SOME COMMENTS TO THE PROBLEM OF EXTENDED CYCLES IN LARGE-SCALE MAGNETIC FIELDS

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ABSTRACT   Analysis of the latitude-time dependence of the sign of the large-scale solar magnetic field shows that there are two waves of activity with the periods of 17 and 23 years. The poleward drift is shown to begin immediately in the equatorial zone. Two systems of recording global magnetic fields are compared.

INTRODUCTION

At present, there are two systems of recording large-scale fields for which large databases are available. The first system consists in direct recording of large-scale fields with a magnetograph. The data obtained in such a way are published by Hoeksema and Scherrer (1986) in the form of coefficients of expansion into spherical functions. Unfortunately, tabulated in this work are only coefficients for $l \leq 9$ and besides, the data are only available for cycle 21. .PP The second system is efficiently developed by McIntosh (1979) and Makarov *et al.* 1987b). Here, Hα observations are used to determine the regions occupied by N and S field. This system does not obviously provide information on the field intensity. However, the data series available go back to 1915, which allows the problem of cycle duration in large-scale fields to be discussed.

THE LATITUDE-TIME POLARITY DISTRIBUTION OF THE LARGE-SCALE SOLAR MAGNETIC FIELD

The Hα synoptic charts for the period of 1915-1982 have been used to study the latitude-time distribution of the sign of the large-scale solar magnetic field (Obridko *et al.* 1989),

$$A(\phi, t) = (S^+ - S^-)/(S^+ + S^-),$$

that displays the deficit of area occupied by the field of one polarity in the 10° latitude zone for one rotation (S^+ and S^-) denote the portions of area

occupied by the "+" and "-" polarity, respectively; $A(\phi,t)$ has the meaning of the magnetic flux. (See Makarov *et al.* 1987a).

The behaviour of $A(\phi,t)$ in different hemispheres over the activity cycles and of the North-South asymmetry are represented, respectively, as

$$D(\phi,t) = [A(\phi_N,t) - A(\phi_S,t)]^{1/2}$$

and

$$C(\phi,t) = [A(\phi_N,t) + A(\phi_S,t)]^{1/2}$$

Figure 1 shows in a) the Wolf numbers, W, b) variation of the $D(\phi,t)$ parameter as a function of latitude, ϕ, and time, t, in two ranges: from 0 to 0.28 and from 0.28 to 1; and c) variation of the $C(\phi,t)$ parameter as a function of latitude, ϕ, and time, t, in two ranges: from 0 to 0.14 and from 0.14 to 1.
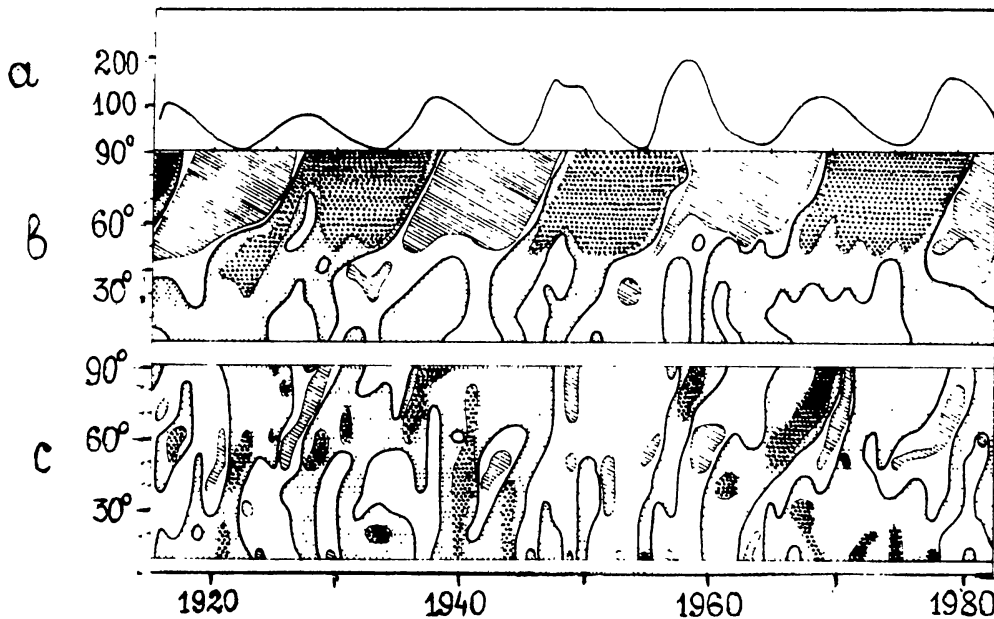

Fig. 1.   Latitude-time diagram for the odd and even large-scale field components relative to the equator as given by $H\alpha$ data.

The behaviour of the $D(\phi,t)$ parameter infers that the excess area occupied by the "−" (dots) or "+" magnetic field displays a latitudinal zonal structure that persists for several years at all latitudes. Every new zone arises at the sunspot maximum and migrates from the equator polewards. The zone appears in the form of a precursor burst. The location of the precursor is marked with an arrow in the Figure. At the beginning of the decay phase, the old field sign is restored for a short time, and then the new polarity is decisively established. The overall lifetime of the unipolar zone since it arises as precursor at the equator until it disappears at the pole is about 17 years, the average width of the zone is 11 years. The zones drift at a velocity of about 1.0 m/s. The behaviour of the $D(\phi,t)$ zones coincides with the properties of the 1st dynamo wave (Makarov *et al.* 1987).
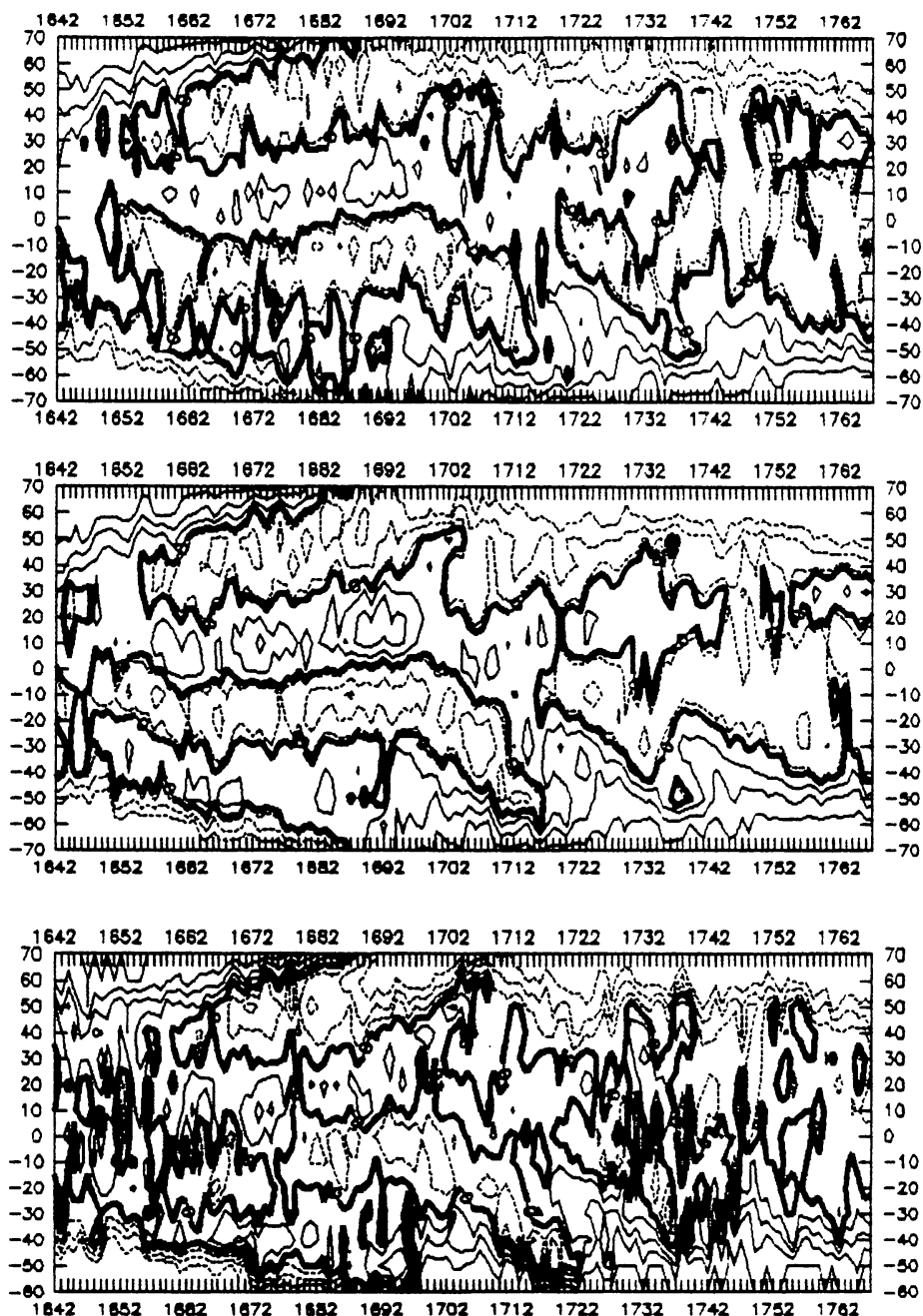
Fig. 2.   Comparison of two recording systems of large-scale magnetic field.

The behaviour of the North-South asymmetry, C(ϕ, t), revealed a regular zonal structure in the asymmetry index, C(ϕ, t). The zones rift polewards at a velocity of 5 to 15 m/s. The life-time of the zones is about 3 years. The properties of the latitudinal zonal structure of C(ϕ, t) coincides with the
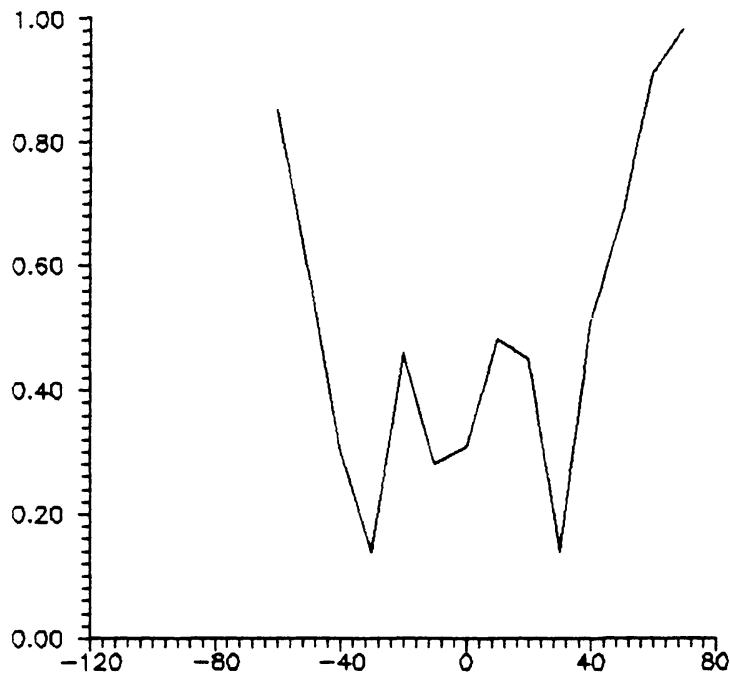
Fig. 3.   Correlation coefficients of SI(ϕ, t) and A(ϕ, t) as a function of the latitude, ϕ.

predicted properties of the 3rd dynamo wave if we assume the field sign in the 3rd wave to be one and the same on both sides of the equator.

As seen from Figure 1 (panel b), the structure of the latitude-time diagram changes sharply at the latitude of 40°, i.e. it becomes finer and more complex. This seems to be due to the fact that contribution of local fields at this latitude increases. On the other hand, it would be important to check this phenomenon using direct magnetographic data.

COMPARISON OF LATITUDE-TIME DIAGRAMS IN TWO SYSTEMS OF DATA

The Hoeksema and Scherrer (1986) expansion coefficients have been used to reconstruct synoptic charts of the magnetic field for each Carrington rotation in cycle 21 from 1642 to 1748 with a 10° resolution in latitude and longitude. The synoptic charts have been used to calculate the values of

$$SI(\phi, t) = \frac{\sum_i^{36} B_i / |B_i|}{36}$$

$$\Phi(\phi, t) = \frac{\sum_i^{36} B_i}{\sum_i^{36} |B_i|}$$

It is obvious that the first value, SI, is merely the normalized difference of areas occupied by different polarities for each latitude, and in this sense it is fully identical with the value $A(\phi, t)$ used before. The second value, Φ, is the normalized flux. SI, Φ, and $A(\phi, t)$ are plotted in Figure 2. One can see that on the whole, the three diagrams are alike.

Therefore, it can be suggested that the properties mentioned in the previous Section are not determined by mere use of Hα recording system. One cal also see a clearly pronounced change of the structure at the latitude of 40°. Let us note, however, that the likeness of the diagrams decreases essentially in the equatorial zone. Figure 3 illustrates variation of the correlation coefficient of SI and A as a function of ϕ.

The cause of this discrepancy is still not clear, but it is obviously associated with the field recording method. We hope to study it in our further work.

REFERENCES

Hoeksema, J. T. and Scherrer P. H. 1986, UAG Report No. 94.
Makarov, V. I., et al. 1987a, *Soln. Dannye*, **5**, 82.
Makarov, V. I. et al. 1987b, *Soln. Dannye*, **12**, 59.
McIntosh, P. S. 1979, UAG Report No. 70.
Obridko, V. N. et al. 1989, *Astron. Tsirk.*, **1536**, 31.