MEASURES OF THE RELATIVE SHIFTS OF THE LINE 5250·218 AND NEIGHBOURING LINES IN MT. WILSON SOLAR MAGNETIC FIELD SPECTRA

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These spectra form part of those obtained in the year 1913 and used by Hale and his collaborators in their researches on the general magnetic field of the Sun *.

The spectra are 27 mm. wide, and divided into about 13 strips, each 2 mm. wide. The scale is 4·65 mm. to the angstrom unit, and the lines represent a section of the Sun along the central meridian in mid-latitudes.

The division into narrow strips is due to the compound quarter-wave plate which was fixed over the spectrograph slit, its function being to cut out in adjacent strips the red and violet components of the Zeeman doublets due to the magnetic field. As the general field, if it exists, is evidently very much weaker than in sunspots, the affected lines would not be split into doublets or triplets as in spot spectra, but would be more or less widened: hence the cutting out of the red and violet components in adjoining strips would have the effect of shifting the centre of an affected line towards red in one strip and towards violet in an adjoining strip. If the strips are numbered 1 to 13, the shift for the odd numbers would have one sign and the even numbers the opposite sign.

The problem of measuring the minute shifts to be expected is complicated by the presence of small irregular Doppler shifts, which I have shown to occur over the Sun's disc, especially between centre and limb, even at times of minimum solar activity †. There are, however, two criteria whereby the Zeeman effect may be recognised, for if the shifts on the whole tend to alternate plus and minus in adjoining strips they are likely to be Zeeman effects, whilst if the sign of the shifts changes in passing from the northern to the southern hemisphere that would also indicate the presence of a solar magnetic field. It happens that the spectra which Dr. Hale selected for me to measure in the year 1933 appeared to satisfy these two conditions fairly well, and so favoured the magnetic effect ‡. They were, however, obviously modified by small Doppler effects, or possibly by local magnetic fields.

The lines measured included the chromium line at 5247·6 and the iron line at 5250·6, but not the line at 5250·2, which, as I have shown in a recent paper §, gives a very much greater Zeeman effect than its near neighbour 5250·6. Here then we have a more certain means of distinguishing between Doppler and Zeeman effect in the relative shifts of these two iron lines, for they would be expected to have similar Doppler shifts, but very different Zeeman shifts.

* *Astrophysical Journal*, 47, 212.
† *M.N.*, 94, 96, 1933.
‡ *M.N.*, 94, 96, 1933.
§ *M.N.*, 99, 217, 1939.

I do not possess the spectra Hale selected for me to measure, or the measures themselves, as both were taken away by him ; but I have been able to measure nine other spectra he left with me, which include these lines.

A set of measures was made first by superposing an ordinary contact positive over a negative without reversing the plates end for end, but displacing the positive laterally by one 2-mm. interval, so that plus shifts in the negative might be covered by minus shifts in the positive. The four following lines were included in the measures :—

	5247·060 *Fe* 1	5247·576 *Cr* 2	5250·218 *Fe* 2	5250·656 *Fe* 3
Approximate widening in spots.	0·09	0·12	0·17	0·05

The widening here shown is the measured difference between the normal width of the lines and the width in spot spectra. The iron line at 5250·2 is clearly split into two in the penumbræ of spots, and is occasionally seen to have a central component in the umbræ.

Of the nine spectra measured, four did not satisfy the first condition—that is, the alternation of shifts in adjoining strips. The remaining five spectra were more favourable to the magnetic effect, although there were marked discrepancies. I give in Table I the mean values in angstroms of the residual shifts from these two sets of measures, disregarding the sign of the shifts.

Table I

	5247·0	5247·6	5250·2	5250·6
Mean of 4 spectra marked 1130 and 1176	0·0003	0·0002	0·0004	0·0004
Mean of 5 spectra marked 1176 and 1129	0·0011	0·0012	0·0012	0·0013
Mean of shifts exceeding 0·0015 A	0·0033	0·0036	0·0035	0·0039

The five spectra which seem to favour the Zeeman effect give mean shifts of about the same amount as found in my earlier measures ; but as regards the second condition, the change of sign of the shifts in going from the northern to the southern hemisphere, nothing can be said, as the requisite data are not with me. Latitudes are only marked on three spectra, and these are all in the same hemisphere. It is true that in each of these the strips of odd or even numbers have usually the same sign, as they should have if the shift is a Zeeman effect, so that if we disregard the relative shifts of the four lines the evidence favours a general magnetic field partly masked by the effects of motion. On the other hand, the relative shifts clearly refute the Zeeman effect and favour the Doppler interpretation, for all four lines give essentially the same shift, whereas they should follow the order of widening in sunspot spectra and of the magnetic effect in the laboratory, if due to a magnetic field.

In all of the nine spectra, shifts are found varying between 0·0015 A and 0·0050 A. In the third series of Table I are given the mean values of shifts exceeding 0·0015. Here again the values are almost the same in the different lines, 5250·6 showing, indeed, slightly larger shifts than 5250·2. These larger shifts, therefore, cannot be ascribed to local magnetic fields, but must certainly be due to motion.

Finally the three spectra marked 1129, which extend in solar latitude from $-25°$ to $-51°$, I have measured again with positives copied through the glass in a long-focus camera. The positive image is then superposed on the negative, film to film, but reversed end for end. In this way the positive image of any strip of spectrum falls on the corresponding strip of the negative, but the shifts are in opposite directions.

The position of the two lines having the greatest and least widening in spots in each of ten strips was measured and compared with the mean position, and the mean of each set disregarding the sign of the shift is given in Table II.

TABLE II

Plate 1129	No. of Strips measured	5250·2	5250·6
° °			
−27 to −31	10	0·0014	0·0020
−33 to −42	11	0·0018	0·0017
−43 to −51	10	0·0014	0·0012
	Means	0·0015	0·0016
Shifts exceeding 0·0015 *A in* 5250·2			
° °			
−27 to −31	4	0·0024	0·0032
−33 to −42	5	0·0030	0·0027
−43 to −51	4	0·0024	0·0019
	Means	0·0026	0·0026

Here again there is little or no evidence of a magnetic effect. The section $-43°$ to $-51°$ appears more favourable to the Zeeman effect than the other sections, but the difference of shift is too small to be of significance, for the Zeeman widening for these lines should be in the ratio three to one.

The method of reversing end for end has the advantage that it will detect any want of symmetry in a line, which might well be produced in the case of Zeeman triplets when one side component has been suppressed. In this case these two lines are perfectly symmetrical in these spectra.

Summary.—Nine of the Mt. Wilson solar magnetic field spectra obtained in the year 1913 have been measured by the positive on negative method, and the relative shifts of four lines determined. Two of these are subject to large Zeeman effects in sunspots and laboratory, whilst the other two are much less affected. The results clearly show that in these spectra the shifts observed are not due to a general magnetic field, or to local magnetic fields, but are Doppler effects due to motion, notwithstanding certain indications to the contrary.