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

PEM26-01 Room:202 Time:May 23 09:00-09:15

North-south asymmetry in global distribution of the solar wind

Munetoshi Tokumaru[1*], Ken'ichi Fujiki[1], Tomoya Iju[1]

[1]Solar-Terrestrial Environment Laboratory, Nagoya University

Interplanetary scintillation (IPS) observations made between 1985 and 2011 were used to investigate north-south (NS) asymmetry in global distribution of the solar wind. IPS data show that marked NS asymmetry occurs in the solar maxima, i.e. during the polarity reversal of Sun's magnetic field, and also show that the NS asymmetry of polar fast wind frequently occurs after the cycle 23 maximum. The fast wind from the north pole was dominant in cycle 23, but that from the south pole became dominant in cycle 24. The NS asymmetry revealed from IPS observations is found to be generally consistent with Ulysses observations. We compare IPS observations with magnetic field data of the Sun. As result, we find that there is good correlation between IPS data and B/f values calculated from the potential field analysis of Kitt Peak observations. While the quadrupole component determined from Wilcox observations exhibits a similar pattern of the NS asymmetry after cycle 23 maximum, we find no significant correlation between quadrupole and IPS data. Therefore, the NS asymmetry of the global solar wind distribution is ascribed to the magnetic field property of the source surface, which includes multiple pole components of the potential field.

Keywords: solar wind, interplanetary scintillation, solar cycle, Sun's magnetic field, heliosphere, space weather

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

PEM26-02 Room:202 Time:May 23 09:15-09:30

Estimation of solar wind speed by the photospheric magnetic field

Kazuyuki Hakamada[1*], Munetoshi Tokumaru[2], Ken'ichi Fujiki[2]

[1]Chubu University, [2]Solar-Terrestrial Environment Laboratory

In this study, we visualize three-dimensional structure of the coronal magneic field by using the Radial-Field model for the coronal magnetic field devised by myself with the synoptic maps of the photospheric magnetic field observed by the

NSO/Kitt Peak, USA. According to our previous analysis on the Carrignton rotation base, the photospheric magnetic field (Log10|Br_pho|), the coronal magnetic field (Log10|Br_sou|) shows good correlation with the solar wind speed (SWS) for the data of (-1.0 <= Log10|Br_pho| <= 1.5, (0.1 G <= |Br_pho| <= 31.6 G), -1.5 <= Log10|Br_sou| <= 0.0, (0.0316 G <= |Br_sou| <= 1.0 G)). We use rotation averages for these SWS, Log10|Br_pho|, and Log10|Br_sou| in this study. We found good multiple correlaion (r = 0.855) among them by using the regression equation in the form of SWS = a + b $*$ log10|Br_sou| + c $*$ log10|Br_pho|. We obtained the empirical equation, SWS = 1027.7 + 181.6$*$log10|Br_sou| - 346.6$*$log10|Br_pho|, by wich we can estimate SWS from the magnetic data Log10|Br_pho| and Log10|Br_sou|. Since the SWS observed by the IPS method and the SWS estimated by the empirical equation show good agreement, we can estimate SWSs during no IPS observation period. The SWS thus estimated shows solar cycle variations with three peaks during the year 1975 and the year 2012 with the amplitude of 300 km/s (between 400 km/s and 700 km/s). The shape of log-term variation of the SWS estimated by the IPS observation is somewhat different from the SWS observed by the Earth orbit satellites, because the IPS observation covers from the north pole to the south pole of the heliospher in contrast to the lower latitude coverage of the satellite. This result is important for the study of space weather and space climate.

Keywords: solar wind, photoshpheric magnetic field, solar cycle variation, estimation

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

PEM26-03 Room:202 Time:May 23 09:30-09:45

Low Solar Activity and the Ionosphere

Kiyoto Shibasaki[1*]

[1]Nobeyama Solar Radio Observatory, National Astronomical Observatory of Japan

Global solar activity of the Sun has been weakening recently. A radio butterfly diagram, synthesized from twenty years of daily full disk images of the Sun at 17 GHz observed by Nobeyama Radioheliograph, shows that both polar and low-mid latitude activities have been declining during the last 20 years. After the deep activity minimum between the cycles 23 and 24, solar activity started to increase in 2009 rather slowly. The year 2013 is expected to be the maximum of the 24th cycle. However, activity is extremely low, lowest in 100 years, and SCOSTEP is organizing one year MiniMax24 campaign observations of solar and terrestrial parameters. In this paper, we study how such a low solar activity influences the terrestrial upper atmosphere by comparing activity indexes of solar and terrestrial upper atmospheres.

For solar activity indexes, we used monthly averaged total radio flux values (1000, 2000, 3750, and 9400 MHz) measured at the Research Institute of Atmospherics (Nagoya University) and the Nobeyama Solar Radio Observatory (National Astronomical Observatory) and monthly mean values of relative sunspot numbers provided by Solar Influences Data Analysis Center (Royal Observatory of Belgium). It is known that radio flux values around 10 cm (3000 MHz) show good correlation with relative sunspot numbers. As radio measurements are not sensitive to weather (cloud, rain, or other) and ionosphere conditions, flux values are often used as a quasi realtime solar activity index. Due to a robust calibration method of radio flux measurements, long-term uniform values are available. Radio flux values at 2800 MHz (F10.7) from Canada have been used as standard solar activity index since 1947. Also in Japan, measurements at 3750 MHz (8 cm) have been continuing more than 61 years since Nov. 1951 and also other long observation at 1000, 2000, and 9400 MHz are available. However, it has been noticed that radio flux values after the year around 2000 are systematically higher than inferred from sunspot numbers, or sunspot numbers are systematically smaller.

For activity index of terrestrial upper atmosphere, we used monthly median values of ionospheric characteristic frequency 'foF2' measured at Kokubunji station (National Institute of Information and Communications Technology) at local noon. The frequencies foF2 have two peaks in a year. To avoid seasonal variations, 13 months running average values (weighted 0.5 at both ends) are used. This frequency corresponds to the plasma frequency of the highest electron density layer (F2 layer) in the ionosphere. Radio waves higher than foF2 can get through the ionosphere, and that lower than foF2 are reflected. Hence this frequency is the characteristic frequency of the ionosphere. Electron density in the ionosphere is determined by balance between photo ionization by solar EUV radiation and recombination. Hence, foF2 and electron density must be closely related to solar activity. We study how recent low solar activity is influencing these quantities. Analyzed period is 43 years since 1969 January up to 2011 December and the total data number is 516.

Analysis methods are: 1) compare time series plots of each index, 2) create correlation plots between solar and ionospheric data, and 3) calculate correlation coefficients between them. Results are: Correlation between radio flux at 2000 GHz and electron density has the highest coefficient of 0.993. Superposition of scaled 2000 MHz flux and electron density time series show that electron density during 23/24 minimum and also during 24th cycle are systematically lower than inferred from 2000 MHz flux. Radio flux correlates better with ionospheric electron density than sunspot numbers.

Keywords: solar activity, long-term variation, sunspot number, total radio flux, ionosphere, foF2

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

PEM26-04 Room:202 Time:May 23 09:45-10:00

Lengths of Schwabe cycles in the 7th and 8th centuries indicated by precise measurement of carbon-14 content in tree rin

Fusa Miyake[1*], Kimiaki Masuda[1], Toshio Nakamura[2]

[1]Solar-Terrestrial Environment Laboratory, Nagoya University, [2]Center for Chronological Research, Nagoya University

Radiocarbon (^{14}C) is produced in the upper atmosphere by galactic cosmic rays, which are modulated by solar magnetic activity. Its content in tree rings is retained and provides a record of past cosmic ray intensity and solar activity. We have measured the ^{14}C content in Japanese cedar tree rings from AD 600 to 760, a time interval including a small grand solar minimum in the 7-8th centuries, with a resolution of 2 year.

Periodicity analysis of the ^{14}C data exhibits a component in the frequency band of the Schwabe cycle with a period of 12-13 years continuing throughout the minimum. This is the fourth case of increase in the length of the Schwabe cycle observed in grand solar minima, after the Maunder Minimum, the Sporer Minimum, and the 4th century BC Minimum. A finding of the fourth of these cases strengthens the evidence that the length of the Schwabe cycle increases during grand solar minima.

Also a difference between the Maunder type and the Sporer type minima was found, i.e. the length of the Schwabe cycle of the Maunder type minima increase during the most period of the minima, while that of the Sporer type minima increase during only the preceding or the beginning of the minima. There is a correlation between the cycle length and the amplitude of the Maunder type minimum.

In addition to the increase in the cycle length, it was also found that short frequency components appear preceding and at the beginning of the minimum. These short frequency components are due to solar magnetic activity which is predicted by the flux-transport dynamo model (Choudhuri and Karak, 2009).

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

PEM26-05 Room:202 Time:May 23 10:00-10:15

Solar wind velocities near the sun observed by Akatsuki radio scintillation measurements

Takeshi Imamura[1*], Munetoshi Tokumaru[2], Hiroki Ando[3], Hiroaki Isobe[4], Ayumi Asai[4], Daikou Shiota[5], mayu miyamoto[3], Kentaro Yaji[6]

[1]Japan Aerospace Exploration Agency, [2]Nagoya University, [3]The University of Tokyo, [4]Kyoto University, [5]Riken, [6]Rikkyo University

Radio scintillation observations of the solar wind velocity at the heliocentric distances of 1.5-20.7 solar radii were conducted during the solar conjunction of the Japanese Venus explorer AKATSUKI during June 6-July 8 in 2011. One-way, X-band down-link signal stabilized by an onboard ultra-stable oscillator was transmitted from the spacecraft and received by an open-loop recording system at the Usuda Deep Space Center. Spectral analyses of the intensity fluctuation (scintillation) provides the velocity of the solar wind. Velocities were derived even in the 'strong scattering' regime near the sun for the first time by comparing the observed scintillation spectra with theoretical ones for strong scattering conditions. Simultaneous observations with a space solar telescope HINODE were also conducted over 4 days around the period of the minimum solar offset distance.

Keywords: solar wind, radio wave, scintillation, Akatsuki

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

PEM26-06 Room:202 Time:May 23 10:15-10:30

Orientations of flux ropes in ICMEs and magnetic field structures of their solar source regions

Katsuhide Marubashi[1*], CHO, Kyongsuk[1], AKIYAMA, Sachiko[2], YASHIRO, Seiji[2], GOPALSWAMY, Nat[2]

[1]Korea Astronmy and Space Science Intsitute, [2]NASA, Goddard Space Flight Center

Do all CMEs that reach 1 AU have flux ropes? Focused on this question a series of the Coordinated Data Analysis Workshop were held in 2010 and 2011 (CDAW 2010, 2011). An additional problem is to find out some possible differences in the properties of solar source events between ICMEs with and without flux ropes if there ever exist both types of ICMEs. For this purpose the CDAW organizers prepared the list of 54 ICMEs attached with the most probable solar source events for them and provided to the workshop participants (CDAW List). The pre-selected ICMEs consist of 23 magnetic clouds (MC) and 31 non-cloud ejecta (EJ).

In this study we first attempted to identify the flux rope structure in each of the 54 ICMEs by the model fitting method. Two flux rope models, cylinder and torus models, were applied in the model fitting. As a result, it was found that magnetic field variations in some part of ICMEs can be well reproduced by a flux rope model in 51 cases out of 54. Then, using the ICME flux rope orientation at 1 AU obtained from the fitting, we estimated the orientation that each flux rope should have had at the time of eruption in the coronal region from. It should be noted here that the model fitting generally provides two or more possible orientations for a single ICME depending on the model, cylinder or torus. Correspondingly two or more possible estimates are obtained for the orientation of a flux rope at the time of CME eruption. Comparing with the magnetic fields in the source region, we could find out at least one estimated flux rope orientation that is close to the orientation of the neutral line in the source region.

Summarizing the above analysis results, we conclude:
(1) All CMEs that reach 1 AU (ICMEs) have flux ropes.
(2) The orientation of flux ropes ejected by CMEs is preserved during propagation to 1 AU and observed as the ICME flux ropes.

Keywords: solar wind, coronal mass ejection, flux rope, cylinder model, torus model, magnetic neutral line

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

PEM26-07 Room:202 Time:May 23 10:30-10:45

Reconstruction of an evolving magnetic flux rope in the solar wind from single-spacecraft data

Hiroshi Hasegawa[1*], Bengt Sonnerup[2], Qiang Hu[3], Takuma Nakamura[4]

[1]Institute of Space and Astronautical Science, JAXA, [2]Dartmouth College, [3]University of Alabama in Huntsville, [4]Los Alamos National Laboratory

In situ measurements, often made by single spacecraft, have a difficulty in revealing spatiotemporal evolution of space plasma structures. We present a single-spacecraft method for decomposing spatial and temporal variations of physical quantities at points along the path of a spacecraft in spacetime, which can be used for reconstruction of slow evolution of two-dimensional (2D) and magneto-hydrostatic structures (namely, Grad-Shafranov equilibria) (Sonnerup and Hasegawa, 2010). The method is applicable to structures that are in Grad-Shafranov equilibrium and in which the flow is incompressible and the frozen-in condition is satisfied. Benchmark tests are conducted by use of synthetic data taken by a virtual spacecraft that traverses, at a constant velocity, a magnetic flux rope growing in a 2D magnetohydrodynamic simulation of magnetic reconnection. It is demonstrated that the new method can better recover the quantities in spacetime than does an earlier version, in which time aliasing effects had not been removed (Hasegawa et al., 2010). The application to a flux rope observed on 25-26 March 1998 by the ACE spacecraft in the solar wind suggests that its core part was evolving in an intriguing way during the ˜17 hour interval of traversal.

Sonnerup, B. U. O., and H. Hasegawa (2010), On slowly evolving Grad-Shafranov equilibria, J. Geophys. Res., 115, A11218, doi:10.1029/2010JA015678.

Hasegawa, H., B. U. O. Sonnerup, and T. Nakamura (2010), Recovery of time evolution of Grad-Shafranov equilibria from single-spacecraft data: Benchmarking and application to a flux transfer event, J. Geophys. Res., 115, A11219, doi:10.1029/2010JA015679.

Keywords: solar wind, magnetic flux rope, Grad-Shafranov equation, magnetohydrostatic equilibrium

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

PEM26-08 Room:202 Time:May 23 11:00-11:15

Debye length in the wake of a non-magnetized object in the solar wind

Tomoko Nakagawa[1*]

[1]Tohoku Institute of Technology

Importance of surface charging of downstream-side surface of a non-magnetized obstacle in the solar wind is studied with 2-D electromagnetic particle-in-cell simulations [1] [2] [3] by changing the size of the obstacle with respect to the Debye length. It was revealed that even in the case of a large obstacle, the electric field in the wake extends far downstream beyond the Debye length in the unperturbed solar wind. It is mainly due to the highly depressed electron density and nearly constant electron temperature in the wake.

References
[1] Kimura, S. and T. Nakagawa, Earth Planets Space, 60, pp.591-599, 2008.
[2] Nakagawa, T., and S. Kimura, Earth Planets Space, 63(6), pp.477-486, 2011.
[3] Nakagawa, T., J.Geophys. Res., 2013, in press.

Keywords: 2-D PIC simulation, Debye length, wake, non-magnetized obstacle, electron density, electric potential

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

PEM26-09 Room:202 Time:May 23 11:15-11:30

Electron acceleration at the termination shock

Shuichi Matsukiyo[1*], Manfred Sholer[2]

[1]ESST Kyushu Univ., [2]Max-Planck-Institut

The ability of the termination shock as a particle accelerator is totally unknown. Voyager spacecraft data and recent kinetic numerical simulations revealed that the compression ratio of the termination shock is rather low due to the presence of pickup ions, i.e., the termination shock appears to be a weak shock. Nevertheless, two Voyager spacecraft observed not only high energy ions called termination shock particles, which are non-thermal but less energetic compared to the so-called anomalous cosmic rays, but also non-thermal electrons. In this study we focus especially on microstructure of the termination shock and the associated electron acceleration process by performing one-dimensional full particle-in-cell (PIC) simulations. The electron acceleration efficiently occurs through a shock drift acceleration mechanism when a shock angle becomes oblique. In the oblique termination shock a new type of self-reformation is seen even if a relative pickup ion density is not small (30%). Variations of the energy distribution functions of the accelerated electrons are discussed for a couple of parameter sets.

Keywords: termination shock, electron acceleration, PIC simulation

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

PEM26-10 Room:202 Time:May 23 11:30-11:45

Ion heating by the nonlinear evolution of low-frequency Alfvenic turbulence in the radially expanding solar wind

Yasuhiro Nariyuki[1*], Takayuki Umeda[2], Takeru K. Suzuki[3], Tohru Hada[4]

[1]Univ. Toyama, [2]STEL, Nagoya Univ., [3]Department of Physics, Nagoya Univ., [4]ESST, Kyushu Univ.

It is well known that the magnetohydrdynamic (MHD) turbulence with the high cross helicity (Alfvenic turbulence) is ubiquitously observed in the solar wind plasmas. The Alfvenic turbulence generated in the vicinity of the photosphere may play an important role in heating of coronal plasmas, and a number of authors have investigated the ”wave modeling” of the solar wind plasmas. On the other hand, while the heating of ions is dominated by the collisionless damping of the low-frequency waves, few models including the low-frequency Alfvenic turbulence have gone beyond the MHD description. In this study, we present the nonlinear evolution of low-frequency Alfvenic turbulence in the radially expanding solar wind by using a kinetic-fluid model (Vlasov-MHD model). The heating of ions by low-frequency Alfvenic turbulence in the absence of the ion cyclotron resonance is demonstrated. In order to discuss the self-consistency of the ion kinetics, we carry out the test-particle simulation, in which the numerical data of the global MHD simulation is used. The other non-MHD effects are also discussed as the phenomenological parameters.

Keywords: solar wind, Alfvenic turbulence, ion heating

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

PEM26-11 Room:202 Time:May 23 11:45-12:00

Peak Flux Distributions of Solar Radio Type-I Bursts from Highly Resolved Spectral Observations by AMATERAS

Kazumasa Iwai[1*], Satoshi Masuda[2], Yoshizumi Miyoshi[2], Fuminori Tsuchiya[3], Akira Morioka[3], Hiroaki Misawa[3]

[1]Nobeyama Solar Radio Observatory, National Astronomical Observatory of Japan, [2]STEL, Nagoya University, [3]PPARC, Tohoku University

Type-I noise storms are one of the most frequently observed solar radio phenomena in the metric frequency range. They are thought to be plasma emission at the local plasma frequency. Type-I noise storms contain many complex fine structures in their spectra called type-I bursts. They are thought to be caused by some inhomogeneities of particle acceleration, wave generation, radio emission, and/or radio propagation processes. However, the detailed spectral characteristics of them have not been understood well because of the complex spectral structures, limited spectral resolutions of the previous observations, and numerous instances of radio frequency interference (RFI) in the observed radio spectra.

We developed a two-dimensional auto burst detection algorithm that can remove RFI and distinguish an individual type-I burst element from complex type-I noise storm spectra. This algorithm removes RFI from the observed radio spectra by applying a moving median filter along the frequency axis. Burst and continuum components are distinguished by a two-dimensional maximum and minimum search of the radio dynamic spectra. Then we derived the peak flux distributions of type-I bursts using AMATERAS (the Assembly of Metric-band Aperture TElescope and Real-time Analysis System; Iwai et al. 2012), a solar radio telescope that can distinguish the fine spectral structures of metric radio bursts with high time and frequency resolution. The analysis result shows that each type-I burst element has one peak flux without double counts or missed counts. The peak flux distribution of type-I bursts derived using this algorithm follows a power law with a spectral index between 4 and 5. This extremely soft spectrum is observed for the first time in solar phenomena.

Keywords: Sun: radio radiation, Sun: corona, ground-based observation, particle acceleration, AMATERAS