Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

PEM030-01 Room:303 Time:May 27 16:30-16:45

Study of differential rotation in rapidly rotating stars in mean field model

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We investigate the internal differential rotation in rapidly rotating stars in an axisymmetric mean field model. The background of this study is the suggestion that the sun rotated faster than now in its younger age. The differential rotation is an important factor for the stellar magnetic field, since the shear of the flow bends the magnetic field and gives energy to magnetic field, i.e. dynamo. We are interested in the morphology of the differential rotation in rapidly rotating stars. We use the model which succeeds in reproducing the solar differential rotation with an adequate latitudinal entropy gradient. Our result is: In the rapidly rotating stars, the meridional flow is not so fast that the latitudinal entropy gradient generated by the meridional flow is not large enough to push the differential rotation far from the Taylor-Proudman state where the contour lines of the angular velocity are parallel to the rotational axis.

Keywords: Sun, Differential rotation, Star, Magnetic activity

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The role of Alfven wave for spicule formation, coronal heating, and solar wind acceleration

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We performed MHD simulations for nonlinear Alfven wave propagation in the solar flux tube. Mode conversion of Alfven waves are known to be one of the mechanisms to explain spicules, jet like phenomena in the solar chromosphere. Moreover nonlinear dissipation of Alfven waves has possibility to explain the coronal heating and the solar wind acceleration simultaneously. However, whether the above models succeed or not highly depends on the power spectrum of Alfven waves driven at the photosphere. In this talk, we examined the existing models by using the observed power spectrum of photospheric velocity newly derived from Hinode G-band movies.

To begin with, we performed 1D MHD simulation for nonlinear Alfven wave propagation along a flux tube. We derived the horizontal velocity spectra at the photosphere using G-band movies observed with Hinode/SOT. The observed power spectra are used to drive Alfven waves in our simulations. Using the observed power spectra, we can reasonably explain spicule motion and energy flux necessary to heat the corona. We also found that the region between the photosphere and the transition region becomes Alfven wave resonant cavity, which works efficiently to heat the corona. Then, we applied almost the same model to the solar wind acceleration by extending our numerical domain. The Alfven wave theory is confirmed to maintain the corona and drive the solar wind with Alfven wave generation by the observed power spectra. Finally, we tested the validity of 1D approximation by performing 2D MHD simulation for Alfven wave propagation in the solar flux sheet.

Keywords: Alfven wave, MHD, spicule formation, coronal heating, solar wind acceleration

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Relationship etween Phase Difference of the Ground Pc5 and Enhancement of Relativistic Electron Flux at the GEO

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Pc 5 pulsations observed at the ground stations are analyzed to investigate the relationship with enhancement of the relativistic (>MeV) electron flux (REF) at the geosynchronous orbit. It is frequently reported in the previous studies that the REF increases during the recovery phase of the magnetic storms. The enhancement of REF sometimes causes the serious troubles of the electric circuit onboard the satellites due to the internal charging, so that it is recognized the physical process of the REF enhancement is one of the most important subject of the space weather study. In this study, we use the magnetic data observed at the high-latitude magnetic stations in both the northern and the southern hemispheres, TJOR (Mag. Lat = 66.51), TRO (66.44), Showa (-66.08), H057 (-66.42), and Skallen (-66.42) to compare the REF enhancement observed by GOES 10 satellite and DRTS satellite. In 12 July, 2008, the high speed (< 700km/s) solarwind with Corotating Interaction Region (CIR) causes the small magnetic storms with Dst of -40 nT. At the timing of the main phase of the magnetic storms, the Pc 5 power increased at all the stations and continued the strong PSD during the recovery phase of the storm. For this event, we estimated the phase difference of the Pc 5 between H057 and Skallen which are located exactly same magnetic latitude. The phase difference in the pre-storm period shows the 7-8 degrees and obviously decreased after the onset of storm. In particular, the phase difference discontinuously changed to the small corresponding to the start of the REF enhancement. However, the increasing of the Pc5 power starts 12 hours earlier than the start of REF enhancement. The same characteristics were shown in the Pc5 in the northern hemisphere stations (TJOR, TRO). The present result indicates that the increasing of Pc5 power started at the onset of the main phase of the storm prior to the REF enhance, then the phase structure of the Pc5 changed corresponding to the REF enhancement. These characteristics of the Pc5 and the REF enhancement could be explained by the drift resonance model the REF enhancement.

Keywords: ULF Pulsation, Relativistic Electron, innner magnetosphere

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Statistical Study of Polar X-ray jets from Hinode/XRT

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The X-Ray Telescope (XRT) aboard Hinode had revealed that X-ray jets occur at very high frequency in the polar region. Savcheva et al. (2007) reported the features of the polar X-ray jets based on 104 events that occurred only in polar coronal hole (PCH). Hence, the difference of the features of the polar X-ray jets that occur in PCH and the quiet region (QR) is not clear. In order to reveal the features of the polar X-ray jets in not only PCH but also QR, we investigated the polar X-ray jets based on 848 jets that occurred around the north pole. We also investigated 96 X-ray jets that occurred around the equator for comparing the polar jets with the equatorial jets.

We used the X-ray intensity for dividing the polar region into PCH and QR. However, generally, the magnetic connectivity is used for dividing into the two regions, and it is possible that the boundary based on X-ray intensity is not correct. To evaluate the uncertainty, we derived the frequency distribution of the minimum distance from the jet to the PCH boundary. The distribution shows that the frequency of the jets in the PCH is roughly uniform and the frequency of the jets in the QR immediately decreases around 10ˆ5 km from the boundary. From the result, we divided the QR into [around coronal hole boundary (CHB)] and [pure polar quiet region (PQR)], based on the distance from the coronal hole boundary. Finally, we divided the jet-producing region into the four regions, PCH, CHB, PQR and equatorial quiet region (EQR), and we compared the features of the X-ray jets that occurred in each region.

From comparing the parameters of the X-ray jets, we found that the ranges, the averages and the frequency distributions of the length, the width, the lifetime and the apparent velocity are independent of the producing regions. On the other hand, the occurrence rate and the frequency distribution as a function of the total X-ray intensity of the flare around the footpoint of the jets differ from the parameters. The occurrence rates of X-ray jets in the PCH and the CHB are higher frequency (16 x 10ˆ-12 events/kmˆ2/hour) than that in the PQR and the EQR (6 x 10ˆ-12 events/kmˆ2/hour). If we assume that the frequency distribution of total X-ray intensity of footpoint flare show the power law distribution, the power law indexes of the frequency distribution at the PCH and the CHB are around -1.8 and the indexes at the PQR and the EQR are around -1.3. From the results, we found that we can divide the jet-producing region into two categories based on the occurrence rate and the frequency distribution of the footpoint flares. One is the category that has high occurrence rates and steep slope of the frequency distribution of the footpoint flares. The category includes the PCH and the CHB. The other category has low occurrence rate and flat slope of the frequency distribution of the footpoint flares and includes the PQR and EQR.

Keywords: X-ray jet, Corona, Flare, Magnetic Field

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Yearly Variation of Magnetic Field in the Solar Polar Regions observed with *Hinode*/SOT

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The polar region of the Sun has not been well understood yet despite the long history of the solar observation. The polarity of the polar regions reverses around the maximum of the solar cycle. For several years around the solar activity minimum a stable and large coronal hole is present in each the polar region. The polar regions has the unipolar magnetic fields open to the interplanetary space. The mechanisms of the polarity reversal and to form, to maintain, and to decay the coronal holes remain to be completely clarified. The polar regions have the polarity opposite to each other and almost occupy the unipolar magnetic field. Therefore, the variation of the polar magnetic field is extremely significant for the polarity reversal. Observations of the polar region of the Sun are critically important for understanding the solar dynamo and the acceleration of solar wind. In order to obtain clues of those problems, we investigated the photospheric magnetic field properties using the high-resolution observation with Solar Optical Telescope (SOT) aboard *Hinode* in this study.

we report the yearly time variation (2006 - 2011) of the magnetic field in the polar regions around solar minimum with high spatial resolution of *Hinode*/SOT. The fraction of the dominant polarity in the both polar regions increases with latitude. We examined the time variation (2008 - 2011) of the vertical and horizontal magnetic fields. The comparison of the areal fraction of the intrinsic magnetic field strength showed that those of the kilo-Gauss vertical field and the horizontal field vary in the North polar region. In the South polar region, however, the areal fraction of the kilo-Gauss vertical field and the horizontal field are almost the same. The magnetic flux density of vertical magnetic field fluctuates in both the polar regions, while that of horizontal magnetic field almost stay flat.

Keywords: photosphere, magnetic field, coronal holes, solar activity, Hinode, spectropolarimetry

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GEMSIS project: Database of coronal magnetic fields calculated from magnetograms of Hinode satellite

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We report the database of coronal magnetic fields of solar active regions. This database is a part of the GEMSIS (Geospace Environment Modeling System for Integrated Studies) project of Solar-Terrestrial Environment Laboratory (STEL), Nagoya University (URL, http://st4a.stelab.nagoya-u.ac.jp/gemsis/index.shtml.ja). The GEMSIS project is the modeling project for understanding energy and mass transportation from the Sun to the Earth in the geospace environment. We, the GEMSIS-Sun working team, are preparing database of coronal magnetic fields of solar active regions calculated from magnetic field data obtained by the Hinode satellite, as one of our projects. This is collaboration with Hinode Science Center, National Astronomical Observatory of Japan. We expect that this database could help solarphysicists to understand energy release processes (e.g., acceleration of high energy particles and trigger mechanisms of solar flares) in the corona.

Magnetic field is a main energy source of solar active phenomena (e.g., filament eruption, solar flare, and others). Thus, in order to understand solar active phenomena, we need to investigate temporal evolution of coronal magnetic fields. Reproduction of coronal magnetic fields is considered as an only way to understand coronal magnetic field structure. At present, it is very difficult to obtain three dimensional structures of coronal magnetic fields from polarized light observations, because of small intensity and optical thinness of solar corona. On the other hand, under the rest condition, we can describe coronal magnetic fields with two simple equations (divB=0 and rotB$*$B=0). This is because the Lorentz force is stronger than the gas pressure and gravity forces in the corona. Such magnetic fields are called as the non-linear force free fields (NLFFFs). Since 1960s, scientists have developed schemes to calculate NLFFFs. In this database, we use a scheme developed by Inoue et al. (ApJ, in submitted). Boundary condition on the photosphere is given from magnetic field data obtained by Hinode. Other boundary conditions are given from potential coronal magnetic fields. Potential coronal magnetic fields are calculated from SoHO/MDI magnetograms.

For this database, we now make a program that automatically perform data fitting between Hinode and SoHO/MDI magnetograms, potential field calculation, and NLFFF calculation. The code for NLFFF calculations is provided from Dr. Inoue (NiCT), and the code for potential field calculations is from Dr. Shiota (Riken). We confirmed results of data fitting and potential field calculations, and now test NLFFF calculation. In this presentation, we report these results, and also report primary results for test active regions.

Keywords: corona, magnetic field, sun

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Basic research on space weather alert for space probes: Comparison EUV and X-ray emissions during solar flares

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Space weather researches have become more and more important, according to the expansion of the "humanosphere" to space. On the other hand, space weather researches are mainly for circumterrestrial space, and it is insufficient to forecast the radiation hazard for deep space probes that are located far from the earth.

We aim to forecast and evaluate the radiation hazard for such space probes far from the earth by using data taken by Extreme Ultra Violet Imager (EUVI) on board Solar Terrestrial RElations Observatory (STEREO). For this purpose, we have to know how much we can predict flares by using only EUV full-disk images. Therefore, we start with validating how accurately we can predict flares by using EUV images taken by Extreme ultraviolet Imaging Telescope (EIT) on board Solar and Heliospheric Observatory (SOHO). We compared EUV fluxes for flares with X-ray GOES fluxes, and found a positive correlation between them. We also examined the temporal properties in EUV emissions both for flare-productive and non flare-productive regions.

Keywords: solar flare, active region, space weather, extreme ultraviolet, soft X-ray

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Long-term variation in the solar quiet geomagnetic field variation and thermospheric wind based on the IUGONET observati

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It has been well-known that geomagnetic solar quiet (Sq) variation is produced by ionospheric currents associated with dynamo process via interaction between the neutral wind and plasma in a region of the thermosphere and ionosphere. The large-scale motion of the neutral particles is caused by heat convection due to solar irradiance and by tidal force of the sun and moon. From the Ohm's equation, the ionospheric currents which lead to the Sq variation strongly depend on ionospheric conductivity, polarization electric field and neutral wind. Then, trend in the Sq amplitude may include information on the long-term trend in the neutral wind of the thermosphere and ionosphere. Recently, Elias et al. [2010] found that the Sq amplitude tends to increase by 5.4-9.9 % at all the stations in the middle latitudes (Apia, Fredericksburg and Hermanus) in a period of 1961-2001. They mentioned that the long-term variation of ionospheric conductivity associated with geomagnetic secular variation mainly determines the Sq trend, but that the rest component is ionospheric conductivity enhancement associated with cooling effect in the thermosphere due to increasing greenhouse gas. However, the research of the long-term variation of Sq amplitude by Elias et al. [2010] includes the following issues: (1) Since they used only the geomagnetic field data obtained from the three geomagnetic stations until 2001, a global signature of the long-term variation of Sq amplitude has been not clarified yet, (2) The quantitative evaluation between the Sq amplitude and sunspot number cannot be performed correctly during the solar minimum when the sunspot number is zero, and (3) they did not compare the long-term trends in the Sq amplitude and the neutral wind in the lower thermosphere and ionosphere. Then, details of physical process of the long-term Sq variation have not been understood yet. In this paper, we try to clarify quantitatively the effect of the Sq variation on the long-term trend in the neutral wind, and to construct a global picture of upper atmosphere variation associated with increasing greenhouse gas using the long-term observation data of geomagnetic field and neutral wind obtained from the ground magnetometer, MF and meteor wind radars. These observation data have been provided from the institutions participating in the IUGONET (Inter-university Upper atmosphere Global Observation NETwork) project which stated in facial 2009. In the present analysis, we used solar F10.7 flux indicating the solar activity, geomagnetic field data with time resolution of 1 hour observed at Memanbetsu, Kakika and Guam. The definition of Sq amplitude is the size of the H-component variation per day when the Kp index is less than 4. As a result, the Sq amplitude observed at three stations strongly depends on 11-year solar activity, and tends to be more enhanced during the high activities (19- and 22- solar cycles) than during the low activity (20-solar cycle). In order to exclude the solar activity dependence on the Sq amplitude, we calculated second orders of fitting curve between the F10.7 and Sq amplitude during 1957-2010, and examined the long-term trend of the deviation of the fitting curve. The deviation showed a clear tendency to increase and decrease during the periods of 1957-1992 and 1993-2010, respectively. Moreover, it should be noted that the deviation around 2010 is almost the same level as that around 1970. This is inconsistent with the result of Elias et al. [2010], who proposed that the long-term variation of Sq amplitude is caused by the ionospheric conductivities enhancement associated with the decrease of the ambient magnetic field intensity and ionospheric electron density due to cooling effect of increasing the greenhouse gas. This result suggests that the variation of the upper atmosphere associated with an extremely quiet solar activity is dominant because the 23-cycle solar activity is the smallest in the period of 1957-2010.

Keywords: Geomagnetic solar quiet variation, Magnetic field intensity, Solar activity, Ionospheric conductivity, Thermospheric wind, Upper atmosphere