LARGE-SCALE MAGNETIC FIELDS OF SUN–HELIOSPHERE MAGNETIC SYSTEM

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Some results of investigations of solar and interplanetary magnetic fields are presented. The time series of the solar background magnetic field (SBMF) of ±20 degree for 1904–2000, solar mean magnetic field (SMMF) for 1975–2003, and interplanetary magnetic field (IMF) for 1947–2001 were used. A change of the Sun's rotation regime in the middle of the 20th century is confirmed. The rotation of the sector structures of SBMF, SMMF, and IMF had not identical character during common interval of the observations.

INTRODUCTION

Solar and interplanetary large-scale solar magnetic fields (LSMF) are observed in the form of the sector structure (SS). It was revealed by Svalgaard and Wilson [2] that the rotation of the SS of 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 [1, 3] allowed one to reveal some distinguishing feature of main SBMF sector structures. But the results of their investigations do not always agree because the problem statement and method of investigations were different. At present, many questions on behaviour of SS LSMF are unresolved.

The results of investigations of LSMF several types sector structure rotation are presented below.

DATA AND PROCEDURE

Time series of the solar background magnetic field (SBMF) of the ±20 degrees latitudinal zone for 1904–2000, of the solar mean magnetic field (SMMF) for 1975–2003, and of interplanetary magnetic field (IMF) for 1947–2000 were used for our analysis. To determine the rotation period of the sector structures of different modes ($m = 1-7$), we used the following procedure. The spectrum was computed in moving window of definite length N for period range corresponding to the SS of m-mode. The period value of the most power peak of this spectrum assumed as the main rotation period of the sector structure of m-mode. The window moved with step h and computing repeated. Finally, the array of rotation period values for the time point $t = N/2 + h$ was obtained. This array of the rotation period was smoothed by moving average and the time variation of the rotation period was obtained. The results presented in this paper are derived under the spectrum computing with moving window of a four-year length and a three-month step.

RESULTS

Solar background magnetic field

It is known that the rotation periods of the ±20 degrees latitude zone lie over the range of 26.9 to 27.7 days. To find the main rotation periods of SS SBMF, several rotation period ranges were tried on the computations of the spectrum, and it was revealed that the most appropriate range was 26.5–30.0 days. This period range was used on obtaining all the results of SBMF investigation mentioned below.

The rotation rate of two-sector structure of SBMF varied with about 11-year cycle during the first half of investigated interval and with about 8-year cycle during the second half. The maximal value of the rotation periods and minimal value of its amplitude were observed under a low level of solar activity. But four-sector structure had about 22-year cycle of the rotation period change and about 11-year cycle of the change of its amplitude over whole interval. The maximal rotation rate of four-sector structure 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 (15, 17, 19, 21).

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

In the middle of the 20th century the mean rotation rate of the main sector structures of SBMF increased. It was revealed that until about 1947 the rotation rate of four-sector structure was greater than two-sector structure rotation rate, after 1947 the rotation rate of both sector structures were almost uniform.

In the middle of the 20th century the power redistribution of the SS occurred as well. The amplitude of sector structure of higher modes ($m \geq 3$) increased and the sector structure character of SBMF changed. For interval 1960–2000, it was revealed that the sector structure rotation period decreased with the increase of its mode m.

Solar mean magnetic field

The SMMF means the strength of longitudinal component of the surface magnetic field averaged at the visible hemisphere of the Sun.

One of interesting features of LSMF is two periods of their quasi-rigid rotation, namely, about 27-day and about 28-day periods.

A low value of rotation periods (about 27 days) of quasi-rigid rotation of both two-sector and four-sector structures of near-equatorial magnetic fields corresponds to a high value of its amplitude as well as two-sector structure of SBMF. But on the contrary to SBMF, the rotation rate of the main sector structure of SMMF had minimal rotation period under a high level of the solar activity. The main sector structures of SMMF have synchronous rotation.

The evolution of the second periods of quasi-rigid rotation (about 28-day period) of SMMF has no cyclicyty.

The difference in evolution of two quasi-rigid rotation periods of SMMF confirms the conception of two independent systems of large-scale magnetic fields.

Interplanetary magnetic field

The main rotation period (about 27-day period) of the two-sector structure of IMF varied with about 22-year cycle: maximal value of the rotation period of IMMF was during about 1952–1956, 1976, 1997.

An analysis of the spectrums of the whole cycles showed that during the 20th–23rd cycles the rotation period of IMF and SMMF was greater in even cycles and smaller in odd cycles. During the 18th–19th cycles the rotation period of IMF was greater during odd cycle and smaller during even cycle.

Possibly, this fact is indicative of a change of the rotation regime of IMF in the middle of the 20th century, and this is an indirect confirmation of the Sun's rotation change.

CONCLUSION

The relationships between large-scale magnetic fields of the Sun–heliosphere magnetic system are complex.

We showed that the evolution of primary rotation period of the SS of SBMF, SMMF, and IMF had not identical character during common interval of observations.

The investigations of the rotation of the SBMF and IMF confirmed a change in the Sun's rotation regime in the middle of the 20th century.

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