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SYNOPTIC CHARTS WITH THE LARGE-SCALE SOLAR  
MAGNETIC FIELD AS OBSERVED AT STANFORD  
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# COMPARISON OF H $\alpha$ 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 H $\alpha$  photographs (McIntosh 1972a; McIntosh 1975; McIntosh and Nolte, 1975) and (2) observations of the photospheric magnetic field made with low spatial resolution (3 arc min.) and high sensitivity using the Stanford magnetograph. The comparison is found to be very favorable.

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I. 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., 1973) is supported by the observations of the green-line corona, white-light corona, and photospheric magnetic fields (Antonucci 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 H $\alpha$  observations (McIntosh, 1972a; McIntosh, 1975; McIntosh and Nolte, 1975).

II. 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 gauss. The magnetograph

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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 arc min. The statistical uncertainty of each measurement is about 0.05 gauss. A systematic error is observed by measuring the signal on the  $g = 0$  (nonmagnetic) line of FeI  $\lambda 5133,7$ . This systematic error is subtracted from each point of the magnetogram. Its magnitude is usually less than 0.1 gauss. 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 neutralline 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  $\pm 0.1$  gauss contour levels.

The neutral line position defined by the Stanford magnetograms is being compared with that derived from the  $H\alpha$  observations (McIntosh, 1972a; McIntosh, 1975; McIntosh and Nolte, 1975). Various features observed in  $H\alpha$ , 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 positions in regions where a clear  $H\alpha$  signature is not discernible. Normally, magnetogram data is also used, but for the present comparison it was not. The  $H\alpha$  synoptic charts for Carrington rotations 1641-1644 are shown in Figures 1-4 overlaying the Stanford neutral line determination. The hatched regions correspond to  $H\alpha$  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  $H\alpha$  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.

### III. 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  $H\alpha$  maps is well-determined (solid line). In certain cases, such as in Figure 1, longitude 240, latitude -50, the well-determined  $H\alpha$  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, longitude 220, latitude 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  $H\alpha$  neutral line position is the extrapolation outside regions where a clear  $H\alpha$  signature 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, longitude 120, latitude 45 and in Figure 4, longitude 90.

The  $H\alpha$  charts used in this comparison are incomplete and preliminary, representing what can be accomplished with only  $H\alpha$  data in near-real-time near a minimum in solar activity. The  $H\alpha$  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  $H\alpha$  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  $H\alpha$  observations as an independent source of magnetic field information.



#### IV. Conclusions

The H $\alpha$  synoptic charts complement direct measurements of the large-scale photospheric magnetic field. In regions where no clear H $\alpha$  signature is present, the magnetic observations give a good determination of the neutral line position. In regions where clear H $\alpha$  features exist, the H $\alpha$  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 H $\alpha$  observations for inferring strong, localized magnetic fields was 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 H $\alpha$  synoptic charts to the study of the large-scale fields combined with the existence of complete H $\alpha$

coverage dating back at least 45 years suggests the possibility of obtaining such a long database. The construction of the H $\alpha$  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.

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### Figure Captions

- Figure 1 Comparison of the H $\alpha$  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  $\pm 0.1$  gauss contour levels. For the H $\alpha$  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 H $\alpha$  charts are indicated by the + and - signs.
- Figure 2 Comparison of H $\alpha$  synoptic chart and magnetogram neutral line for Carrington rotation 1642.
- Figure 3 Comparison of H $\alpha$  synoptic chart and magnetogram neutral line for Carrington rotation 1643.
- Figure 4 Comparison of H $\alpha$  synoptic chart with magnetogram neutral line for Carrington rotation 1644.

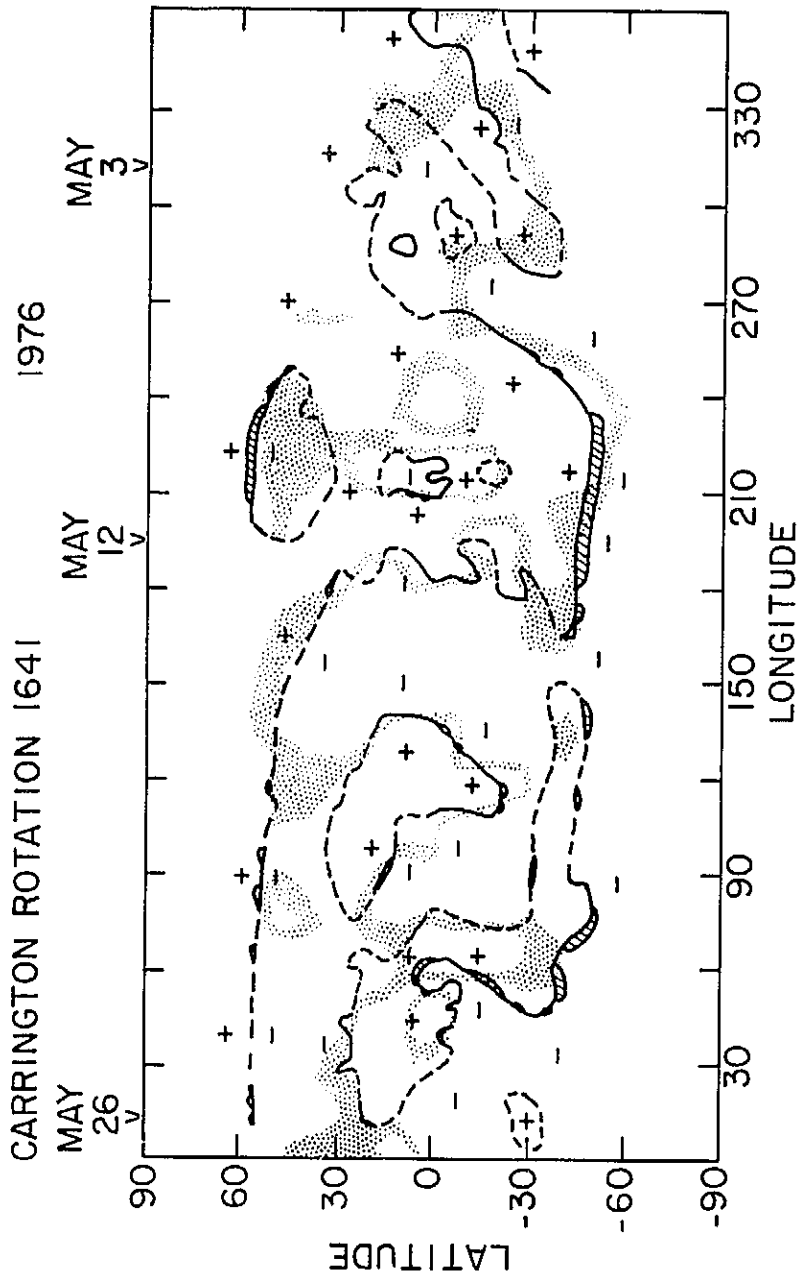


Figure 1

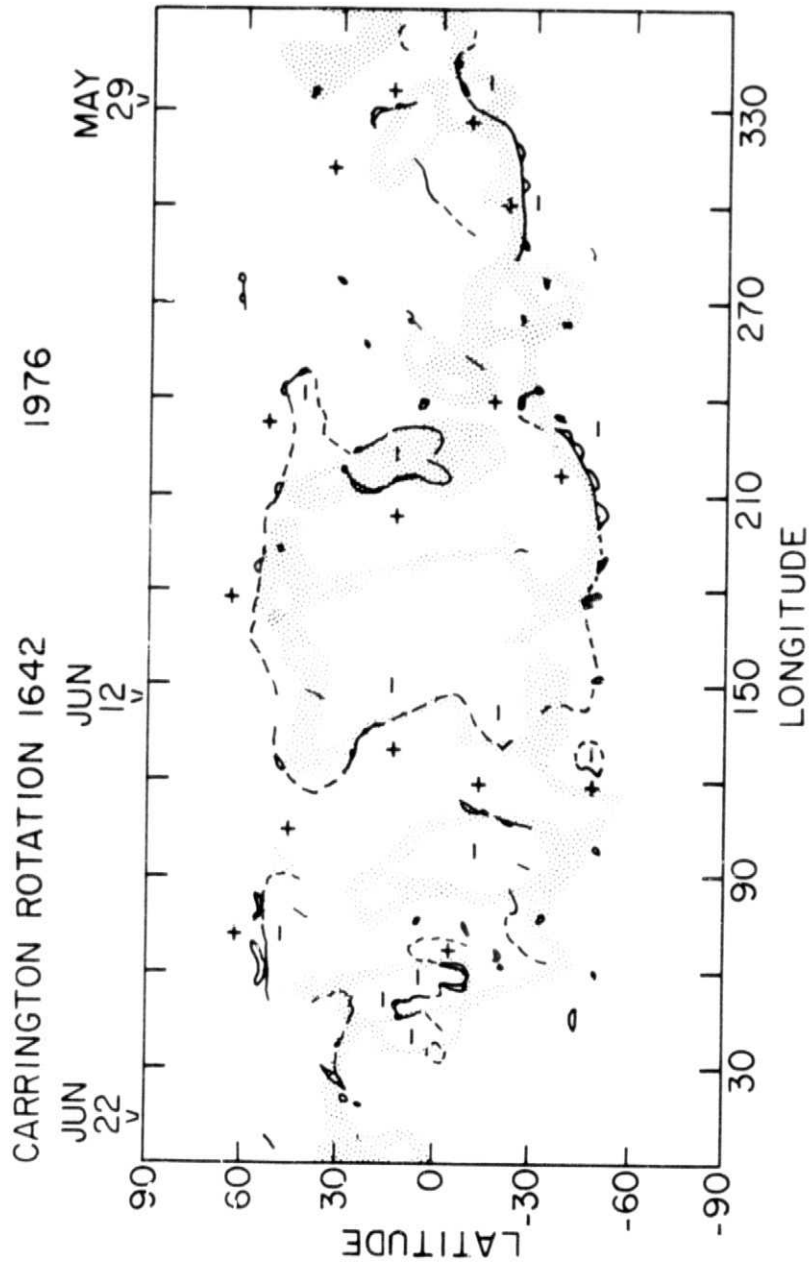


Figure 2

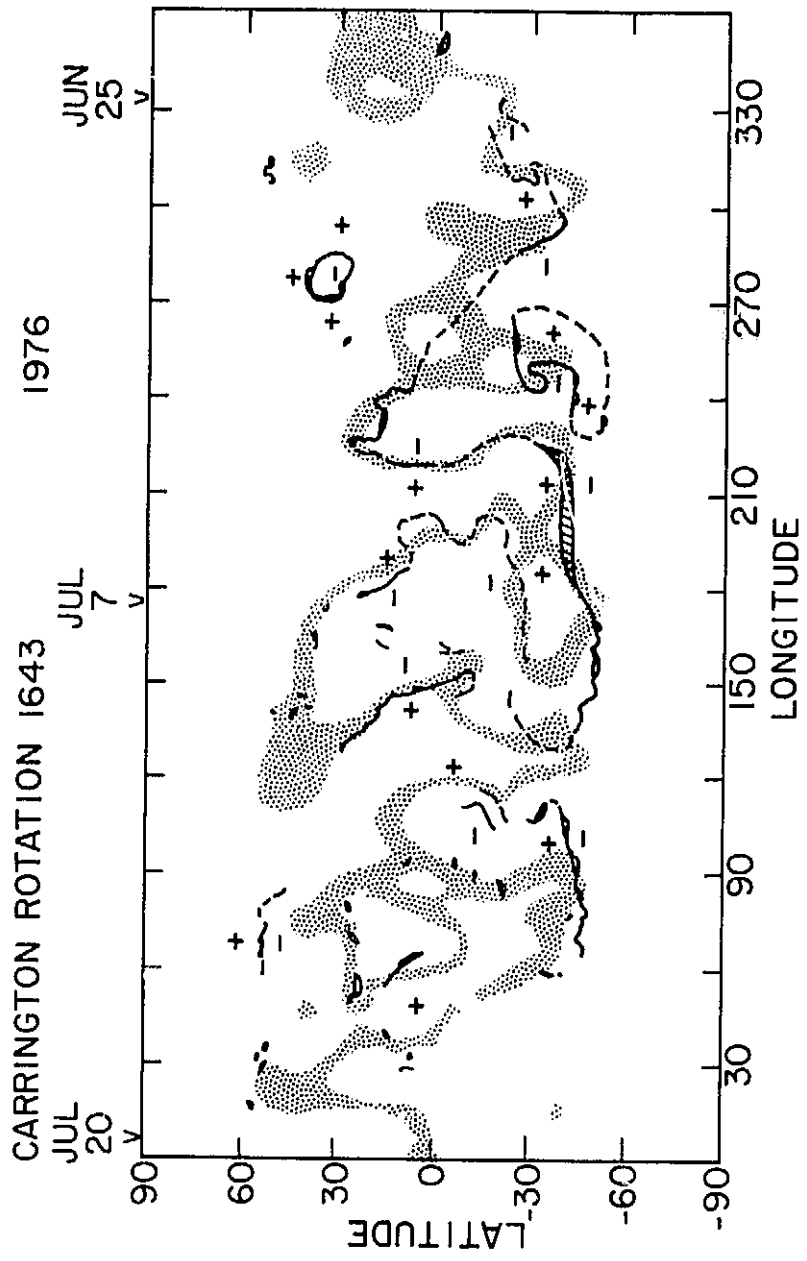


Figure 3

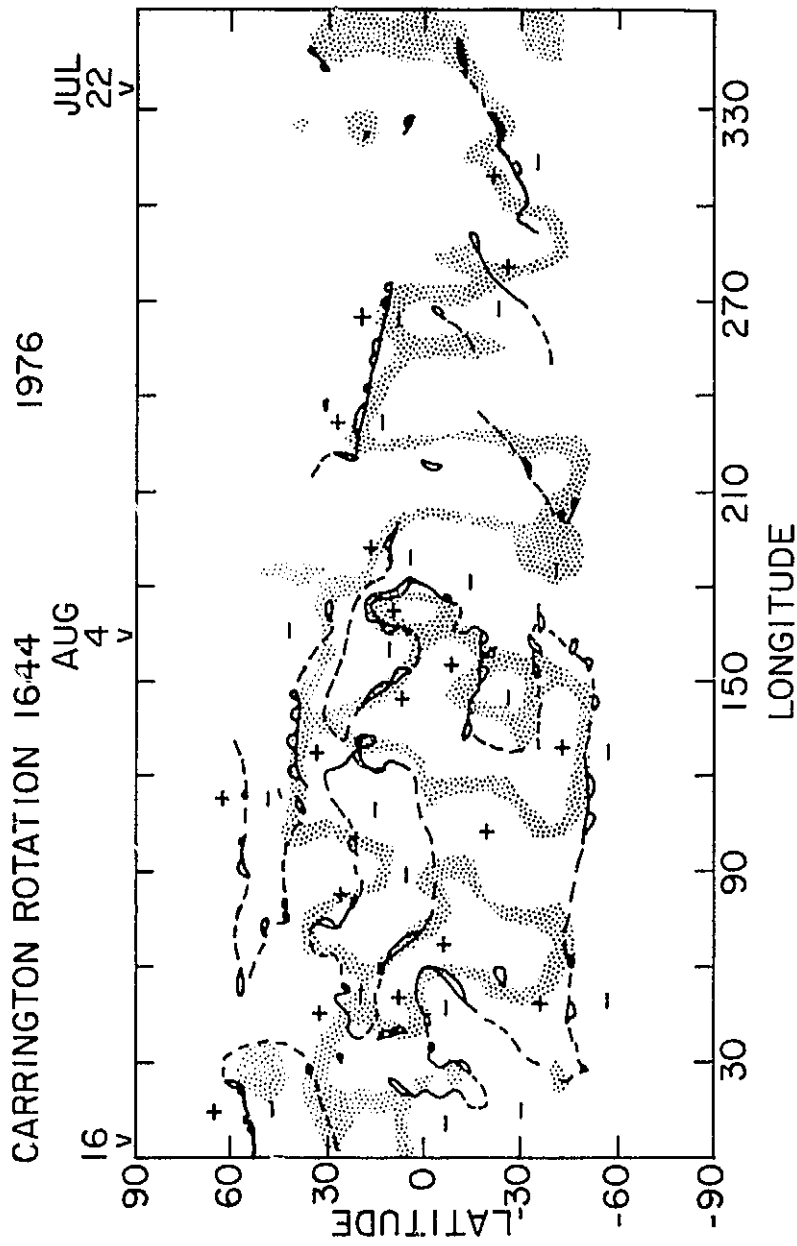


Figure 4