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On the epochs of polarity reversals of the polar magnetic field of the sun during 1870–1982

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Abstract. Using the H-alpha synoptic charts for the period 1904–1982 and the data on the polar prominences for the period 1870–1905, we present a summaiy of the results of the polarity reversal of the polar magnetic field on the sun for 11 solar cycles.

Key words : sun—magnetic field—polarity reversals

The structure of the large scale magnetic field on the sun is determined by the distribution of unipolar regions which have length scale many times the dimensions of the supergranulation cells. The pattern of distribution of these unipolar regions is evident in magnetograms. Alternatively the unipolar regions can be identified in the H-alpha synoptic charts (McIntosh 1972) and the filaments and filament channels that outline the boundaries of these regions can be used as agencies for tracing the evolution and migration of the large scale magnetic field regions on the solar surface. When features in the H-alpha spectroheliograms can be identified clearly, the neutral line pattern associated with these large scale magnetic field regions can be derived with greater care and accuracy than can be inferred from magnetograms (Duvall *et al.* 1977). McIntosh (1972) has constructed H-alpha synoptic charts for the period 1964–1974. We prepared synoptic charts on the same lines from the Kodaikanal H-alpha and Ca II K spectroheliograms for the solar rotations 675–1486 that correspond to the period 1904–1964. In figure 1 we present a few sample charts. We have used these to derive the drift trajectory of the neutral line of the large scale field in the same way as Makarov & Fatianov (1980).

The synoptic charts show that the polarity of the large scale magnetic field for any longitude alternates in sign at several latitudes between the equator and the poles, the line of demarcation being the filament bands that run approximately east to west. It is possible to assign a mean latitude to every filament band over each

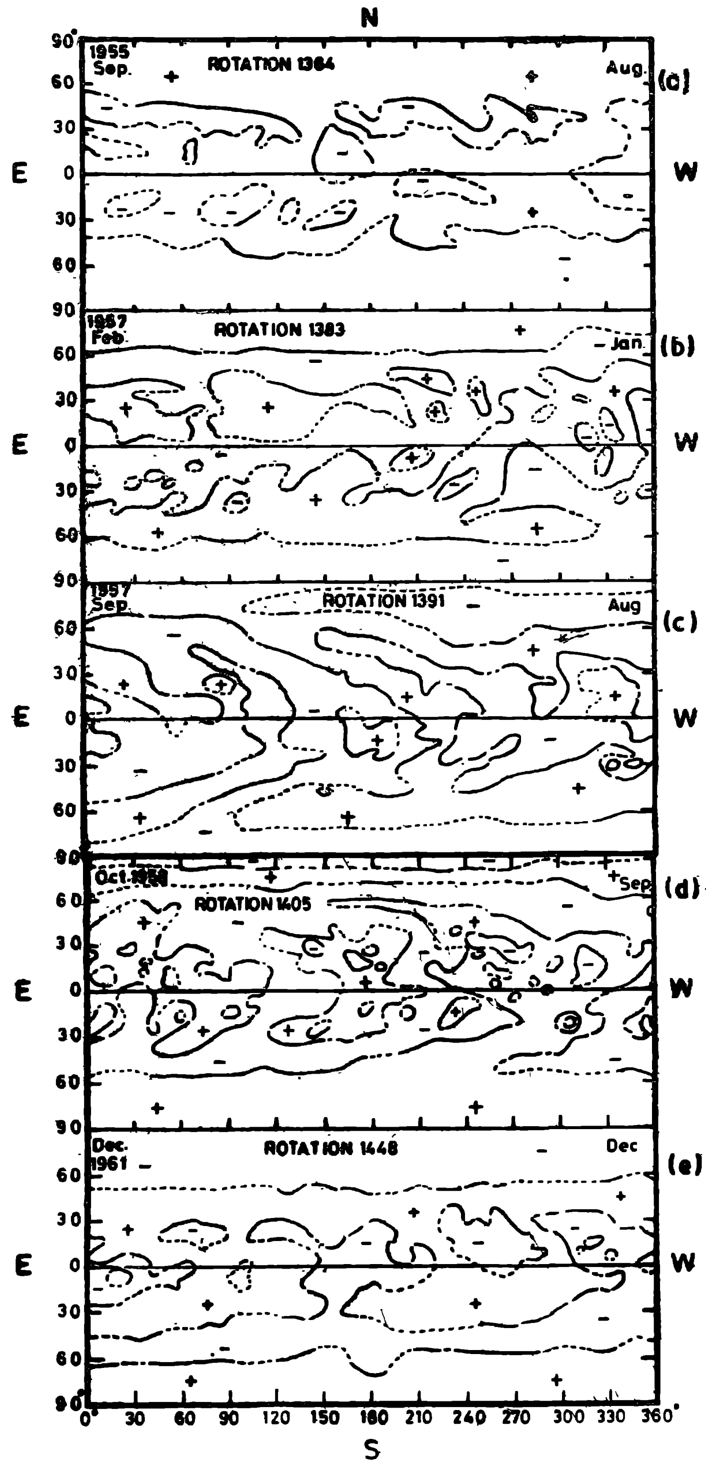

Figure 1. Examples of H-alpha synoptic charts corresponding to five epochs of solar activity for the 19th cycle. Solid lines are the H-alpha dark filaments and the dashed lines are the filament channel systems.
(a) Shows the start of activity. The polarity of the N-pole is positive at the start of this cycle.
(b) & (c) At the ascending phase of the activity, the polemost filament band has migrated and reached the polar region. The first reversal of the polar magnetic field is now complete.
(d) The second filament band has now reached the polar region in the N-hemisphere.
(e) The pattern of the large scale magnetic field two years after the final reversal of the polar magnetic field.

solar rotation. To make this mean value representative, we measure the latitudes of the filament band in every 20° longitude zones and average them over one solar rotation. This mean value now forms one data point on the migration trajectory curve. From a plot of such points in the time frame for the filament bands that are closest to the poles in the two hemispheres, we obtain the trajectory of the poleward boundaries of magnetic regions of one dominant polarity as they migrate to high latitude with the progress of solar activity.

We have compared the drift trajectories of the filament bands and the polarity changes these bands subsequently cause as they reach the poles, with the corresponding magnetograms of Howard (1974) for the period 1966–1972 and those of Babcock (1959) for the earlier period reaching back to 1957. The absolute agreement between the results from magnetograms and ours gave us confidence about the validity of using the filament bands for such a study. We extended this analysis back in time to 1870 (Makarov & Sivaraman 1983; Makarov 1983) for which magnetograms do not exist and derived the epochs of the reversals of the polar field for the entire period 1870–1981. We present our results in table 1. For the period 1870–1903, we used the Italian data of Ricco (1914) on the distribution of prominences in the polar zones. In figure 2 we show the plot of the poleward migration trajectory of the neutral line for the period 1945–1982 which would serve as a typical sample.

Table 1. Epochs of the reversals of the polar magnetic field in the two hemispheres of the sun. The figures in columns 2, 4 and 6 represent the epochs of polarity reversals in years correct to a decimal. The figures within brackets are not precise because the exact epoch of migration could not be decided for want of prominences on the sun. Notice the monopole on the sun in cycles 12, 14, 16, 19 and 20. These are underlined for convenience.

Cycles	Northern hemisphere	Polarity change	Southern hemisphere	Polarity change	Final reversal
11	1872.3	+/−	1872.3	−/+	1872.3
12	1883.4	−/+	1883.7	+/−	1883.7
			(1884.9)	−/+	
			(1885.8)	+/−	1885.8
13	1895.0	+/−	1895.0	−/+	1895.0
14	1906.7	−/+	1905.3	+/−	
			1906.8	−/+	
			1908.4	+/−	1908.7
15	1918.6	+/−	1918.7	−/+	1918.7
16	1927.9	−/+			
	1929.3	+/−			
	1929.9	−/+	1928.5	+/−	1929.9
17	1940.1	+/−	1940.0	−/+	1940.1
18	1950.2	−/+	1949.0	+/−	1950.2
19	1958.0	+/−			
	1958.8	−/+			
	1959.7	+/−	1959.5	−/+	1959.7
20	1969.7	−/+			
	1971.1	+/−			
	1971.5	−/+	1970.6	+/−	1971.5
21	1981.0	+/−	1981.8	−/+	1981.8

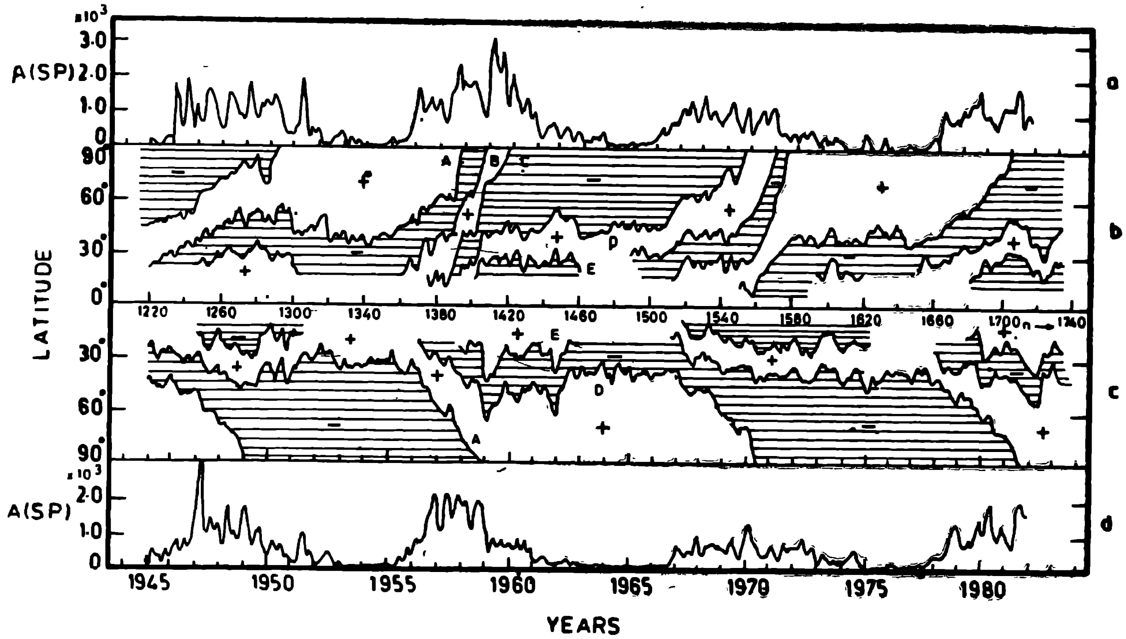

Figure 2. Boxes b and c : Curves A, B, C represent the migration of the mean latitude (averaged over 3 rotations) of the neutral line of the large scale magnetic field for solar cycles 18–21 in the north and south hemispheres. + and – stand for the polarity sign of the magnetic field in the conventional way. A start of a new boundary corresponds to the epoch of H-alpha charts when the total length of the neutral filament boundary exceeds 240° in longitude. n, the number of the Carrington solar rotation. D & E represent the positions of low latitude filament bands.

Boxes a and d : Continuous curves show the run of mean daily areas of sunspots averaged over one rotation with 3 point smoothing. $A(S_p)$ are the sunspot areas expressed in millionths of the visible hemisphere for these cycles for the northern and southern hemisphere.

We present below a summary of the results of our study :

(i) There is close agreement between the polarity reversals derived from the drift trajectory of the neutral line and those from magnetograph observations.

(ii) A threefold polarity reversal of the magnetic field of the sun took place in the 12th and 14th solar cycles in the south hemisphere and in the 16th, 19th and 20th solar cycles in the north hemisphere.

(iii) The filament bands in the two hemispheres do not reach the respective poles simultaneously. Whenever one of the hemispheres has a threefold change in polarity and the other only a single fold, a relative shift occurs in the epochs of the arrival of the filament bands at the two poles. This shift in time in the polarity change at one pole relative to the other causes an apparent monopole situation on the sun.

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