

DISTRIBUTIONS OF THE SOURCES OF THE MAGNETIC FIELD DURING THE DOUBLE MAGNETIC CYCLE

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The longitudinal and latitudinal distributions of the solar magnetic field have been investigated by many authors see e.g. (Bumba and Howard 1969; Gaizauskas et. al. 1983). The main longitudinal structures such as active longitudes, sector boundaries in the solar wind, and coronal holes appear to be the consequence of non-symmetric magnetic modes (Stix 1971; Ivanova and Ruzmaikin 1977) and can be explained within the framework of dynamo models. According to these models, solar magnetic fields are generated by helicity and differential rotation in the solar convection zone (Parker 1979) and the linear dynamo process may generate a carrier frequency ω_c ($\omega_c = 2\pi/T$, $T = 22$ yr).

The 22-yr cycle of solar activity is a magnetic cycle that manifests itself as a change of polarity of the sunspots. In parallel with this, the poloidal magnetic field, or background field (B_r -component), shows a 22-yr periodicity (Howard and LaBonte 1981).

According to the studies (Stenflo 1994) the low-latitude and polar fields clearly show the 22-year periodicity too and there is an indication for low-amplitude power at higher frequencies, corresponding to periods of about 2 yr. In non-linear theory stable frequencies with a period shorter than that of the cycle period may occur (Hoyng 1990). All above mentioned allow to assume that cycle consists of two component: high frequency (Hale cycle) and low frequency (biennial cycle). The purpose of our investigation is to find longitudinal structure of the solar magnetic cycle.

Line-of-sight ($B_{||}$) magnetograph data observed by the Wilcox Solar Observatory at Stanford are used in the present investigation. Synoptic observations of the Sun's photospheric magnetic field were obtained covering the interval from 1976 to 1996, spanning cycles 21 and 22.

In the analysis, the first harmonic (f_1) corresponds to $T_1 = 256$ Carrington rotations (being, approximately, 20 yr), and the tenth harmonic (f_{10}) corresponds to $T_{10} = T_1/10$ (being, approximately, 2 yr). The results are obtained as a power spectrum $P_{yy}(\mu, f)$ ($\mu = \cos\theta$) for each longitude l_i . Finally, the

power spectra $P_{yy}(\mu, f)$ were averaged over latitude, separately, for northern and southern hemispheres.

This investigation has revealed that the low-frequency (f_1) and high-frequency (f_{10}) components of longitudinal distribution are distributed non-uniformly on the solar surface and rotate approximately at the same rate. In particular, both the low-frequency (f_1) and high-frequency (f_{10}) components reach their maximum values in different longitudinal zones that are separated by 20° .

A natural question is whether differences between the latitudinal distribution of the low-frequency f_1 component and high-frequency f_{10} component take place for a given longitude.

The first harmonic f_1 , having a period $T_1 = 20$ yr, appears dominant and has a maximum at latitudes greater than 40° in both hemispheres, as does the f_{10} component with $T_{10} = 2.0$ yr. These results coincide with those found in the distribution of high-frequency and low-frequency components of the magnetic field for the axisymmetrical case (Benevolenskaya 1994, 1995). Thus, it may be conceivable that these distributions correspond to the reality to the physical picture of a double magnetic cycle of which both components reach their maximum values at high latitude.

Therefore, we conclude that the poloidal magnetic field of the solar activity cycle consists of both axisymmetrical and non-axisymmetrical modes: a high-frequency (biennial) component and a low-frequency (Hale) component.

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References

- Benevolenskaya, E. E. 1994, *Astron. Lett.*, 20, 468
- Benevolenskaya, E. E. 1995, *Solar Phys.*, 161, 1
- Bumba, V. and Howard, R. 1969, *Solar Phys.*, 7, 28
- Gaizauskas, V., Harvey, K. L., Harvey, J. W. and Zwaan, C. 1983, *Astrophys. J.*, 265, 1056
- Hoyng, P. 1990, *Solar Photosphere: Structure, Convection and Magnetic Fields*, Stenflo, J. O., IAU Symp. 138, 359
- Howard, R. and LaBonte, B. J. 1981, *Solar Phys.*, 74, 131
- Ivanova, T. S. and Ruzmaikin, A. A. 1977, *Astron. Zh.*, 54, 846
- Parker, E. N. 1979, *Cosmical Magnetic Fields*, Oxford University Press
- Stenflo, J. O. 1994, *Solar Surface Magnetism*, Rutten, R. J. and Schrijver C. J., NATO Advanced Research Workshop, Kluwer
- Stix, M., 1971, *Astron. Astrophys.*, 13, 203