THE SUN'S POLAR MAGNETIC FIELD

HAROLD D. BABCOCK
Mount Wilson and Palomar Observatories
Carnegie Institution of Washington, California Institute of Technology
Received April 6, 1959

ABSTRACT

The polarity of the high-latitude dipolar magnetic field of the sun was opposite to that of the earth's field from 1953 to 1957. About the middle of 1957, the polarity of the magnetic field near the south heliographic pole was reversed; reversal of the field near the north pole was not observed until November, 1958. At present, the sun's polar field is parallel to that of the earth.

This paper presents new data on the weak persistent magnetic fields characteristic of high heliographic latitudes. These fields were discussed by Babcock and Babcock (1955), who concluded, on the basis of a series of observations from 1952 to 1955, that the magnetic polarity of the sun was opposite to that of the earth. Variations of structure and of extent into lower latitudes were noticed; the effective intensity was of the order of 1 gauss.

The new observations reported here were made with the solar magnetograph at the Hale Solar Laboratory in Pasadena. The instrument and the method of calibration have been described by H. W. Babcock (1953). In this work, the length of the slit usually used corresponds to about 1 minute of arc on the sun's image. As before, a magnetic vector directed toward the observer is called "positive," and vice versa.

On standard magnetograms made by automatic scanning under good observing conditions, the sign of a polar field whose intensity is 0.5 gauss is unambiguous. With weaker fields or impaired atmospheric transparency, it is advantageous to hold the sun's image fixed and to average the magnetic signal over a longer time; most of the results reported here were obtained in the latter way. The solar image is held fixed at each of seven positions in each polar zone while the resulting deflection is recorded as a function of time. Average values are obtained from the records for each of the seven positions, yielding a final mean for the zone.

The foregoing method is used when the atmospheric transparency is high and nearly constant for at least 1 hour. Under adverse observing conditions, useful results may be obtained by reading deflections on an oscilloscope while the image is held fixed for a few minutes at selected high-latitude positions.

Confirmation of the reality of the weak fields observed is obtained by inserting above the electro-optic analyzer a half-wave plate of mica; this reverses the sign of any circularly polarized component in the solar beam and consequently reverses the sign of the observed deflections.

Effects of limb darkening and of small uncertainties in the position of the slit with respect to the image, as well as the effect of averaging along the slit, preclude exact statements of the heliographic latitudes involved in this work. The effective annual range of latitudes observed is $\pm 80°$ to $\pm 50°$. During the minimum phase of the sunspot cycle (1954–1955), polar fields have extended on rare occasions nearly to the solar equator. During sunspot maximum, weak extensions of strong low-latitude fields, characteristic of bipolar magnetic regions associated with the toroidal belts, have sometimes intruded poleward to latitude 60°. The data assembled here are considered fairly representative of the polar zones.

Figure 1 shows the observed sign and intensity of the sun's polar field from 1956.0 to 1959.3. All available data have been included, irrespective of observing conditions.

Most of the points represent mean values from either 5 or 10 days of observation with the Pasadena magnetograph. I have derived a few results from magnetograms obtained by W. C. Livingston on Mount Wilson in the summer of 1957.

It is apparent from Figure 1 that the south polar field reversed its sign between March and July, 1957. The sign of the north polar field, however, remained positive until November, 1958, when it rather abruptly became negative. For more than a year, the unexpected peculiarity was presented of two poles with the same sign.

It was earlier noted (Babcock and Babcock 1955) that near the north and south limbs of the sun the apparent relative magnetic intensity, as well as the area observably affected by the polar fields, varies with the earth's heliographic latitude. During the half-year, December 8–June 6, in which the north end of the sun's axis is inclined away from the earth, the observed south polar magnetic intensity exceeded that near the north pole, and vice versa in the other half-year. This effect remained evident, as the observations continued, until the spring of 1957, when for a few months the polar fields fell below the threshold of measurement. In July, 1957, the south polar field reappeared with positive sign; in the next month weak positive fields were found near the north pole.

The current phase of the cycle of sunspot numbers has not advanced sufficiently to fix the date of the maximum, but a provisional date is 1958.3 (Waldmeier 1958). It is interesting to note that this date, four years after the preceding minimum, is midway between the observed dates of reversal of the south and north solar magnetic poles.

As of early 1959, the sun's polar magnetic field is oriented like that of the earth. Its other characteristics remain as first reported.

REFERENCES

Babcock, H. W. 1953, *Ap. J.*, **118**, 387.
Babcock, H. W., and Babcock, H. D. 1955, *Ap. J.*, **121**, 349.
Waldmeier, M. 1958, unpublished material.

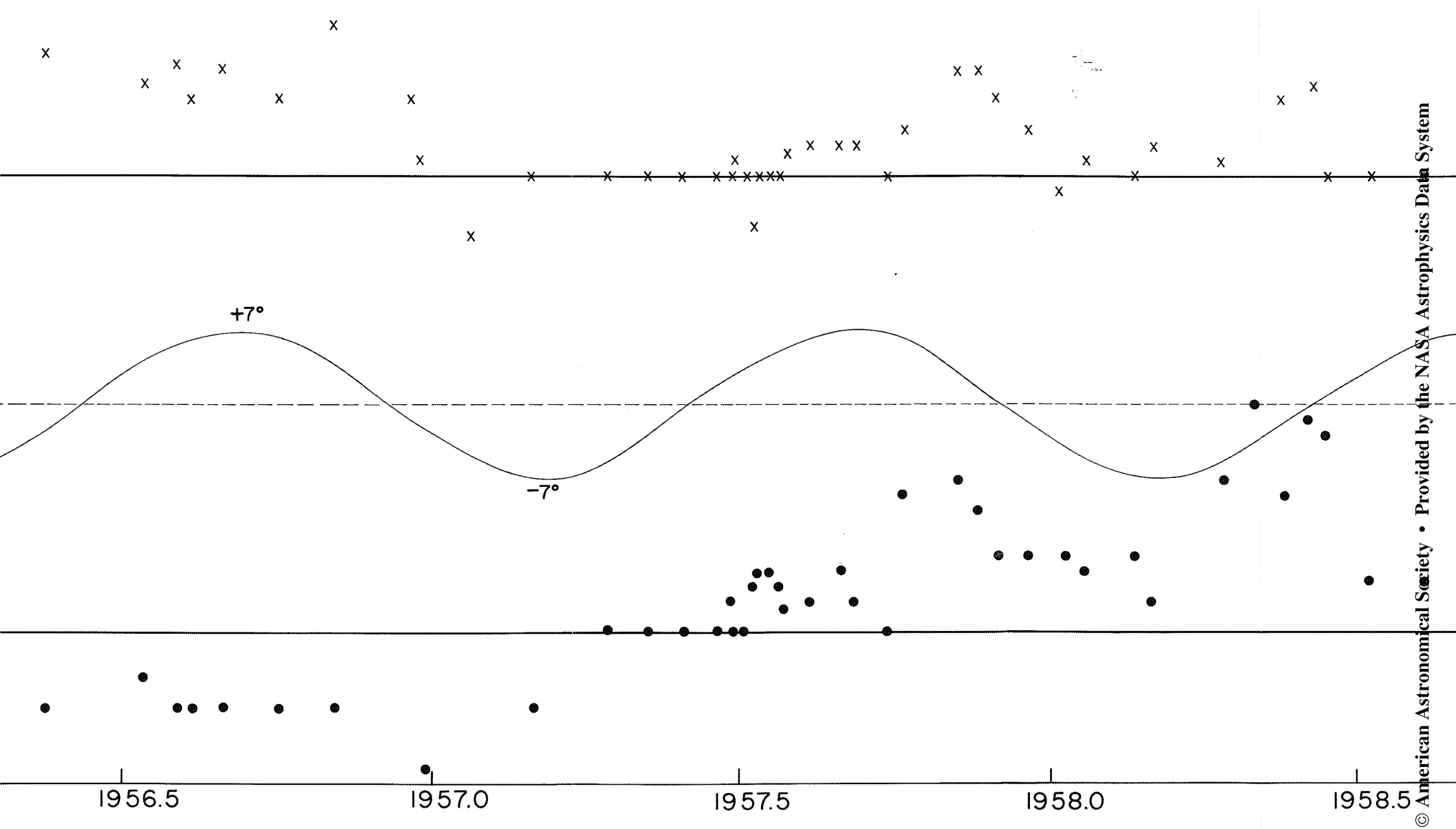

FIG. 1.—Signs and average intensities of the sun's polar magnetic field. *Above*, north polar zone; *bottom*, south polar zone; *center*, earth's heliographic latitude