Solar Activity and its Magnetic Origin
Proceedings IAU Symposium No. 233, 2006
V. Bothmer & A. A. Hady, eds.

doi:10.1017/S1743921306001426

Longitudinal structure of the photospheric magnetic field

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Abstract. Longitudinal structure of the photospheric magnetic field over last tree solar cycles has been studied. The reconstruction of the longitudinal structure in the heliographic system rotating rigidly with Carrington rate was performed and compared with longitudinal distributions of random origin.

Keywords. Sun: magnetic fields, photosphere, activity

The Wilcox Solar Observatory (WSO) data from http://wso.stanford.edu/synoptic.html used for the analysis are composed of 30 equal steps in latitude sine ($\sin(\theta)$ from 75.2 North to 75.2 South degrees and of 5 degree steps in heliographic longitude.

Longitudinal activity was a subject of detailed studies with different tracers in the rigidly rotating coordinate systems. Two approaches could be used for the analysis of the longitudinal structure of the magnetic field. If the SMF activity is originated from a deep rigidly rotating level then the differential rotation of the upper layers would influence the original distribution of the activity. In this case the longitudinal structure reconstruction should be performed taking into account the rotational rate of the photospheric plasma. Since we know that this rotational rate is changing in time the coordinate system should follow this variation too. The results of this reconstruction can be found in the paper of Gavryuseva & Godoli (2006) at www.sciencedirect.com.

If the level from which the SMF is originated is not too deep under the photospheric level and the SMF is rigidly rotating then the SMF longitudinal structure reconstruction should be performed using the SMF as they are observed. In this contribution the longitudinal structure of the photospheric field is presented in the Carrington system.

In Fig. 1 is plotted the distribution of the magnetic field on the solar surface along the latitudes from -75 to 75 degrees and the longitudes from 0 to 360 degrees mean over 260 Carrington rotations (covering two solar cycles No 21 and No 22 since CR No 1642). The yellow and blue (light and dark in white-and-black version) colors correspond to high positive (up to 170 micro Teslas) and negative (up to -125 micro Teslas) values of this SMF mean latitudinal-longitudinal distribution (LLD) located around active meridians at about 20 degrees heliolatitudes. The contours correspond to the $0, \pm 50, \pm 100$ micro Teslas. The averaging over all latitudes gives the mean longitudinal distribution (LONGD) which is varying from about -30 to 40 micro Teslas.

This LLD distribution should be compared with the ones corresponding to models with random longitudinal SMF distribution (RLSMF). The adequate model of the RLSMF should have all the main characteristics of the solar activity. The RLSMF models was calculated by randomization of the real SMF for each Carrington Rotation at each latitude. With this procedure all the important characteristics (latitudinal distribution, activity cycles, etc.) are present in the model. The only difference is the random character of the SMF longitudinal distribution. The LONGD SMF amplitude is 7–10 time higher than

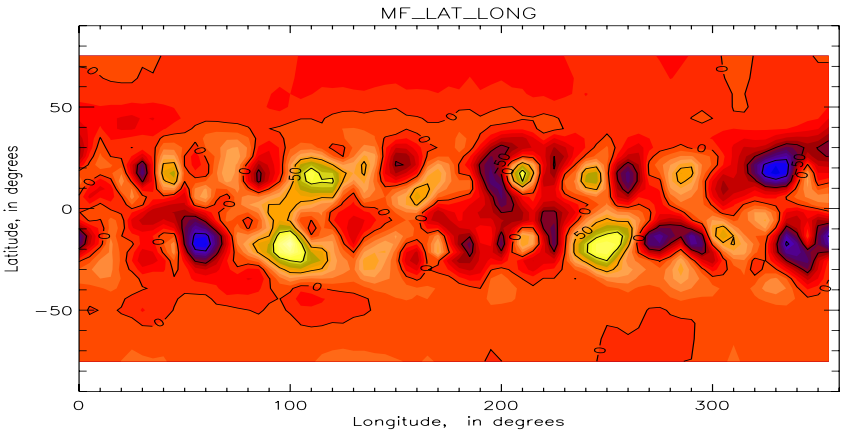

Figure 1. Distribution in longitude and in latitude of the mean over 260 Carrington rotations magnetic field on the solar surface.

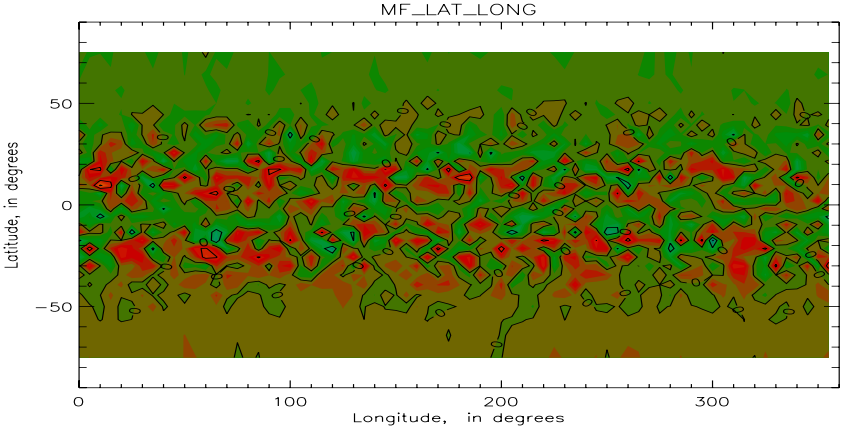

Figure 2. Distribution in longitude and in latitude of the mean over 260 Carrington rotations magnetic field on the solar surface for the model with random longitudinal SMF distribution.

the LONGD RLSMF ones shown in Fig. 2. This confirms that the real SMF longitudinal distribution can not be described by the models of the random SMF distribution. The longitudinal activity is characterized by the amplitude of the magnetic field and not only by its polarity which is changing in time. To prevent the reduction (or even annihilation) of the mean magnetic field over 28-year interval due to the various inversions of polarity, the longitudinal distribution of the absolute value of the SMF averaged over all the latitudes and over 260 CR rotations (LONGD of the SMFI) has been computed and compared with the distributions corresponding to the models of the random LONGDs of the SMF intensity. The LONGDs of the RLSMFI is 6.5 times lower than the LONGD of the absolute values of the measured SMF. The longitudinal distribution of the intensity of the solar magnetic field shows that there are two active longitudes around 10 and 220 degrees. This result is in a good agreement with the conclusions of other studies related to the longitudinal distribution of different characteristics of solar activity.

These results exclude the possibility of the interpretation of the longitudinal distribution of the photospheric magnetic field by the models of fully random perturbations.

I thank the WSO team for the possibility to use the observational data.