COMPARISON OF Hα SYNOPTIC CHARTS WITH THE LARGE-SCALE SOLAR MAGNETIC FIELD AS OBSERVED AT STANFORD

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Abstract. Two methods of observing the neutral line of the large-scale photospheric magnetic field are compared: (1) neutral line positions inferred from Hα photographs (McIntosh, 1972a, 1975; McIntosh and Nolte, 1975) and (2) observations of the photospheric magnetic field made with low spatial resolution (3′) and high sensitivity using the Stanford magnetograph. The comparison is found to be very favorable.

1. Introduction

Observations of large-scale magnetic patterns in the solar photosphere are necessary for understanding the solar source of the interplanetary magnetic sector structure (Wilcox, 1968). An understanding of this solar source would give the ability to predict the occurrence of interplanetary and terrestrial phenomena related to the sector structure, including geomagnetic activity (Wilcox, 1968) and the effect on atmospheric vorticity (Wilcox *et al.*, 1974). A model of the solar source in which photospheric magnetic sectors are combined with the polar fields (Svalgaard *et al.*, 1974) is supported by the observations of the green-line corona, white-light corona, and photospheric magnetic fields (Autonucci and Duvall, 1974; Howard and Koomen, 1974; Hansen *et al.*, 1974; Svalgaard *et al.*, 1975). The present paper compares two methods of observing the neutral line of the large-scale photospheric magnetic field: (i) direct observations of the photospheric field using the Stanford magnetograph, and (ii) neutral line positions inferred from Hα observations (McIntosh, 1972a; McIntosh, 1975; McIntosh and Nolte, 1975).

2. Observations

The measurement with a magnetograph of the large-scale solar magnetic field is a difficult observational problem. Extrapolating the magnetic field strength observed in interplanetary space back to the sun yields a photospheric field strength of the order of 1 G. The magnetograph at Stanford was designed to measure accurately magnetic fields of this magnitude over large solar regions. The observations used in the present study consist of daily full disk magnetograms with a spatial resolution of 3′. The statistical uncertainty of each measurement is about 0.05 G. A systematic error is observed by measuring the signal on the $g = 0$ (nonmagnetic) line of Fe I λ5123.7. This systematic error is subtracted from each point of the magnetogram. Its magnitude is usually less than 0.1 G. The time period used for the present study is May–August 1976 (Carrington rotations 1641–1644). Synoptic charts of the magnetic field strength for these four solar rotations were constructed using observations made near central meridian. For the present study of neutral line positions, a shaded band was plotted (Figures 1–4) surrounding the neutral, or zero field, line. The boundaries of the shaded region correspond to the ±0.1 G contour levels.

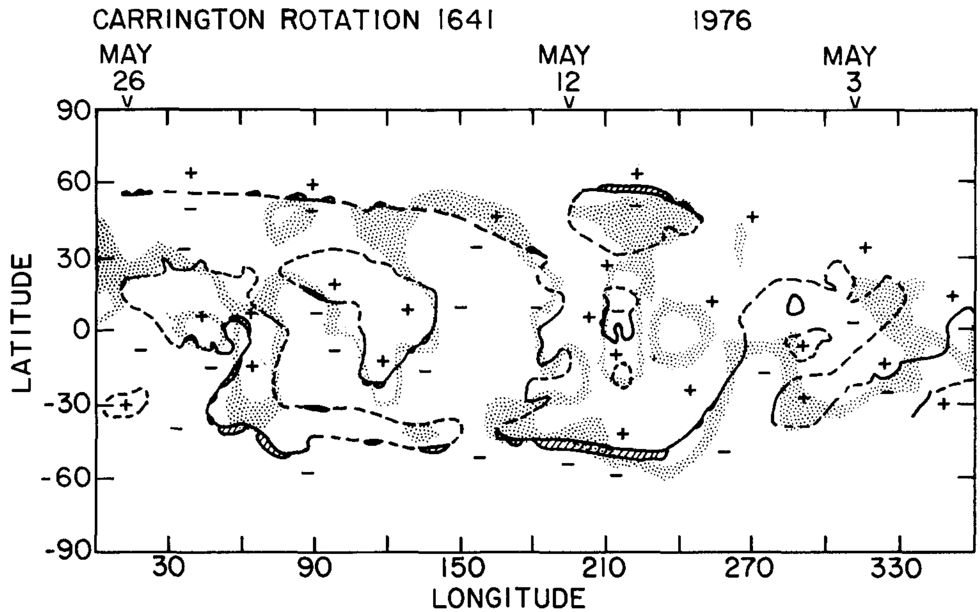

Fig. 1. Comparison of the Hα synoptic chart and the neutral line determined from the Stanford magnetograms for Carrington rotation 1641. The shaded band surrounds the Stanford neutral line. The boundaries of the band correspond to the ±0.1 G contour levels. For the Hα synoptic chart, the hatched regions correspond to filaments, solid lines are more well-determined neutral lines, and dashed lines are less well-determined neutral lines. Magnetic polarities from the Hα charts are indicated by the + and − signs.

The neutral line position defined by the Stanford magnetograms is being compared with that derived from the Hα observations (McIntosh, 1972a, 1975; McIntosh and Nolte, 1975). Various features observed in Hα, including filaments, filament channels, plage corridors, 'iron filing' patterns of fibrils near active centers and arch-filament systems, are used to infer the neutral line position. Sunspot polarities are used to infer the sign of the field on each side of the neutral line. Data from previous rotations and a general knowledge of solar physics are used to infer the neutral line

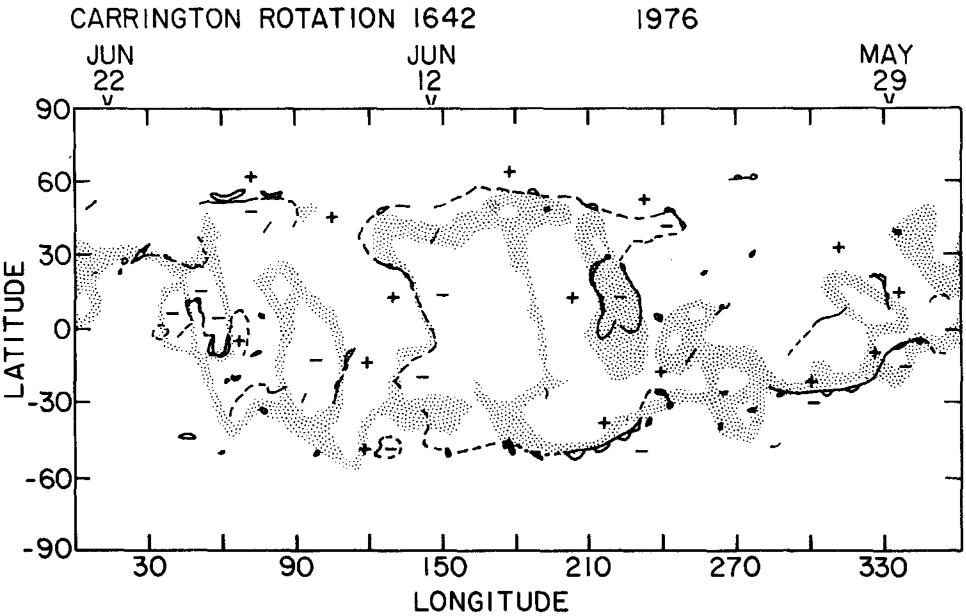

Fig. 2. Comparison of Hα synoptic chart and magnetogram neutral line for Carrington rotation 1642.

positions in regions where a clear Hα signature is not discernible. Normally, magnetogram data is also used, but for the present comparison it was not. The Hα synoptic charts for Carrington rotations 1641–1644 are shown in Figures 1–4 overlaying the Stanford neutral line determination. The hatched regions correspond to Hα filaments, the solid lines to a more certain neutral line, and the dashed lines to a less certain neutral line. The polarities shown on Figures 1–4 are those of the Hα synoptic charts. The polarities for the Stanford data can be inferred from the fact that the northern polar field is positive, southern negative, and crossing the neutral line causes a change of polarity.

3. Discussion

The comparison of the two neutral line determinations in Figures 1–4 is seen to be generally favorable. The agreement is best when the neutral line of the Hα maps is well-determined (solid line). In certain cases, such as in Figure 1, long. 240, lat. −50, the well-determined Hα neutral line lies outside the region of uncertainty of the Stanford neutral line. Such an error is probably due to the coarse spatial resolution of the Stanford instrument. In Figure 1, long. 220, lat. 50, we see a fairly large region where the magnetic polarity is ill-defined according to the Stanford observations. The filament in this region is probably a better indication of neutral line position than can be gotten from the Stanford data. The most difficult aspect of inferring the Hα neutral line position is the extrapolation outside regions where a clear Hα signature

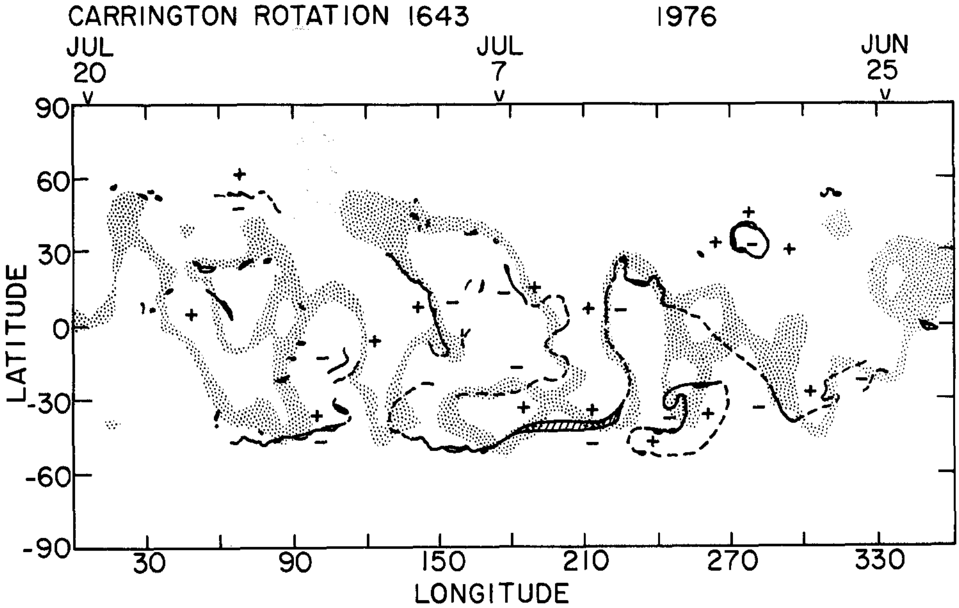

Fig. 3. Comparison of Hα synoptic chart and magnetogram neutral line for Carrington rotation 1643.

exists. A number of these extrapolations fail because the neutral line was inferred to be east–west when it should have been north–south. Examples of this are seen in Figure 1, long. 120, lat. 45 and in Figure 4, long. 90.

The Hα charts used in this comparison are incomplete and preliminary, representing what can be accomplished with only Hα data in near-real-time near a minimum in solar activity. The Hα synoptic charts in Figures 1–4 appeared in NOAA's Preliminary Report and Forecast of *Solar-Geophysical Data* within days after the observations were made. More detailed maps can be constructed by many additional hours of study and intercomparison of Hα data, especially at a time when the solar surface is filled with numerous active centers (McIntosh, 1975; McIntosh and Nolte, 1975; Roelof and Krimigis, 1973). The comparison with measured magnetic fields in this paper represents a conservative and objective test of Hα observations as an independent source of magnetic field information.

4. Conclusions

The Hα synoptic charts complement direct measurements of the large-scale photospheric magnetic field. In regions where no clear Hα signature is present, the magnetic observations give a good determination of the neutral line position. In regions where clear Hα features exist, the Hα synoptic charts often give a more accurate determination of neutral line position.

This paper establishes the veracity of inferred large-scale solar magnetic fields. The accuracy of Hα observations for inferring strong, localized magnetic fields was

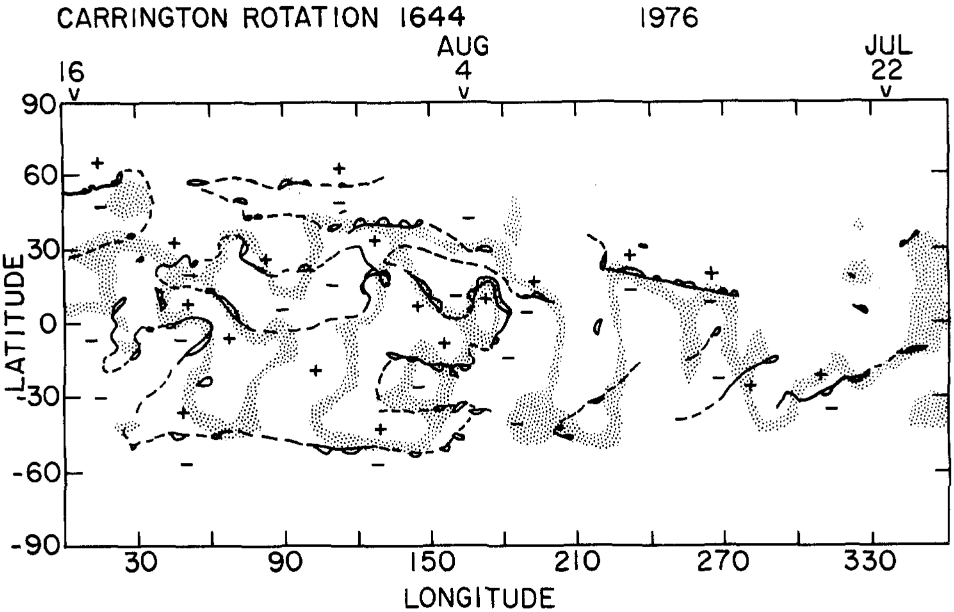

Fig. 4. Comparison of Hα synoptic chart with magnetogram neutral line for Carrington rotation 1644.

tested for a limited but very active period in 1970 (McIntosh, 1972b). Sunspot and plage polarities were inferred correctly as compared with Mt. Wilson spot polarity observations for 80% of the 282 determinations during that two-month period, but the inferences were judged 93% correct after a careful investigation of the possible reasons for the disagreements.

The study of large-scale magnetic structures in the photosphere would benefit greatly by the existence of a longer database than is presently available. The long time constant of the large-scale fields requires more data in order that a representative sample of cases can be observed. The applicability of the Hα synoptic charts to the study of the large-scale fields combined with the existence of complete Hα coverage dating back at least 45 yr suggests the possibility of obtaining such a long database. The construction of the Hα synoptic charts is a difficult and time-consuming task. However, an extension of these charts back in time would be an important contribution to the study of the large-scale solar magnetic fields.

Acknowledgements

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