

SPECTRAL LINES FROM PHOTOSPHERE TO CHROMOSPHERE, OBSERVED DURING THE MARCH 1970 ECLIPSE; A FIRST COMPARISON WITH THEORY

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Abstract. A brief report is presented on observations of line profile variations in the transition region from the photosphere to the chromosphere, based on high-resolution eclipse spectrograms. We also show some computations for several lines whose behaviour agrees in general with the observations.

The spectral region observed is from 4545 Å to 4579 Å, with a dispersion of 1.7 mm Å⁻¹ and a spectral resolution of about 200 000 (Houtgast *et al.*, 1970a, b).

The most interesting exposures were taken round second contact, when the spectrograph was provided with a narrow slit of 12 μ with a solar image of 32 mm diameter. Two spectra are shown in Figure 1. A first inspection of the photometric records of some crucial spectra shows the characteristics, given in Table I.

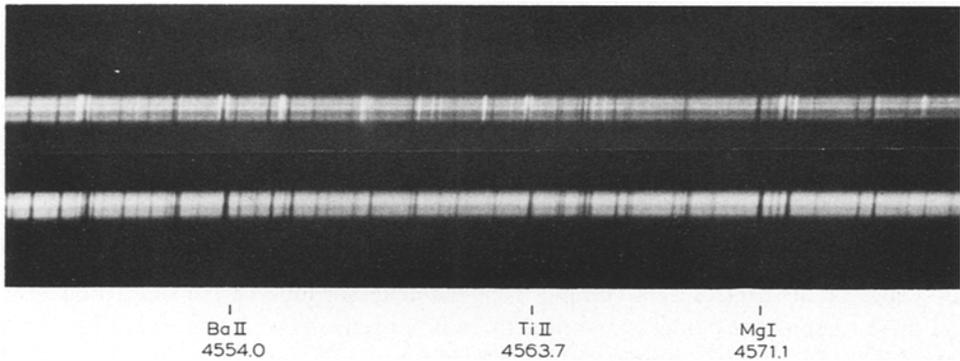


Fig. 1. Two of the eclipse spectra: No. 17, exposure time 0.285 s, covering the region between 2430 and 2350 km inside the solar limb (below), and No. 26, 1.037 s, between 768 and 456 km (top).

A small region of the spectrum at $\sin \theta = 0.95$ and of the spectra with numbers 25, 26, 27 (see Table I) with intensity profiles of different lines is shown in Figure 2. Correction for apparatus function has not yet been applied, nor are the absolute intensities determined.

It is interesting to compare already in this stage some observational features with computations based on the Harvard Smithsonian Atmosphere model (Gingerich *et al.*, 1970). As to this we are still in the beginning of the development of a model

TABLE I

Number of spectrum	Exposure time	Distance to Sun's limb covered during exposure time, in km	Appearance of spectral lines
22	0 ^s .345	-1614 to -1512	General appearance same as on the solar disc, but: rare earths going into emission
24	0.441	-1182 to -1050	Development of emission wings of Ba II 4554 and Ti II 4572; strong Fe II 4556 in emission; moderate Fe II lines disappear
25	0.437	-975 to -846	Development of emission wings of Ti II 4564; moderate Fe II lines weak in emission
26	1.037	-768 to -456	Moderate Fe I lines weak in absorption; self-reversal Ba II 4554 and Ti II 4564; 4572; strongest absorption line Mg I 4571
27	1.022	-384 to -76	No more lines in absorption; strong Fe I lines in emission. Mg I 4571 broad, weak emission; strong features of ionic lines, of which Ba II 4554 with strong reversal, Ti II 4564; 4572 with reversal
28	8.656	0 to +2598	Mainly ionic emission lines left; of the atomic lines Mg I 4571 is the strongest, central intensity that of Ce II 4562, but profile broader (2 ×)

which takes account of the complex structure of the solar atmosphere and the physical processes which take place.

With the Harvard Smithsonian Reference Atmosphere model line profiles have been calculated. Although in general the excitation temperature does not follow the electron temperature, the calculations are made with the assumption that both are equal. So no deviations from LTE are taken into account, just to get a general idea of the behavior of spectral lines coming from the neighborhood of the solar limb. For the same reasons the model is assumed to be homogeneous with a constant isotropic turbulence of 1 km/sec. Line shapes are found from the Doppler effect and the natural line width.

The calculated line profiles are not integrated over the slit, nor smeared for the apparatus profile and seeing, nor the moving limb of the Moon is taken into account.

The results of the computations are in so far surprising that the change from absorption into emission takes place over a very short distance, mostly within 75 km for lines of moderate strength, and this is much faster than follows from the observations (Figures 3 and 4).

The computed lines show many details in the profiles. Of these, with the spectral resolution of 0.02–0.025 Å, only the central self-reversals of some strong lines can possibly be shown by our observations. It is clear that many interesting features need a higher resolution.

lines, independent of strength and takes place at about -25 km (inside the solar limb, defined at $\tau_{\text{tang}}=1$); for ionic lines the transition takes place much deeper for strong lines than for weaker lines (TiII 4564 at more than 1000 km inside the limb, for TiII 4568 at -25 km);

(3) A central reversal of atomic lines of moderate strength is pronounced at a height of about 50 km; ionic lines of this strength do not show self-reversal.

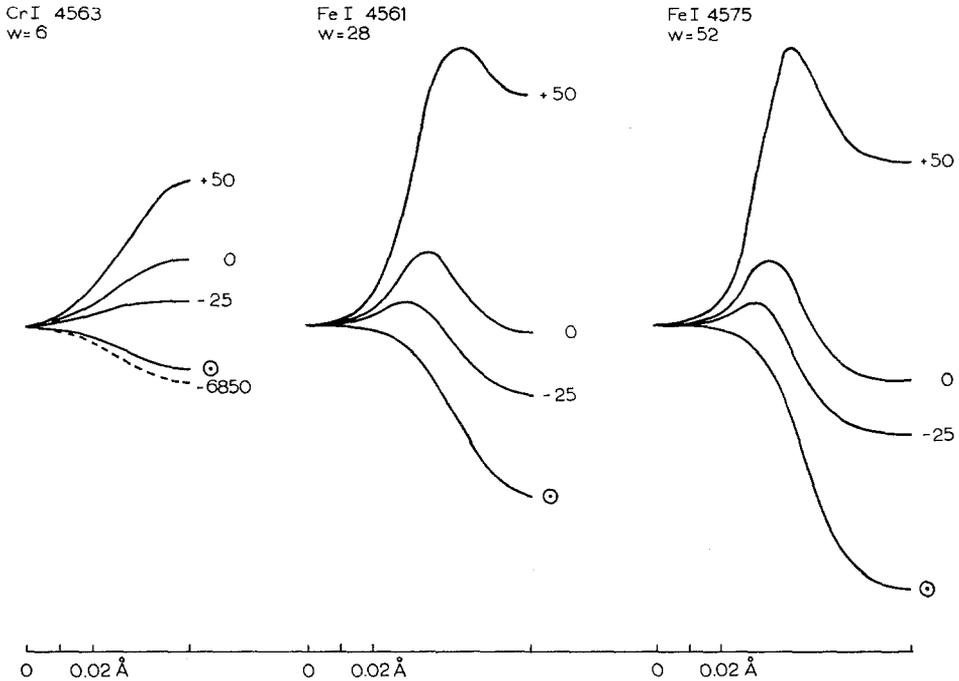


Fig. 3. Calculated profiles of different atomic spectral lines of which W is the equivalent width for the centre of the solar disk (\odot). The distance at which the line of sight passes the solar limb is indicated in km for each profile. Intensities are relative to continua. Line centre is at right end of each profile.

This last point is in agreement with a remark made by one of the authors related to the Khartoum spectra of Redman (Houtgast, 1968). It was mentioned then that in these spectra atomic lines of moderate strength show self-reversals (doubling of the lines), while ionic lines do not. From the model-computations it now appears that a homogeneous model of the solar atmosphere can indeed give rise to reversals in line profiles.

It goes without saying that high quality eclipse observations of line profiles near the solar limb will be of crucial importance for checking our assumptions about the solar atmosphere. The point may be stressed that more eclipse parties should put these observations on their programmes.

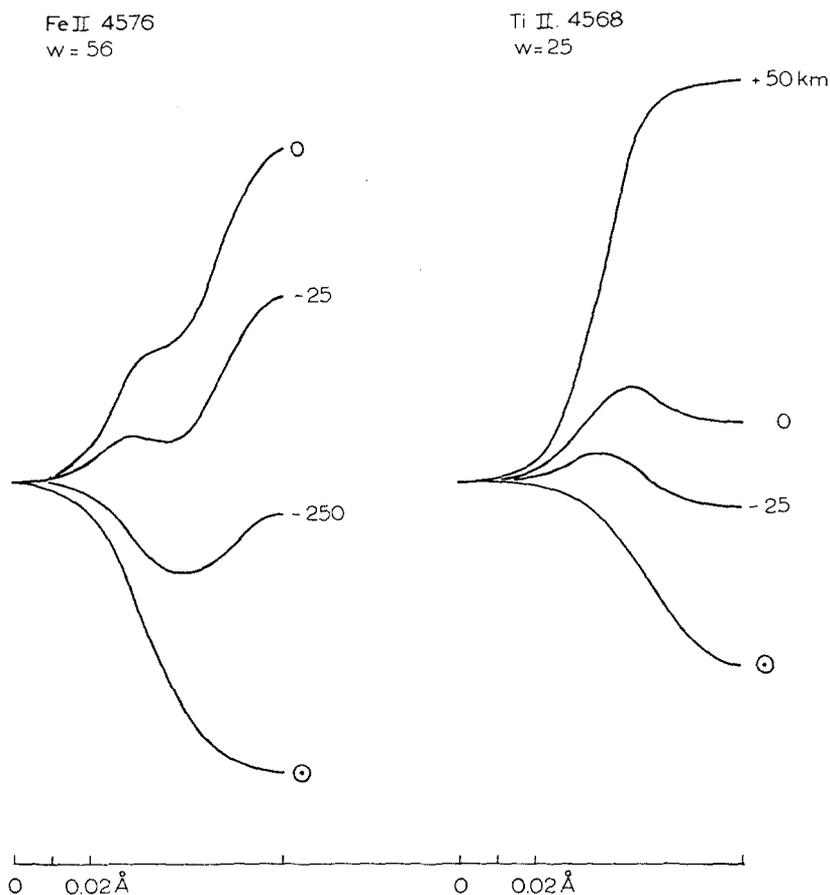


Fig. 4. The same as Figure 3 for some ionic spectral lines.

Acknowledgements

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