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Rotation variations of large-scale solar and interplanetary magnetic fields

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Abstract. The results of complex investigations of solar and interplanetary large-scale magnetic fields (LSMS) are set out. A rotation of sector structures of several types of LSMF was studied analysing evolution of their primary (main) rotation periods. It is confirmed the changing of Sun's rotation regime in the middle of century XX.

1. Introduction

Large-scale magnetic fields (solar and interplanetary) are observed in a sector structure (SS) form. It was revealed by Svalgaard & Wilcox (1975) that the rotation of the SS interplanetary magnetic field (IMF) had multicomponent and variable periods during 1926–1973. Investigations of large-scale solar background magnetic fields (SBMF) over long time interval (Obridko & Shelting (2000), Vasil'eva *et al.* (2002)) allowed to reveal some distinguishing feature of main SBMF sector structures. But results of their investigations are not always agree due to the deference of problem statement and computational technique. At present many questions on SS of LSMF are unresolved.

The results of investigations of SS rotation of LSMF several types are set out below.

2. Data and technique

Time series of the solar background magnetic field (SBMF) of the ± 20 degrees latitudinal zone,1904–2000, the solar mean magnetic field (SMMF), 1975–2003, and interplanetary magnetic field (IMF), 1947–2000, were analysed. To detrmine of the rotation period of the SS of different modes ($\boldsymbol{m}$= 1–7) such technique was applied. The spectrum was computed in moving window of definite length $\boldsymbol{N}$ for period range corresponding to the SS of $\boldsymbol{m}$-mode. The period value of the most power peak of this spectrum assumed as the main rotation period of the SS of $\boldsymbol{m}$-mode. The window moved with step $\boldsymbol{h}$ and computing repeated. Finally the array of rotation period values for the time point $\boldsymbol{t = N/2 + h}$ obtained. This array of rotation period was smoothed by moving average and the time variation of the rotation period was obtained. Results presented in this paper found by spectrum computing with moving window of four years length and step of three months.

3. Results

3.1. *Solar background magnetic field*

It is known that rotation periods of the ± 20 degrees latitude zone lie over the range of 26.8–27.8 days. To find the main rotation periods of SS SBMF several rotation period ranges were tried and it was revealed that the most appropriate range was 26.5-30.0

days. This period range was used for obtaining of all mentioned below results of SBMF investigation.

The rotation rate of two-sector structure of SBMF varied with ∼11-year cycle during the first half of investigated interval and with ∼8-year cycle during the second half. The maximal rotation rate was observed under low level of solar activity But four-sector structure had ∼22-year cycle change in the rotation rate over whole interval. The maximal rotation rate was observed during maximum of even cycles (14,16,18,20,22) and minimal rate of the rotation was observed during maximum of odd cycles.

In the middle of century XX the mean rotation rate of main sector structures of SBMF increased. It was revealed that until ∼ 1947 rotation rate of four-sector structure was greater of two-sector structure rotation rate, after 1947 their rotation rate are something like.

In the middle of century XX the power redistribution of the SS occured as well. The amplitude of sector structure of the more high modes ($\boldsymbol{m} \geqslant 3$) increased and the sector structure character of SBMF changed. For interval 1960–2000 it was revealed that the period of the sector structure rotation decreased with increase of its mode $\boldsymbol{m}$

Thus, main sector structure of SBMF are independent and it seems they are generated in different depth of convective zone.

3.2. *Solar mean magnetic field*

The SMMF means the strength of longitudinal component of the photospheric (bagkground) magnetic field averaged all the visible hemisphere of the Sun. But the rotation rate of main sector structure of SBMF the two-sector and four sector structures of SMMF had minimal rotation period under high level of solar activity. The main sector structure of SMMF are dependent.

3.3. *Interplanetary magnetic field*

The main rotation period of the twosector structure of IMF varied with ∼22-year cycle: maximal value of the rotation period of IMMF was during ∼1952–1956, ∼1976, ∼1997.

The analyse of the spectrums of whole cycle shown that during cycles 20–23 the rotation period of IMF and SMMF is greater in even cycle and smaller in odd cycle. During cycles 18-19 rotation period of IMF was greater during odd cycle and smaller during even cycle.

Possibly this fact indicates the changing of the rotation regime of IMF in the middle of century XX and it is indirect confirmation of the changing of Sun's rotation.

4. Conclusion

We have shown,that the evolution of primary rotation period of the SS of SBMF,SMMf and IMF had not identical character during common interval of observation.

It is confirmed of the changing of Sun's rotation regime in the midle of century XX.

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