Room:303 Time:May 20 16:30-16:45

Influence of a giant solar energetic particle event on atmospheric chemistry

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In a giant Solar Energetic Particle (SEP) event associated with a giant solar flare, high-energy protons bombard the stratosphere with high-energy neutrons and high-energy photons. The SEPs ionize and dissociate nitrogen and oxygen molecules along with their tracks, and subsequent chemical reactions induce the change of chemical compositions. Here we investigate the chemical composition changes in the middle atmosphere caused by a giant SEP event. Our calculation includes detailed ion chemistry for the first time to assess this problem.

The SEPs firstly yield charged products (N^+, O^+, $N2^+$, $O2^+$, and e^-) and neutral atoms ($N(^4S)$, $N(^2D)$, $N(^2P)$, $O(^3P)$, and $O(^1D)$) in the atmosphere. These ions are relatively short-lived, and are soon converted into neutral chemical species. It is suggested[1)], however, that detailed ion chemistry is crucial to understand the chemical composition changes during/after a SEP event. For this, we have considered 12 high-energy radiation processes (radiolysis) and more than 200 chemical reactions as the first step, including ion-molecule reactions, photo-dissociations, ion-ion and ion-electron recombinations, as well as neutral chemical reactions such as NO_x (odd nitrogen radicals), HO_x (hydrogen oxide radicals), and ClO_x (chlorine oxide radicals) cycles. We numerically solve the simultaneous differential equations for these reactions in a reaction network within the so-called box model: a zero-dimensional, *i.e.*, local model where no transport processes are considered. In the box model, climatological temperature for several geometric altitudes between 25 km (lower stratosphere) and 75 km (upper mesosphere) are employed to find the equilibrium state in the concentration of chemical species. The fluence of SEPs is then estimated based on ion-pair production rate calculation[2)], and is introduced into the equilibrium state in the box model as an energy input perturbation. In this talk, chemical composition changes in the stratosphere during/after the event will be reported on the timescale of several *days*, for which the transport processes are not important. In particular, we will focus our attention on the enhancement in the concentration of reactive nitrogen (NO_y) and on the depletion in the concentration of ozone (O_3) in the stratosphere. This is because NO_y species become the source of nitrate that plays an important role when they precipitate, and because O_3 depletion in the stratosphere changes the temperature and the winds thus may be related with the climate change near the surface.

The results of our box model will be combined with a three-dimensional chemistry-climate model (CCM) to study global influence of the giant SEP event. Here the distribution of chemical compositions is investigated on the timescale of several *years*, where the transport processes are essential and are properly considered. We will then briefly discuss some results from our CCM simulations (in more detail, refer to a presentation by Akiyoshi *et al.* in the session “stratospheric processes and their role in climate” of this meeting).

References

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Keywords: solar energetic particles, atmospheric chemistry, model calculations

PEM05-09 Room:303 Time:May 20 16:45-17:00

Rapid events in the carbon-14 content of tree-ring

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Measurement of cosmogenic nuclides, which are radioisotopes produced by cosmic rays, can provide us important information to search past extraterrestrial high-energy events such as supernova, solar proton event (SPE), and so on. Until now, the contents of ^{14}C in tree-rings and ^{10}Be in ice cores have been used for this purpose. However, no clear evidence has been found by ^{14}C and ^{10}Be.

We show the results of ^{14}C content measurement in Japanese cedar annual rings from AD 600 to 1020 with 1- to 2-year resolution, and report two findings of rapid increases of ^{14}C content from AD 774 to 775 and AD 992 to 993. These are clear increases against its measurement errors. The shapes of the two series are very similar, i.e., a rapid increase within one year followed by a decay due to the carbon cycle. The scale of the AD 993 event is 0.6 times as large as the AD 775 event.

The 10Be flux in the Antarctic ice core also shows peaks corresponding to these two ^{14}C events. The proportions of flux increase ($^{14}C/^{10}Be$) of the two events are consistent with each other. Therefore, it is highly possible that these events have the same origin.

Although the cause of this event can be explained by a large solar proton event (SPE) or a short gamma-ray burst, we conclude that solar activity is a plausible cause because the occurrence rate of ^{14}C increase events is inconsistent with a observed rate of an short gamma-ray bursts.

PEM05-10 Room:303 Time:May 20 17:00-17:15

The magnetosphere-ionosphere convection in the solar wind without magnetic fields

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We investigate the magnetosphere-ionosphere convection when merging between the interplanetary magnetic field (IMF) and the magnetospheric one is not effective. To perform the simulation in this condition, we assign the IMF with extremely small intensity. The simulation reveals that the magnetosphere has long magnetotail unlike the closed magnetosphere proposed by Axford and Hines [1961]; this means traditional viscous interaction may not play an important role. It is also obtained that the ionospheric convection exhibits a 2-cell pattern like the magnetosphere-ionosphere convection system for the southward IMF condition. It is revealed that the magnetosphere-ionosphere convection is associated with the R1 field-aligned current generated in the cusp-mantle region where the convection plasma flow traverses the cusp region with enhanced plasma pressure. The traversing plasma flow in the cusp region is fed by the magnetosheath flow which enters into the cusp region along the magnetic field lines. Thus, the magnetosphere-ionosphere stationary convection is performed without the merging.

Keywords: Extreme space weather, solar wind-magnetosphere interaction, magnetosphere-ionosphere convection, MHD simulation, compound system, viscous interaction

PEM05-11 Room:303 Time:May 20 17:15-17:30

Measurements of Chromospheric and Coronal Magnetic Fields by Nobeyama Radioheliograph

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The magnetic fields of the corona and the chromosphere are important to understand various coronal phenomena and improve the space weather research. In magnetized plasma, ordinary and extraordinary modes of the free-free emission have different optical depths. Hence, the radio circular polarization observation enables us to derive the longitudinal component of the magnetic field. In this study, we have derived coronal and chromospheric magnetic fields from circular polarization observations by Nobeyama Radioheliograph (NoRH).

NoRH observes the full solar disk every 1 second at 17 GHz (intensity and circular polarization) and 34 GHz (intensity). We selected an active region located near the center of the solar disk that has large longitudinal component of the magnetic field. Then, a frequency spectral slope of radio brightness temperature was derived from the ratio of brightness temperatures at 34 GHz and 17 GHz. The brightness temperatures of the quiet Sun at 17 GHz and 34 GHz are assumed to be 10000 K and 9000 K, respectively, from Selhorst et al (2005). The radio spectral slope of the quiet region is about 0.15 using this assumption. The observed radio spectral slope is between 0.2 and 0.6 around the active region. The ratio between the observed radio magnetic field and the corresponding photospheric magnetic field is about 0.4 to 0.6.

The observed radio magnetic field contains both of the coronal and chromospheric components. We assume that the solar atmosphere observed at microwave range has two components; the optically thin corona and the optically thick chromosphere. The radio circular polarization images are compared with the ultraviolet images observed by AIA onboard the SDO spacecraft and potential field extrapolations using the photospheric magnetic field. Around the edge of the active region, the location of the observed radio circular polarization corresponds to that of the coronal magnetic field and its loop structures. On the other hand, the chromospheric component is dominant at the center of the active region. Hence, it is suggested that the 17 GHz observation can derive both of the coronal and chromospheric magnetic fields. Circular polarization observations at multiple frequency bands can separate the coronal and chromospheric components more accurately.

Keywords: Sun: radio radiation, Sun: magnetic fields, Sun: corona, Sun: chromosphere, Nobeyama Radioheliograph, circular polarization degree

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PEM05-12 Room:303 Time:May 20 17:30-17:45

Association of Polar Faculae with the Polar Magnetic Patches as Revealed with Hinode Observations

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Polar faculae are small bright features in the polar region of the Sun. They are observed with concentrations of magnetic fields. Previous studies have shown that the number of polar faculae observed at latitudes greater than 60 degree has 11-year periodicity like the sunspot cycle and that their occurrence maximum is anti-correlated with the solar cycle. The aim of this study is to understand the properties of polar faculae, which are believed to be associated with the polar magnetic patches. We analysed data of the north polar region taken by the Hinode/SOT spectropolarimeter (SP) in September 2007. Accurate measurements of vector magnetic fields at high spatial resolution by Hinode/SP for the first time allow us to compare polar faculae with polar magnetic fields in detail. The continuum intensity map is corrected for limb darkening. There are many patchy magnetic field structures in the polar region and thresholds on both size and intensity for the patches are applied to automatically choose polar faculae pixels. The definition of magnetic patch is same as in Shiota et al. (2012 ApJ).We find that: (1) magnetic patches are not uniformly bright but contain smaller faculae inside. (2) polar faculae tend to have stronger and more vertical magnetic fields than their surrounding within the magnetic patches.(3) almost all magnetic patches with total magnetic flux greater than 10^{18} Mx are associated with polar faculae. From Shiota et al. (2012), such magnetic patches vary with the solar cycle.(4) polar faculae flux accounts only for less than 12% of the total vertical magnetic flux of the polar region observed in this study. But as polar faculae are associated with large magnetic flux concentrations they can be considered as good proxy of the cycle varying component of the polar magnetic field.

Furthermore, we confirm two previous studies:(5)The contrast of polar faculae decreases towards the limb (Okunev and Kneer, 2004).(6)Polar faculae with polarity opposite to that of the polar magnetic field exist, but they are very small in number which is consistent with the result by Blanco Rodriguez et al. 2007.

Keywords: Sun, Photosphere, Polar Magnetic Field, Polar Faculae

PEM05-13 Room:303 Time:May 21 09:00-09:15

Derivation of the Solar Plage Index using the Flare Monitoring Telescope at Hida Observatory

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It is well known that the solar irradiance modulates at 11-year solar cycle. There have been many arguments on the relation between the solar cycle and the earth's climate, but at least it is well established that UV/EUV directly affect the upper atmosphere of the earth. The solar UV radiation is mainly emitted by the chromospheric height. In the solar chromosphere, magnetic features such as dark filaments and bright plages are observed . Recently Bertello, Ulrich, and Boyden (2010) developed the Ca II K plage index based on the area occupied by plages and active network on the solar disk,and found good consistency with the UV irradiance.

We aim to derive a proper index of solar UV radiation using the chromospheric H-alpha images observed by the Flare Monitoring Telescope. The Flare Monitoring Telescope has operated at Hida Observatory since 1996 and at Ica University in Peru since 2010. It obtains the full disk images of the Sun at H-alpha center and wings. In this work we analyze the H-alpha center images in order to estimate the area of dark filaments and plages. We report our method to derive the filament and plage indices based on the histogram of the H-alpha intensities. We also makes indices separated into the low and high latitudes, to see their differences of their long-term variation.

The preliminary results show that the plage index in the solar minimum 23/24 is lower compared to the one in the solar minimum 22/23. This is consistent with the recent satellite observation of UV radiation (e.g., Stanley et al. 2010). However, if we calculate the plage index only in the high latitude, the indices of the two minima are about the same. Relations between average magnetic field strength, EUV images, and coronal holes will be discussed. Our results tells that the plage index may work as a powerful tool for the estimation of UV radiation back decades in time before the start of the satellite observations, and additionally gives some insights to their origins.

Keywords: solar chromosphere, H-alpha, ultraviolet, solar irradiance

PEM05-14 Room:303 Time:May 21 09:15-09:35

Long-Term Relativistic Radiation Belt Electron Responses to GEM Magnetic Storms

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We present a long-term radiation belt simulation for a 200-day period starting on 25 January 1991, which includes both six geomagnetic storms identified by the Geospace Environment Modeling (GEM) focus group and non-stormy periods of the Combined Release and Radiation Effects Satellite (CRRES) mission, using 3-D time-dependent Versatile Electron Radiation Belt (VERB) code, and compare the simulation results with a multisatellite phase space density (PSD) reanalysis obtained using Kalman filtering of observations from CRRES, GEO, GPS, and Akebono satellites, as well as with the CRRES MEA 1 MeV electron observation. The processes accounted for in the model are radial diffusion-driven by Ultra-Low Frequency (ULF) electromagnetic fluctuations and local (pitch-angle and energy) scattering by plasmaspheric hiss and chorus waves, respectively, inside and outside the plasmasphere. The observations show that a significant decrease in the relativistic electrons in the outer radiation belt is observed in association with the solar wind dynamic pressure enhancement during the main phase of each storm, while during the recovery phase, different types of relativistic electron flux profiles are identified: increased, decreased, and unchanged relative to the pre-storm flux level. First, for an increase of relativistic electrons relative to the pre-storm flux level, the comparison of simulation with reanalysis shows that inward radial diffusion and local acceleration coupled with each other result in a net acceleration. Second, for a decrease or lack of change in relativistic electrons, competing effects of pitch-angle scattering, outward diffusion, and acceleration produce the net decrease in electron PSD and fluxes. The results show that the overall time evolution of the radiation belt is in good agreement with our model simulations, indicating that modeling, including radial diffusion and pitch-angle scattering, is reasonable in predicting the general long-term structure of the outer radiation belt. In addition, with the assistance of local acceleration by chorus waves, the overall flux level in the outer radiation belt becomes comparable to the observation.

Keywords: Radiation Belt, Magnetic Storm, Diffusion Simulation

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PEM05-15 Room:303 Time:May 21 09:35-09:50

Long-Term Variation of Solar UV/EUV Radiation Examined by Full-Disk Solar Images

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We report the estimation of long-term variations of solar UV/EUV radiations, which affect on the upper thermosphere, by using full-disk solar images. The SOHO/EIT has shown us full-disk features of the sun in EUVs over 15 years. These data enable us to derive the, spatially resolved, long-term variation of area, brightness of coronal holes, active regions, and so on. In this work we examined the EUV 304 A emission in different latitudes by using full-disk images taken by SOHO/EIT.

By comparing the EUV 304 A emissions at solar minima, we found that the EUV emission at low (high) latitude is darker (brighter) at the solar minimum 23/24 than those at the minimum 22/23. We also discuss the relation between the abnormal behaviors at the solar minimum 23/24 and the magnetic field structure by using magnetograms obtained by SOHO/MDI and

by Wilcox Solar Observatory. On the other hand, ground-based chromospheric observations also give us another indicator of solar UV emission, since solar UV radiation mainly comes from the chromosphere. From these data, we try to derive the main features on the solar surface that affect on the upper thermosphere and to estimate the long-term UV/EUV variations.

Keywords: Solar Cycle, Long Term Variation, UV/EUV Radiation

PEM05-16 Room:303 Time:May 21 09:50-10:05

Development of a high-resolution whole atmosphere-ionosphere coupled model

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Geospace is a highly complex system, consisting of the solar wind, the magnetosphere, the ionosphere, and the neutral atmosphere. In particular, the magnetosphere, the ionosphere, and the neutral atmosphere are strongly coupled with each other, and interaction between the regions is nonlinear and extremely complicated. Furthermore, the upper atmospheric environment is significantly affected not only by electromagnetic energy and particles from the sun, but also by various kinds of atmospheric waves from the lower atmosphere. In order to quantitatively understand such a complicated system, it is necessary to model the entire region by including all fundamental processes self-consistently. A number of numerical models of geospace have been constructed and used to study space weather disturbances in many institutions in the world. We have developed an atmosphere-ionosphere coupled model, which includes the whole neutral atmosphere and the ionosphere. The model is called GAIA (Ground-to-topside model of Atmosphere and Ionosphere for Aeronomy). Using GAIA, some unsolved phenomena in the upper atmosphere have been reproduced and studied. The model will be a useful tool for space weather research and forecast. Based on GAIA, we are developing a more realistic atmosphere-ionosphere model with higher spatial resolution and more physical processes. We will report previous results obtained by GAIA, and a plan for the next-generation model.

Keywords: model, atmosphere, ionosphere, coupling, space weather, geospace

PEM05-17 Room:303 Time:May 21 10:05-10:20

Detection of the emerging magnetic flux beneath the visible surface of the Sun

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Solar active regions including sunspots are thought to be the consequence of the emerging magnetic flux from the deeper convection zone. They may cause catastrophic outbursts, i.e., flares and CMEs, into the interplanetary space. Therefore, it is important to study the signature of the emerging flux in the convection zone. However, looking inside the interior by direct optical observations is difficult. In this study, we report the detection of the emerging flux in the uppermost convection zone by helioseismic technique. We use SOHO/MDI Dopplergrams of NOAA AR 10488 to investigate the temporal evolutions of acoustic oscillation powers at six different layers (-15 to -2 Mm) beneath the visible surface of the Sun. As a result, we detect the power reductions up to 2 hours before the flux begins to emerge at the surface. The start times of the power reductions show a rising trend of the order of 1 km s^{-1}, with a gradual deceleration with time. If we assume that the power-reducing agent detected here is actually the magnetic flux, the rising speed of 1 km s^{-1} is well in accordance with previous observations and numerical simulations. The detection of the emerging magnetic flux under the solar surface may allow us to know the mechanism of the magnetic process in the Sun, and may improve space weather science.

Keywords: Sun, magnetic field, solar interior, photosphere, space weather

PEM05-18 Room:303 Time:May 21 10:20-10:39

Physics-based space weather modeling and forecasting activities at NASA GSFC Space Weather Research Center

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[1]NASA GSFC

NASA GSFC Space Weather Research Center (SWRC) leverages the capabilities of the Community Coordinated Modeling Center (CCMC) that hosts a great number of state-of-the-art physics-based space weather models developed by the international space physics community. In its role to support transition to operations activities, CCMC currently runs many of these models in a real-time mode. The real-time runs enable a wide spectrum of novel space weather products that SWRC uses to provide space weather information to the NASA customer. Examples include real-time execution of heliospheric MHD models that provide ensemble information about background solar wind conditions, predictive simulations of coronal mass ejection (CME) propagation in the interplanetary medium, magnetospheric MHD simulations and real-time modeling of the ionosphere-thermosphere conditions.

In this paper we provide an overview of the current physics-based space weather modeling and forecasting activities at CCMC and SWRC. We will discuss the usage of series of models to cover the entire space weather chain from the solar corona down to the upper mantle of the Earth. Tools such as cone model-based CME analysis procedure that have been developed at CCMC and SWRC to enable efficient usage of the physics-based simulation capacity will be reviewed. Further, CCMC has carried out and supported many verification and validation (V&V) activities that are a core element of model transition to space weather operations. Key elements of these V&V activities are also briefly discussed.

Keywords: space weather, modeling, physics-based simulations, forecasting

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

PEM05-19 Room:303 Time:May 21 11:00-11:20

Dependence of Properties of the Tearing Mode on the Lundquist Number and the Background Environment

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We perform a set of 2D MHD simulations of the magnetic reconnection process in a long current sheet (CS) developed in the solar eruption, and studied the properties of the CS. The configuration is line-tied to the bottom boundary and open at the other sides. The energy conversion process depends not only on the magnetic Reynolds number, R_m, of the background, but also on the density and the gas pressure inside the CS. The high plasma density and pressure inside the sheet prevents reconnection from taking place quickly. In reality, on the other hand, the CS forms in the disrupting magnetic field and either density or pressure inside may not be high, as suggested by the coronal dimming observed during the early stages of eruptions. This allows fast reconnection to occur in our simulations of solar flares. Further investigations indicate that the time it takes for the first plasmoid to form in the CS increases with the value of R_m, and that the corresponding height decreases.

Keywords: Flares, Magnetic reconnection, Current sheet, Plasma instabilities, Turbulence, Fine structures

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

PEM05-20 Room:303 Time:May 21 11:20-11:35

Characteristics and origin of structured current sheet in the magnetotail

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Recent multi-point THEMIS observations have evidenced that the current sheet in the tail plasma sheet exhibits various structures and evolutions such as weakening of the magnetic field magnitude at the magnetic equator, a local magnetic field minimum in the near-Earth tail region, and bifurcated current sheet. These appear during a growth phase of substorms and may play an important role in the substorm dynamics, magnetic reconnection, etc. In the present study, we have examined the origins of these structures by comparing the details of the THEMIS observations and the 3D global MHD model. The structured current sheets stated above have been reproduced in the model, while it is found that the formation processes and origin are not always the same as observations. Namely, weakening of the magnetic field magnitude at the magnetic equator is associated with the current sheet thinning, but it was much less effective for the modeled current sheet to compare with the observed thinning. On the other hand, the origin of the bifurcated current sheet may be due to the stretched configuration of the plasma sheet for both observations and the models. These findings enable us to assess the extent and applicability of the present MHD models for simulating the current sheet formation in the magnetotail.

Keywords: substorm, global MHD simulation, plasma sheet, current sheet, bifurcated current sheet, weak magnetic field

PEM05-21 Room:303 Time:May 21 11:35-11:50

Doing Space Weather by Using Ground-based Optical Instruments in the Polar Region

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Various ground-based optical observations have been carried out in the polar ionosphere for a long time. Those observations have been done mainly for the purpose of detailed understanding of the plasma physics in the magnetosphere-ionosphere coupling system (physics of aurora etc.). However, such optical data are also helpful for doing space weather studies in the high-latitude part of the Earth. In this talk, we introduce two examples of optical observations in the high-latitude region and discuss those cases in terms of space weather applications in that region.

One example is optical observations of polar cap patches, which are regions high-density plasma in the F region ionosphere streaming from the daytime sunlit region into the dark hemisphere. Ground-based all-sky imager can detect such structures as enhancements of 630.0 nm airglow intensity. Patches are known to be accompanied by smaller scale plasma density irregularities; thus, they would be sources of ionospheric scintillations on the satellite signals in the polar cap region. Within polar cap patches, an enhancement of total electron content (TEC) is also observed, which could be a source of ranging inaccuracy in the satellite-based navigation system such as GPS. In this sense, studies of polar cap patches, in particular understanding of their structuring process (i.e., generation of density irregularities), are fairly important for the space weather applications in the highest latitude part of the Earth.

The other example is ionospheric scintillations on the GPS signal in the auroral latitudes. We often observe such aurora-induced scintillations in the phase of the GPS signal received on the ground at the time of auroral breakup (substorm). An enhancement of TEC of ~10 TECU tends to be observed when the ray path of the GPS signal passes through an intense auroral arc. Such enhancements of phase scintillation and TEC are considered to be manifestations of increase and fluctuation in the electron density at the E region altitude. In this talk, we show how typical GPS receiver responds to the dynamical behavior of breakup aurorae during a relatively large geomagnetic storm, and then demonstrate the impact of the electron density variation in the E region due to the auroral particle precipitations to the satellite-based navigation system.

Keywords: Aurora, Polar cap patches, Satellite Navigation, Ionospheric scintillation

Japan Geoscience Union Meeting 2013
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PEM05-22 Room:303 Time:May 21 11:50-12:05

Hinode Spectroscopic Observation of Magnetic Reconnection in a Solar Flare

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Magnetic reconnection is a key process both in solar flares and substorms in the solar system, so it is important to reveal the fundamental mechanism of onset and energy release via magnetic reconnection in cooperation with solar and space observations. In the Hinode (Solar-B) era, it has become possible to directly measure the plasma flow velocity and electron temperature using the EUV Imaging Spectrometer (EIS). Recently solar activity has increased, and we have succeeded in obtaining spectroscopic observations of a few cusp-shaped flares. The cusp-shape is thought to be the reconnection X-point structure, but whether it is related to slow-shocks or not is still under discussion.

Here we show one of the first spectroscopic observations of a cusp-shaped flare on 2011 February 14. It was simultaneously observed with Hinode, SDO and RHESSI. All these observations enable detailed investigation of the temporal evolution and spatial distribution of the temperature. We found that, first, an emerging magnetic loop triggers magnetic reconnection. This is followed by a hard X-ray burst and a plasmoid ejection. The ejection triggers another neighboring magnetic reconnection, which was observed as a second hard X-ray burst and a cusp-shaped structure. Observed nonthermal electrons are in the energy range of 15-25 keV, and thermal electrons in the cusp-shape are heated up to 10^7 K. This thermal temperature and its distribution were measured by EIS and X-ray telescope (XRT) independently, and their results are almost consistent. During the impulsive phase, we also found bi-directional upward and downward fast flows at the loop-top, i.e. reconnection jet (~100 km/s), and an fast evaporation flow at the footpoint of the loops (~400 km/s) after some time delay. In this observation, reconnection inflow was too weak to measure compared with the background flows, and the ion temperature was also not successfully measured. These observations would be interesting for future work exploring the details of the slow-shocks attached to the X-point.

Keywords: Magnetic Reconnection, Solar Flare, Hinode (Solar-B)

PEM05-23 Room:303 Time:May 21 12:05-12:20

EUV dimming associated with a coronal jet observed by SDO, Hinode and STEREO

Kyoung Sun Lee[1*], D. E. Innes[2], Yong-Jae Moon[3], Kazunari Shibata[4], Jin-Yi Lee[3], Y.-D. Park[5]

[1]ISAS, JAXA, [2]Max Plank Institute for Solar System Research, [3]School of Space Research, Kyung Hee Univ., [4]Kwasan and Hida Observatory, Kyoto Univ., [5]Solar and Space Weather Research Group, KASI

We have investigated a coronal jet observed near the limb on 2010 June 27 by the Hinode/X-Ray Telescope (XRT), EUV Imaging Spectrograph (EIS), and Solar Optical Telescope (SOT), and the SDO/Atmospheric Imaging Assembly (AIA), and on the disk by STEREO-A/EUVI. From EUV (AIA and EIS) and soft X-ray (XRT) images we have identified both cool and hot jets. There was a small loop eruption seen in Ca II images of the SOT before the jet eruption. We found that the hot jet preceded its associated cool jet by about 2 minutes. The cool jet showed helical-like structures during the rising period which was supported by the spectroscopic analysis of the jet's emission. The STEREO observation, which enabled us to observe the jet projected against the disk, showed dimming at 195A along a large loop connected to the jet. We measured a propagation speed of 800 km s^{-1} for the dimming front. This is comparable to the Alfven speed in the loop computed from a magnetic field extrapolation of the photospheric field measured 5 days earlier by the SDO/Helioseismic and Magnetic Imager (HMI), and the loop densities obtained from EIS Fe XIV 264.79/274.20 line ratios. We interpret the dimming as indicating the presence of Alfvenic waves initiated by reconnection in the upper chromosphere.

Keywords: Solar activity, Chromosphere, Corona, UV radiation, Spectroscopic, Stereoscopic

PEM05-24 Room:303 Time:May 21 12:20-12:35

High sensitivity hard X-ray imaging and spectroscopy with the Focusing Optics X-ray Solar Imager (FOXSI) sounding rocket

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We made an unprecedented high sensitivity solar hard X-ray (HXR) imaging and spectroscopic observation using focusing optics with the Focusing Optics X-ray Solar Imager (FOXSI) sounding rocket, in collaboration with Space Science Laboratory, University of California, Berkeley, and NASA.

Accelerated electrons in solar flares emit HXRs by bremsstrahlung process as they travel and lose their energy in the solar corona. Therefore, HXR observations of the Sun provide important information about the energy release process in solar flares. Although high sensitivity observations of HXRs from accelerated particles in solar flares are important to investigate solar activity and space weather, Fourier reconstructions are required to obtain images with past HXR instruments such as the RHESSI satellite and the Hard X-ray Telescope onboard the Yohkoh satellite, and the sensitivity is limited. To improve the sensitivity, grazing-incidence HXR focusing optics are a promising new technology for future solar observations. By using focusing optics, arrival directions of incident photons can be determined directly, and image reconstructions are not necessary. FOXSI tested out grazing-incidence HXR focusing optics combined with position-sensitive focal plane detectors for solar observations. The replicated nickel optics are used as the focusing optics, and fine pitch silicon strip detectors with low noise front end ASICs (Application Specific Integrated Circuits) are used as focal plane detectors. In the target energy range of 4-15 keV, the angular resolution of optics is 8 arcseconds with the focal length of 2 m. FOXSI achieves superior sensitivity; two orders of magnitude better than that of RHESSI.

FOXSI was launched on November 2, 2012 and HXR images and spectra from a microflare are successfully obtained. We successfully demonstrated the concept of the high sensitivity instrument, and showed the new vision for the future solar HXR observations. In this presentation, we will report the concept of the FOXSI instrument and observational result. We will also present the plan for the second launch opportunity of the FOXSI rocket, and a spaceborne solar observer featuring similar optics we are to propose.

Keywords: the Sun, solar flare, X-ray, particle acceleration

PEM05-25 Room:303 Time:May 21 14:15-14:30

Equatorial counterelectrojets during geomagnetic storms and their possible dynamos in the magnetosphere

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The convection electric field and Region-1 field-aligned currents (R1 FACs) are generated by the solar wind dynamo and are conveyed by the shear Alfven waves to the polar ionosphere, extending near-instantaneously to low latitude by means of the Earth-ionosphere waveguide. The transmitted electric field drives the DP2 currents at mid-equatorial latitudes with enhancement in amplitude at the dayside equator (EEJ). The convection electric field further extends to the inner magnetosphere and generates the ring current. The partial ring current would work as a dynamo for the overshielding electric field responsible for the equatorial counterelectrojet (CEJ) when the convection electric field reduces its intensity. The convection reduction has been a major cause of the overshielding, but our recent studies [Hashimoto et al., 2011] show that the substorm works as a dynamo for the overshielding electric field even under the steady southward IMF. In this case, the substorm intensifies both the R1 and R2 FACs, but the R2 FACs are strong enough to cause the overshielding. In this paper we show that the CEJ occurs during both the main and recovery phases of the storm and attempt to identify the dynamo for the CEJs. Using solar wind and ground-based data, we suggest that the stormtime CEJ is caused by the northward turning of the IMF, sudden decrease in the solar wind density, and the substorm expansion. It is to be noted that the substorm overshielding plays a crucial role in the generation of the electric field at subauroral latitude responsible for the high speed auroral plasma flow and SAPS.

Keywords: geomagnetic storm, substorm, overshielding, equatorial counterelectrojet, Region-2 field-aligned current

PEM05-26 Room:303 Time:May 21 14:30-14:45

Solar local dynamo in global scale

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We have achieved high resolution calculation of the solar global magneto-convection in spherical geometry with a top boundary at 0.99Rsun. The reduced speed of sound technique (RSST) is adopted in this study. Compared with the anelastic approximation, the RSST has two major advantages: One is the good scaling in parallel computing. Second is the accessibility to the real solar surface. These enable us to use a large grid of 720x1280x3072 and to set the location of the top boundary at 0.99Rsun. Due to large contrasts between the bottom and top regions in the density ($>$600 times) and the pressure scale height, our calculation includes multi-scale thermal convection, i.e., 100 Mm scale at the base and 10 Mm scale near the top boundary. This type of the small convection pattern is achieved for the first time in the global convection. In our current calculation, the rotation is not included in order to investigate the local dynamo effect in the global scale.

We find that the small scale convection generated near the surface layer unites in relatively deeper layer and becomes strong downflow. Thus at the downflow region, the convection is significantly turbulent and the vorticity has large value. At these regions, the local dynamo is very effective and super-equipartition magnetic field is frequently generated. It is also found that this local dynamo action depends on the location of the surface layer.

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PEM05-27 Room:303 Time:May 21 14:45-15:00

Misleading of Dungey's convection

Takashi Tanaka[1]*

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Magnetosphere-ionosphere (M-I) convection is the magnetohydrodynamic (MHD) motion maintained against the dissipation caused by the ionospheric current system. Primary energy to replenish the ionospheric dissipation is, without any doubt, the solar wind motional energy. In the M-I coupling flow, the magnetospheric motion is transmitted to the ionosphere by the field-aligned current (FAC) to maintain the ionospheric convection potential. The central problem is, therefore, how the solar wind motional energy is converted inside the magnetopshere to the electromageic energy of the FAC. Energy conversion process acts between three types of energy, flow motional energy, plasma thermal energy, and the electromagnetic energy. Whereas the general physics ruling these energy conversion is well known, it is not easy to know how, where, and which energy conversion acts in the real configuration of the huge magnetosphere. So that the understanding has not progressed from the cartoons such as the Dungey convection, the Bostrom current, and the current wedge. In recent years, however, the problem is becoming definitely accessible from the development of three dimensional (3D) M-I coupling simulation. Now, we can draw the distributions of energy conversion rate between three kinds of energy, and can trace current lines.

From the simulation results, five electromagnetic energy conversion layers are identified in the magnetosphere, (1) the bow shock, (2) dayside magnetopause-low-latitude cusp, (3) high-latitude cusp-mantle, (4) the plasma sheet, and (5) the inner magetosphere. The first layer is at the bow shock, where flow motional energy is the driver of the energy conversion. Here we refer the energy associated with the force that does the work for the energy conversion as the driver, and the energy associated with the counter force as the acquire. At the bow shock, most of driving energy (flow motional energy) is converted to thermal energy with some to electromagnetic energy. This configuration is quite reasonable with respect to the nature of the fast shock. The second is at the dayside magnetopause-low-latitude cusp, where magnetic tension released on the dayside is the driver of energy conversion ($J.E>0$). This driving energy is mainly converted to thermal energy with a little to flow motional energy. The second energy conversion layer on the dayside magnetopause continuously extends to the low-latitude side of the cusp and deposits generated thermal energy to the cusp. Flow motional energy generated in the second layer (it can be called the Dungey flow) is lost and converted to thermal energy through the flow braking, before reaching the cusp. The third energy conversion layer is on the high-latitude side of the cusp to the mantle. Here, thermal energy (driver) is converted to electromagnetic energy (acquire) to generate the region 1 FAC ($J.E<0$), and equivalently the magnetospheric convection. Strict overapping is seen between this dynamo layer and the layer in which thermal energy is the driver. These results indicate that the dynamo is driven by the flow crossing pressure gradient and the region 1 FAC is closed by diamagnetic current inside the dynamo.

From the Dungey convection, we first get an image of excitation of convection by the magnetic force. This image must result in the driver layer by electromagnetic energy that overlaps with acquire layer for flow motional energy. If such layer is distributing all over the magnetosphere, it may be just the Dungey convection. In the simulation results, however, such layer distributes only in a narrow region along the dayside magnetopause. The second image from Dungey convection is the dynamo driven by the solar wind motional enrgy, namely the driver layer by the flow motional energy that coinsides with acquire layer for the electromagnetic energy. For this configuration, inertial current will close the FAC. In the simulation results, neither of these two estimation is realized.

Keywords: convection

PEM05-28 Room:303 Time:May 21 15:00-15:15

On the Origin of the Supergranulation and the Magnetic Network in Solar Quiet Regions

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The supergranulation and the magnetic network are the most conspicuous horizontal structures observed in the lower-atmospheric (UV and IR) emission of the sun.
The origin of these structures remains unsolved for over 50 years. We newly develop a radiative magnetohydrodynamic simulation code for the realistic calculation of the solar surface magneto-convection. The results of two-dimensional convection simulations are presented to show the formation process of supergranulation and the magnetic network.

When the magnetic field strength is moderate, no supergranular peak is found in the kinetic energy spectrum. However, the magnetic energy spectrum has an clear peak at the scale of the magnetic network. The horizontal structure of this magnetic network has a correlation with the horizontal flow at a depth of about 3 Mm. This result is interpreted that the large-scale structure of the magnetic network is formed by the merging of the strong downflows with the smaller scale convection.

When the magnetic field becomes sufficiently strong, the back reaction from the magnetic network to the supergranular convection occurs and the supergranular spectral peak appears in the kinetic energy spectrum. This suggests that the magnetic network is not the result of the supergranulation but the exciter of the supergranular convection in the solar surface.

Based on the results above, we suggest a scenario for the formation process of the magnetic network and supergranulation.

Keywords: supergranulation, magnetic network, photosphere, convection

PEM05-29 Room:303 Time:May 21 15:15-15:30

Statistical properties of magnetic patches on the solar surface

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We investigate statistical properties of magnetic patches on the solar surface, especially velocity and lifetime, by means of auto-tracking algorithm in this study.

The solar surface is covered with the convection and the magnetic field, which are important not only as the energy source of the coronal heating problem but also as the actual example of magneto-convection system on the stellar surface. Despite its importance, the comprehensive description of their properties is difficult because of thier complexity and the frequency of their interactions and high frequency of occurrence.

We investigate statistical properties by using our patch tracking method for two sets of line-of-sight magnetograms in quiet regions, one not of which has higher time resolution of nearly 1 minute and the other has long observational period of nearly 140 hours, and out patch tracking method. Both data sets are obtained by the Solar Optical Telescope (SOT) onboard Hinode satellite. We track ˜3200 and ˜40000 patches as sums of both polarities for each data sets, respectively.

Various relationships are investigated. The distribution of proper velocity of patch structures is investigated. We find that the frequency peak is concentrated around 1.0x10^5 cm s^{-1} and the median value is 8.0x10^4 cm s-1. We also find that the velocity has a slight negative correlation with flux content of patches and the relation is expressed with a power-law form. The power-law index is derived as -0.23. WAddition to the apparent velocity, we investigate the frequency distribution of patch lifetime as well. By comparing the results of the high- cadence data data set and the long-duration one, we find the common steep power-law distribution. The power-law index obtained in our analysis is ˜-2.5. On the other hand, there is a maximum value in the lifetime around 100 minutes, which is substantially enough shorter than the observational duration.

We will discuss the turbulent diffusion coefficient on the solar surface and stability the stability of patch structures on the solar surface from these results in the presentation.

Keywords: the Sun, photosphere, magnetic field, megneto-convection, automatical detection

PEM05-30 Room:303 Time:May 21 15:30-15:45

Status quo of the JAXA space environment measurement

haruhisa matsumoto[1*], Kiyokazu Koga[1], Hideki Koshiishi[1], Nana Higashio[1], Osamu Okudaira[1]

[1]Japan Aerospace Exploration Agency

In order to monitor space environment and its temporal variations, JAXA Space Environment Group has been developing space radiation detectors and installing them on Low Earth Orbit(LEO) satellites, Geostationary Orbit (GEO) satellites, Geostationary Transfer Orbit (GTO) satellite,

Quasi Zenith Orbit (QZO) satellite and Japanese Experimental Module (JEM) of the International Space Station (ISS).

We are using these space environment data to know the situation of space environment and to provide warning messages to the satellite operators, when the space environment will be harmful. Based on our observation data, we also have constructed a quasi-dynamic radiation belt model for the use in satellite manufacturing.

We report on the status quo of the JAXA space environment measurement.

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PEM05-31 Room:303 Time:May 21 15:45-16:00

Solar-Wind Proton Anisotropy Versus Beta Relation

Jungjoon Seough[1*], Peter H. Yoon[1], Khan-Hyuk Kim[1], Dong-Hun Lee[1]

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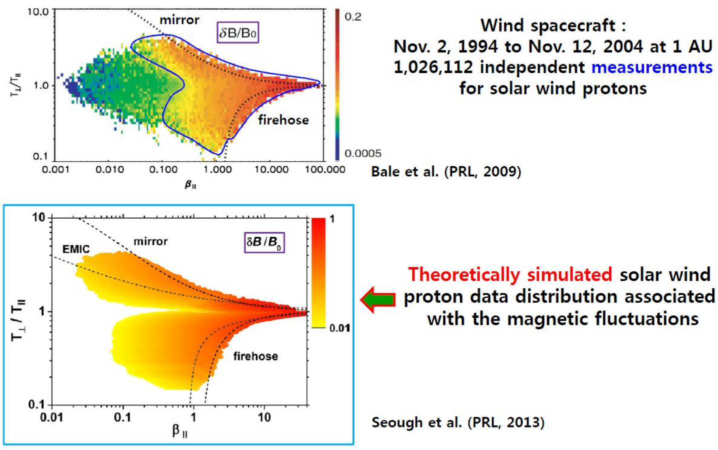
We address an outstanding problem of the proton temperature anisotropy versus plasma beta inverse corrrelation in the solar wind. The measured proton temperature anisotropy from the Wind spacecraft at 1 AU is regulated by the oblique (the mirror and oblique fire-hose) instabilities. This observation is inconsistent with the prediction of linear kinetic theory which suggests that the ion-cyclotron and parallel fire-hose instabilities would dominate over the oblique instabilities within a certain range of parallel plasma beta. In the present paper, we put forth a new idea to explain the solar wind observations of the proton anisotropy which do not agree with the current theories. Making use of the fact that the local magentic field intensity near 1 AU undergoes intermediate-scale temporal variations, we carry out the quasilinear analysis of the temperature anisotropy-driven instabilities with a time-varying local magentic field, assuming arbitrary initial temperature ratios and parallel betas. It is found that the simulated solar wind proton data distribution in ($beta_{parallel}$, $T_{perp}/T_{parallel}$) space is bound by the mirror and oblique fire-hose instabilities, which is superficially similar to the observation.

Keywords: Solar wind proton, Anisotropy-beta relation, Temperature anisotropy-driven instabilities



PEM05-32 Room:303 Time:May 21 16:15-16:30

Measurement result of the neutron monitor onboard SEDA-AP on the ISS - Kibo Exposed Facility

Kiyokazu Koga[1*], haruhisa matsumoto[1], Osamu Okudaira[1], Tokonatsu Yamamoto[2], Yasushi Muraki[2]

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To support future space activities, it is very important to acquire space environmental data related to space radiation degradation of space parts and materials and spacecraft anomalies. Such data are useful for spacecraft design and manned space activity.

SEDA-AP was mounted on Kibo of ISS (International Space Station) to measure the space environment of the 400 kilometres altitude for 3 years.

Neutrons are very harmful radiation because of their strong permeability attributable to its electrical neutrality. The Neutron Monitor measures the energy of neutrons from thermal to 100 MeV in real time using a Bonner Ball Detector and a Scintillation Fiber Detector. The Bonner Ball Detector discriminates neutrons from other charged particles using 3He counters, which have high sensitivity to thermal neutrons. It also measures neutron energy using the relative response, which corresponds to different polyethylene moderator's thickness (6 pcs.). The Scintillation Fiber Detector measures the track of incident particles using a cubic arrangement sensor on which are heaped up 512 scintillation fibers. The sensor discriminates neutrons using differences of these tracks, and measures neutron energy by measuring its track length.

There are three kinds of neutrons measured in space as follows,

1. Albedo Neutron
Caused by galactic cosmic ray and radiation react with atmosphere
2. Local Neutron
Caused by galactic cosmic ray and radiation react with spacecraft
3. Solar Neutron
Caused by accelerated particle in solar flare

Because the shield is difficult, and the influence is large to the human body, the neutron is very important for the astronauts radiation exposure management. Moreover, it is important to measure the albedo neutron because it is thought that the proton that is generated by neutron decay is an origin of the radiation belt. This theory is called as CRAND (Cosmic Ray Albedo Neutron Decay).

An accurate energy spectrum of the solar neutron is measured in space in which the atmosphere is not attenuated, and information on the high energy particle generation mechanism at flare is obtained. This becomes a valuable basic data to do the forecast of flare in the future.

The candidate of some neutron events was found as a result of analyzing the data of the solar flare of $M>2$ from September, 2009. The detailed analysis on the event on March 7, 2011 was done in these candidates.

This paper reports the development, mission objectives, instrumentation and the result of these analyses.

Keywords: ISS, SEDA-AP

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(May 19-24 2013 at Makuhari, Chiba, Japan)

PEM05-33 Room:303 Time:May 21 16:30-16:45

White-Light Flare Observations by Hinode/SOT

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In association with solar flares, we sometimes observe enhancements of visible continuum radiation, which is known as a ”white-light flare”. These flares are mainly associated with energetic events, such as X-class flares, and they are still only rarely observed since first being discovered more than 150 years ago. Because many observed events show a close correlation between the time profiles and locations of white-light emission, and the hard X-rays and/or radio emission, there is some consensus that the origin of white-light emission is due to accelerated particles, especially non-thermal electrons. During big flares which show white-light emission, huge amounts of electrons are accelerated to high energies ? there might also be huge amounts of protons and ions accelerated to high energies. These large amounts of high energy particles are released into interplanetary space as Solar Energetic Particles (SEPs) and sometimes they reach very near the Earth, and also affect the Earth’s environment.

Hinode/SOT has the capability of observing white-light flares in the G-band and continuum (Blue, Green, Red) with a broadband filter. Using the Hinode Flare Catalogue (Watanabe et al., 2012), we searched for white-light events using G-band and continuum data. We found more than 20 Hinode/SOT white-light events in association with M-class or larger flares between launch (September 2006) and December 2012. We compared the white-light emission data with hard X-ray emission data and/or the strength of the photospheric magnetic fields and looked for any relationship between them.

First, we analyze one of the white-light flares that occurred on December 14, 2006 in detail. We use G-band data from SOT for white light emission and hard X-ray data observed by the RHESSI satellite. We compared the white-light power and the electron power assuming a blackbody for the white light and the thick-target model for the non-thermal electrons, obtaining a good correlation (Watanabe et al., 2010).

However, this is hard to understand in terms of the expected respective emission heights. Theoretically, white-light emission is generated near the photosphere, but non-thermal electrons of energy ˜50-100 keV should deposit their energy in the lower chromosphere, more than 500 km above the photosphere.

We investigate this problem with observations of the near-limb X1.7 flare of 27 January 2012, using three continuum bands of the Hinode/SOT. The near-limb location allows us to determine the heights of the emissions. We found the white-light emissions to be located low down, apparently at the photosphere, with the Ca II H emission originating from higher up. We also calculated the temperature distribution from the three white-light continuum bands. The white-light emission temperature is calculated to be about 5500K, and we found that the lower layer has a higher temperature. These findings suggest that high energy particles penetrate to near the photosphere, heating the ambient atmosphere from very low (near photospheric) layers.

In this paper, we present some of the Hinode/SOT white-light events and discuss the flare parameters and origin of the white-light emission.

Keywords: solar flare, white-light

PEM05-34 Room:303 Time:May 21 16:45-17:00

Cosmic-ray exposure and Space weather information during aircraft operation

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Effects of exposure to cosmic-ray during aircraft operation are divided into exposure of aircrew and operational impact.

International Commision on Radiological Protection (ICRP) issued a recommendation to include occupational exposure of aircrew with a jet operated exposure from natural radiation source in 1990. Radiation Council consists of the Ministry of Education, Culture, Sports, Science and Technology, the Ministry of Health, Labour and Welfare, the Ministry of Land, Infrastructure, Transport and Tourism establised "Guidelines for management of aircrew exposure to cosmic radiation" in 2006. In response to this, airlines keep record of assessed doses on each aircrew using Japanese Internet System for Calculation of Aviation Route Doses (JISCARD-EX) developed by National Institute of Radiological Sciences (NIRS).

Impacts of space weather on aircraft operations can be classified into communications and navigations.

For communicaton, it includes difficulties on HF radio due to Dellinger Phenomenon while flying out of range of VHF coverages as international flight. And also includes difficulties on SATCOM voice communication and Controller Pilot Data Link Communication (CPDLC) in oceanic region.

Modern navigation by Global Navigation Satellite System (GNSS) is becoming mainstream. GNSS are used all phase of aircraft operation during on the ground, depareture, en-route, and approach. Future of operations aim high category precision approach using automatic approach and landing by GNSS even extremely low visibility until stop on runway. Cosmic-ray re-write the data in memory known as soft error on electronic equipment onboard aircrafts.

Use of Space Weather forecast, how to provide the information to aircrew and how to make decisions are urgent consideration.

For these problems International Airways Volcano Watch Operations Group (IAWOPSG) which one of operations group of International Civil Aviation Organization (ICAO) is making draft "Concept of Operations (ConOps) for international space weather information in support of international air navigation". Adoption of ConOps is targeted for ICAO/WMO divisional meeting in 2014.

PEM05-35 Room:303 Time:May 21 17:00-17:15

Development of WASAVIES (Warning System of AVIation Exposure to SEP): System Overview

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When solar energetic particles (SEP) are incident to the atmosphere, they can induce air showers by generating varieties of secondary particles. Such secondary particles can reach deep into the atmosphere, and enhance the level of radiation doses, which can be a hazard of aircrews. In order to precisely estimate the radiation doses during large SEP events, we are developing a warning system of aviation exposure to SEP, WASAVIES. In the system, the time profile of anisotropic SEP spectrum incident to the Earth are estimated from the latest knowledge of space weather information [1,2], such as basic parameters of flare and coronal mass ejections (CME). The enhancement of the radiation doses at flight altitudes during the event is then calculated from the incident SEP fluxes in combination with a database developed based on air shower simulation performed by the PHITS code [3]. The WASAVIES has been tested and verified by making a comparison between the measured and calculated count rates of several neutron monitors during past GLE (ground level enhancement) events. The final goal of our project is to predict the enhancement of radiation doses due to SEP exposure within 6 hours from the GLE onset.

[1] Kataoka et al. JpGU2013
[2] Kubo et al. JpGU2013
[3] http://phits.jaea.go.jp/

Keywords: SEP, Cosmic-ray exposure, Airshower simulation, WASAVIES, PHITS

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

PEM05-36 Room:303 Time:May 21 17:15-17:30

Development of WASAVIES (WArning System of AVIation Exposure to SEP): Science Modeling

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The prediction of solar energetic particles (SEP) is important to mitigate the space weather hazard toward increasing solar activities, and is also an ultimate problem for physics-based modelers because of the hybrid nature of MHD fluid and particles. We are developing a forecast system called Warning System of AVIation Exposure to Solar energetic particles (WASAVIES). The trigger of WASAVIES is the automated detection of ground level enhancement (GLE) onset by multiple ground-based neutron monitors [Kuwabara et al., Space Weather, 2006]. We then obtain basic parameters of flare and coronal mass ejections (CME) as input parameters for focused transport of SEP [Kubo et al., JpGU2013]. Realistic inner heliosphere is also dynamically reconstructed at the same time [Shiota et al., JpGU2013], and additional control parameters (e.g., mean free path of SEP) are evaluated for solving the focused transport of SEP. Tracing the SEP particles in a Tsyganenko model, we obtain the time-varying proton rigidity spectra at the top of atmosphere, and the aviation route doses based on the predicted dose-rate are finally evaluated by air shower simulations [Sato et al., JpGU2013]. We show first results and discuss the limitation of the science modeling and possible further development.

Keywords: solar energetic particles, cosmic rays, radiation dose, interplanetary magnetic field, coronal mass ejections

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

PEM05-37 Room:303 Time:May 21 17:30-17:45

Prediction model for a decay phase of high-energy solar energetic particle events

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Forecasting of solar energetic particle (SEP) events is one of the most important topics in space weather research as SEPs cause severe radiation hazards such as satellite malfunctions, radiation exposure for astronaut, high radiation doses of air crew, and loss of communications by high-frequency radio waves. There are two kinds of SEP forecasting research, forecasting of 1) SEP occurrence itself and 2) time evolution of SEP intensity. In this study, we focus on the time evolution of SEP intensity, especially, for high-energy SEPs having energy of over 100 MeV.

As a typical interplanetary shock can hardly accelerate ions up to 100 MeV, the high energy SEPs are accelerated near the Sun (namely, solar flares and/or coronal shock waves), then transported in interplanetary space followed by being observed at the Earth. We can simulate SEP transport in interplanetary space and reproduce an observation data of high energy SEPs by solving focused transport equation. Therefore, a time evolution of high energy SEP intensity may be predicted by using numerical simulation.

This study is dedicated for a deterministic prediction of decay phase of a high energy SEP event by the numerical simulation and observation data of initial phase of the event.

Keywords: Solar energetic particles, Particle transport

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

PEM05-38 Room:303 Time:May 21 17:45-18:00

Development of automatic daily MHD simulation of solar wind and coronal mass ejections in inner heliosphere

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MHD modeling of the solar wind and coronal mass ejections (CMEs) is important to understand the solar-terrestrial environment and to establish space weather forecast because they are the main sources of space weather disturbances. In addition, three-dimensional interplanetary magnetic fields formed by solar wind and CMEs affect the transport of solar energetic particles, and therefore a realistic modeling of the inner heliosphere is required also for the purpose of prediction of solar energetic particles (SEPs) [Kataoka et al., JpGU2013; Sato et al., JpGU2013; Kubo et al., JpGU2013].

We have developed a three-dimensional global MHD simulation of the inner heliosphere. We use daily updated synoptic map of the photospheric magnetic field as a minimal input. As a first step, we calculate coronal magnetic field with potential field source surface model and obtain maps of open magnetic field and expansion factor. Applying empirical models (such as Wang-Sheeley-Arge model), we obtain solar wind synoptic map. Using time series of the solar wind maps as the inner boundary (25 solar radii), we perform the global MHD simulation in 2 AU. The time series of MHD parameters at the Earth position are passed to a radiation belt model [Miyoshi et al. 2004] for forecasting of radiation belt electron flux. These programs are executed everyday on a server in STEL, Nagoya University.

The solar wind as background for propagation of CMEs is prepared in this way. We also report the method to automatically detect flares from observations and to inject associated CMEs, which contains magnetic flux ropes, into the inner boundary of the global MHD simulation. We will introduce modelling results of several CME events associated with high SEP proton flux and discuss the validation of our model and the further developments.

Keywords: space weather, solar wind, magnetic field, coronal mass ejection, solar energetic particle