But the further citation of individual bands of this nature in detail would serve no useful purpose at the moment. The complete unravelling of the spectrum can in fact only be performed by the help of plates of spectra, which have been mainly instrumental, rather than tables of wave-lengths, in enabling the present writer to arrive at the conclusions in this section. Our purpose has been merely to show that the secondary spectrum of hydrogen, in so far as it shows no Zeeman effect, is entirely a scattered band-spectrum, and to determine some of the mathematical structure of an individual band with a view to a theory of its origin which we develop afterwards. The general similarity of the bands shows that this structure is of the same type in all cases.

We shall discuss the lines showing Zeeman effect, which are of a very different type, later.

General Conclusions.

1. The two Fulcher bands are numerically related, and form a single system.

2. The lines of the secondary spectrum, not showing Zeeman effect, are of the form of widely separated bands analogous to those of Fulcher, and it is probable that the number of distinct bands is very small.

Note on Spectroheliograms taken with Different Parts of the H_α Line.

By T. Royds, D.Sc. (Plate 13.)

When the second slit of a spectroheliograph is sufficiently narrow and is set centrally on the H_α line, the resulting spectroheliogram presents well-known features of which the most noteworthy are (1) dark markings, and (2) bright flocculi, whilst the general surface of the sun is represented by a fine network or réseau in which the photographic contrast is not large. This réseau is due to the presence of innumerable faint reversals of the H_α line rather than to darkenings of the H_α line.

The routine H_α spectroheliograms of the Kodaikanal Observatory are required principally for the record of the dark markings. Since the darkenings of the H_α line causing dark markings generally extend across the whole width of the line, the record of dark markings is preserved when the second slit of the spectroheliograph has a considerable width, say 0·8 Å.* It is found that with a slit width of 0·4 Å. the dark markings are practically identical, whether the middle of the slit or either of its edges is central on the H_α line. Consequently, if the slit is widened to about 0·8 Å., the dark markings are recorded with a shorter exposure, but of course at the expense of a smaller resolving power, which is unimportant for these features.

The second slit of the spectroheliograph cannot be made much wider than 0·8 Å. without encroaching on the edges of the H_α line, and as soon

* Slit widths of this order of magnitude have been used by Mr. J. Evershed, F.R.S., for H_α spectroheliograms at Kodaikanal.

as this happens the characteristics of the resulting spectroheliogram begin to change completely. The irregular edges are perhaps the most obvious feature of the H_α line in the sun, and as soon as the slit is wide enough to include the edges of the H_α line, or even is kept narrow but displaced far enough from the centre to include either edge of the H_α line, continuous spectrum passes through the slit in an amount corresponding to the irregularity of the edge of the H_α line. In fact, the character of the H_α spectroheliogram is now principally determined by the varying amounts of continuous spectrum, and darkenings and reversals of the H_α line play a minor part.

If the second slit of the spectroheliograph has a width of about 0·5 Å. and is moved from the centre of the H_α line step by step towards either edge of the line, no remarkable change in the resulting spectroheliogram takes place until the centre of the second slit is about 0·3 Å. from the centre of the H_α line. Thereafter continuous spectrum begins to affect the spectroheliogram. Dark markings and bright flocculi become less conspicuous as the slit is moved further away from the centre of the H_α line, and by the time the mean edge of the H_α line is about the centre of the slit they are generally not to be traced. Very striking is the much coarser network or réseau over the general surface of the sun, and the contrast in the réseau is much greater than in the spectroheliogram with central setting.

The H_α line is often shifted by Doppler displacements (sometimes in both directions simultaneously), and these play a part in the interpretation of spectroheliograms when the slit is set on the edge of the H_α line. These Doppler effects are not under discussion in this paper, but only the effects of the varying width of the H_α line, *i.e.* expansion or contraction of both edges of the H_α line simultaneously, such as is generally interpreted as due to variations in density or pressure or both in the lower regions of the sun's atmosphere.

Two striking features and one less striking are revealed in the vicinity of sunspots in spectroheliograms obtained when the slit of about 0·5 Å. width is set on one edge of the H_α line. (1) A bright spot ring, such as that illustrated in fig. 1, 1924 July 3, is to be seen, often complete and unbroken, round nearly all spots of medium size. In such spots the H_α line is usually narrower than normal just outside the penumbra for a distance approximately equal to the radius of the spot. When the slit is set on the edge of the H_α line, more continuous spectrum than normal falls on the photographic plate where the line is narrow, thus causing in the spectroheliogram a bright ring round the sunspot. The narrowing of the H_α line round spots is often accompanied by a reversal of the line, so that the spectroheliogram obtained with the slit central on the H_α line will also often show a bright ring round the spot; but such rings are never so conspicuous as when the slit is on the edge of the line, for in the latter the reversal combines with the narrowing of the line to enhance the brightness round the sunspot. Bright rings round spots in spectroheliograms with the slit set in the middle on the line were first noticed by Hale, using the H_δ line.*

* Hale, *Astroph. Journ.*, **23**, 54, 1906.

(2) Outside the bright ring round a sunspot the H_α line is wider than normal, and there it produces a dark area when the slit is set on the edge of the line. These dark areas are the well-known "dark hydrogen flocculi." * They are, however, quite distinct from "dark markings." Dark markings are best seen in spectroheliograms obtained with the slit set in the middle of the H_α line, whereas the dark flocculi cannot be shown with the H_α line unless the edge of the line is on the slit. Fig. 2 of 1920 October 15 shows an extensive dark flocculus round a sunspot group when the slit was set on the edge of the H_α line. Fig. 3 shows the same region as fig. 2, but when the edge of the H_α line was excluded from the slit of the spectroheliograph, *i.e.* when the slit was central on the H_α line. Spectroheliograms obtained with the slit central on the H_α line generally show a delicate tracery of fine "dark markings" and of bright flocculi round sunspots, but those obtained with the slit on the edge of the H_α line, as in fig. 2, show a dark flocculus comparatively massive and featureless.

(3) A less striking feature in spectroheliograms obtained with the slit on the edge of the H_α line is a bright surround which intervenes between the dark flocculus and the coarse réseau of the general surface of the sun. In fig. 2 the réseau of the general surface can be seen near the edge of the figure, but it will be seen that the dark flocculus is bounded by a region in which the bright patches are considerably more extensive than those in the general undisturbed surface of the sun. The bright patches in the surround of the dark flocculus are often interrupted by dark features combining to suggest the spot vortex, which is generally best exhibited in the delicate tracery obtained only when the slit is central on the H_α line.

Either the red or the violet edge of the H_α line gives the above three features, generally without any essential differences.

It is believed that these three features are typical of the majority of sunspot disturbances, and that the story they tell of what is taking place in the lower levels of the sun's atmosphere is an essential part of a spot disturbance.

Explanation of the Plate.

Fig. 1. 1924 July 3, showing a bright ring round the spot, with diameter about twice that of the spot. The slit of the spectroheliograph was set on the violet edge of the H_α line, but not so far from the centre as to obliterate the dark markings. The dark flocculus and bright surround are not well developed in consequence.

Fig. 2. 1920 October 15, showing dark flocculus and its bright surround. The slit of the spectroheliograph was set on the red edge of the H_α line. The spot ring extends only halfway round the spot.

Fig. 3. 1920 October 15, but with the slit set nearly centrally on the H_α line. There is here no suggestion of the features in fig. 2.

The diameter of the sun is approximately three times the width of figs. 2 and 3.

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* Hale and Ellerman, *Proc. Roy. Soc.*, A, **83**, 177, 1909.

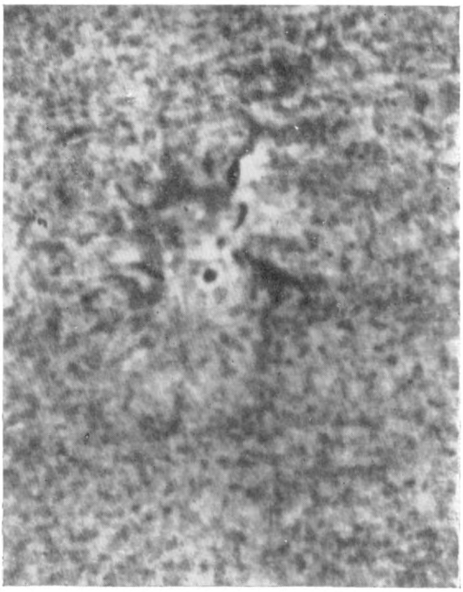


Fig. 1. 1924 July 3.

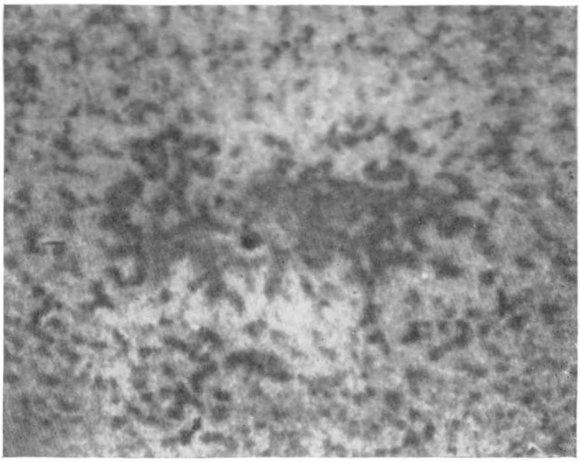


Fig. 2. 1920 Oct. 15.

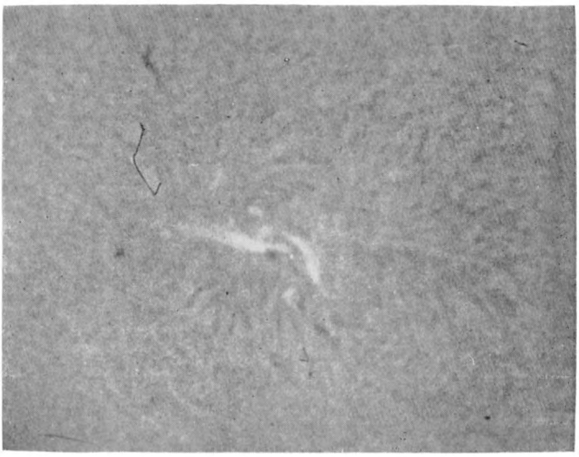


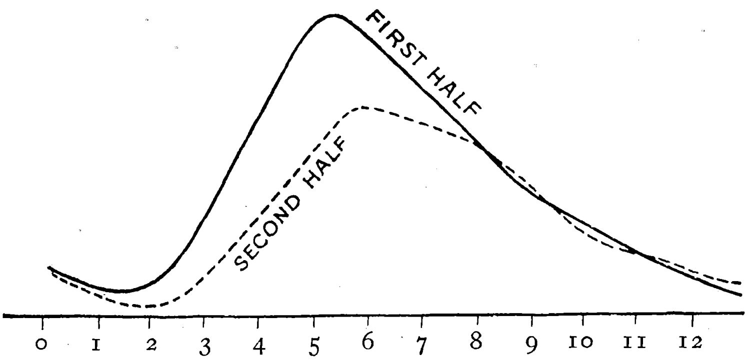
Fig. 3. 1920 Oct. 15.

Note on the Alternation of the Eleven-year Solar Cycles.

By H. H. Turner, D.Sc., F.R.S., Savilian Professor.

1. The discovery that the magnetic polarity of sunspots is reversed at minimum, and then maintained until the next minimum, calls attention to an essential difference between one solar cycle and the next. A difference of this kind was noted in 1913 (*M.N.*, **74**, 94) before the magnetic reversal at minimum was discovered. It is there stated:

> Now in the first place we find that there is not a satisfactorily uniform period of $11\frac{1}{2}$ years, but rather a double period of 23 years, the halves of which are not quite symmetrical.



Alternate Halves of 23-Year Cycle compared.

The diagram given from an analysis of Wolf's numbers may perhaps be reproduced here for convenience.

2. More material is now available, and it seems desirable to re-examine the point. But instead of taking Wolf's numbers we may now take the Greenwich measures, which have been published up to 1923 (see *M.N.*, **84**, 742; **75**, 19; **63**, 466; and **49**, 382). Both the N and S mean latitudes have been subjected to harmonic analysis; as also the logarithms of the N and S spotted areas (whole spots). The logarithms were used rather than the areas themselves to avoid the swamping influence of the large numbers at maximum. Harmonic analysis is specially simple when 12 terms are used; and though 12 years is longer than the cycle, the analysis in the paper cited indicated that it was not much longer than the present value of the cycle, the length of which will, of course, appear from the progressive change of maximum. Hence 4 sets of 12 years ending with 1923, as shown in Table I., were analysed.

Table I.

1876–1923. *N Latitudes.* *Unit* $+0^\circ\cdot1$.

126	91	71	236	200	182	160	110	107	105	99	88
71	73	222	205	151	149	123	143	136	83	98	62
66	86	188	181	163	117	140	101	104	95	86	79
205	248	211	180	151	138	120	98	113	73	88	139