SPECTRAL ANALYSIS OF A WHITE LIGHT FLARE

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ABSTRACT

We discuss observations of a solar flare located close to the limb (N15, W75) at 07 00 UT on 26 September 1963 from the Crimean Astrophysical observatory.

Stark broadening and hence electron density have been obtained from measured time profile and half-width of the Balmer series lines from Hα to H_{14}.

The emission mechanism has been deduced from a study of the continuum intensity as a function of wavelength.

I. INTRODUCTION

Line widths in the Balmer series, from Hα to H_{14}. were measured on 7 spectrograms taken about 2 minutes apart. The width is very wide for the smaller quantum numbers and decreases to a minimum somewhere around H_{γ} and then increases slowly to higher numbers (Figure 1). By assigning Stark broadening to the higher quantum numbers we derive values of the electron density. This method, for deducing electron densities from total half widths, was introduced by Suemoto and Hiei (1959).

Our analysis confirms previous results, that the electron density from the line widths is of the order of 10^{13} cm^{-3}. Table I shows the lines (between n = 10 and n = 14) that were used for the determination of Ne ; other lines were either not photographed or were too faint to be measurable. The differences between electron density values are of the same order as the errors in the half-widths measurements. We conclude that the electron density remained constant during the observations (for about 10 minutes).

II. CONTINUUM EMISSION

As in our previous paper (1985), the continuum emission was analysed by a photometric determination of the contrast [$\Delta I(\lambda)/I_0(\lambda)$] in the wavelength range 3700 - 4300 Å.

First, we plotted experimental curves against continuum windows for only 5 spectral sequences (instead of 7 as used for the Balmer lines). According to our observations, continuum emission lasted for about 7 minutes during the main phase of the flare (07:14:30 - 07:21:30 UT.)

For each time sequence we selected some 10 continuum windows. The width of the windows ranged between 0.5 and 1.2 Å. The increase in continuum intensity during the flare, with respect to the nearby undisturbed photospheric continuum $I_0(\lambda)$, gives the intensity excess $\Delta I(\lambda)$ at the location of the flare. We measured the ratio $\Delta I(\lambda) / I_0(\lambda)$ for the selected continuum windows.

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We normalised the ratio $\Delta I(\lambda)/I_0(\lambda)$ for the 5 spectra, to the corresponding ratio at $\lambda = 5000$ Å (reference wavelength). In figure 2 we show R (, $_R$) curves for the 5 time sequences.

III. ORIGIN OF THE CONTINUUM SPECTRUM

To explain the emission curves we investigated only two possible mechanisms : (1) H^- and (2) hydrogen Paschen continua. and calculated the normalized contrast given by :

$$R(\lambda, \lambda_R) = \frac{\Delta I(\lambda)}{I_0(\lambda)} \bigg/ \frac{I(\lambda_R)}{I_0(\lambda_R)}$$

where $\lambda_R = 5000$ Å

(1) We assumed the possibility of an optically thin H^- emission ; the theoretical curves obtained for the following temperatures 6000. 7000, 8000 and 9000 K were compared to the experimental curves. Because none of the theoretical curves match the observed results, we conclude that the continuum was not produced by H^- emission.

(2) We studied the Paschen free-bound recombination and plotted the theoretical $R(\lambda, \lambda_R)$ values obtained with temperatures running from 7000 to 14 000 K and taking into account N.L.T.E. effects (departure coefficient, b_3 , between 2 and 9). Several theoretical curves fit our observations quite well (Figure 3). Thus we conclude that the continuum of the flare was produced by Paschen emission.

IV. CONCLUSION

Our results are not surprising as the character of Balmer lines observed in the spectra may give an indication concerning the origin of the continuum emission.

According to Svestka (1965), when Balmer lines are narrow, the origin of the continuum is likely to be H^- emission. If they are wide, however, the mechanism responsible for the continuum is Pashen emission. The Balmer lines that we have analysed are very wide.

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TABLE I

TIME VARIATION OF THE ELECTRON DENSITY

TIME	LINE	$\Delta\lambda$ (1/2) (Å)	$Ne \times 10^{-13}$ (cm^{-3})	$\overline{Ne} \times 10^{-13}$ (cm^{-3})
7 : 14 : 30	H10	1.1	2.1	
	H11	1.3	2.0	
	H12	1.5	1.6	1.68
	H13	1.4	1.2	
	H14	2.0	1.5	
15 : 30	H10	1.3	2.5	
	H11	1.6	2.4	2.37
	H12	1.8	2.2	
16 : 30	H10	1.2	2.3	2.40
	H11	1.6	2.5	
7 : 18 : 30	H10	1.2	2.3	
	H11	1.4	2.2	
	H12	1.5	1.6	1.70
	H13	1.0	1.0	
	H14	1.9	1.4	
21 : 30	H10	1.2	2.3	
	H11	1.4	2.2	2.03
	H12	1.5	1.6	
23 : 30	H10	1.1	2.0	
	H11	1.2	1.6	1.70
	H12	1.4	1.5	
7 : 25 : 30	H10	1.15	2.2	
	H11	1.15	1.5	1.68
	H12	1.2	1.2	

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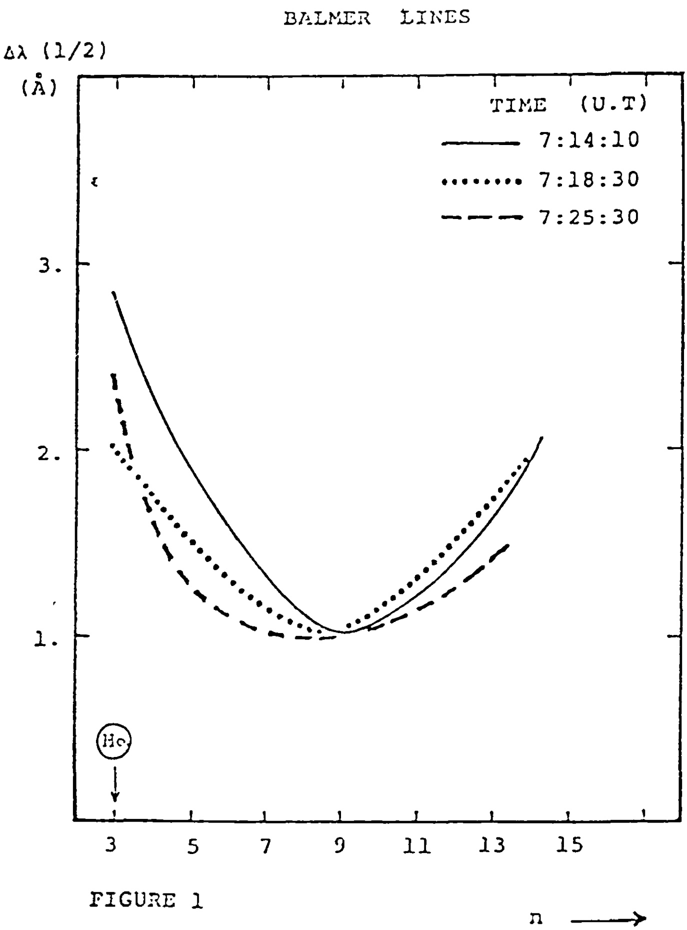

FIGURE 1

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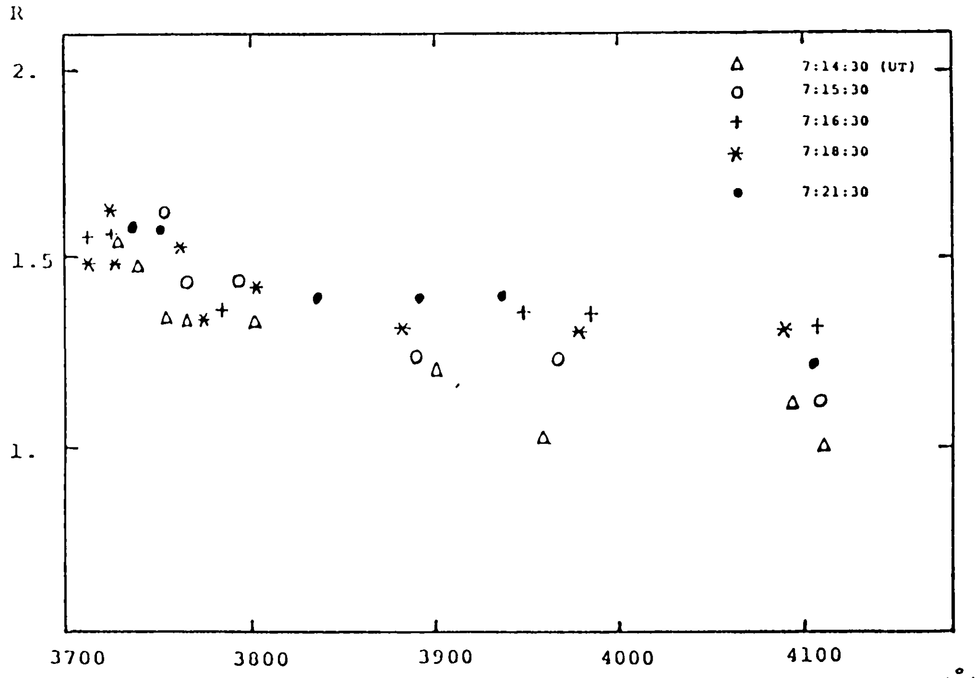

FIGURE 2

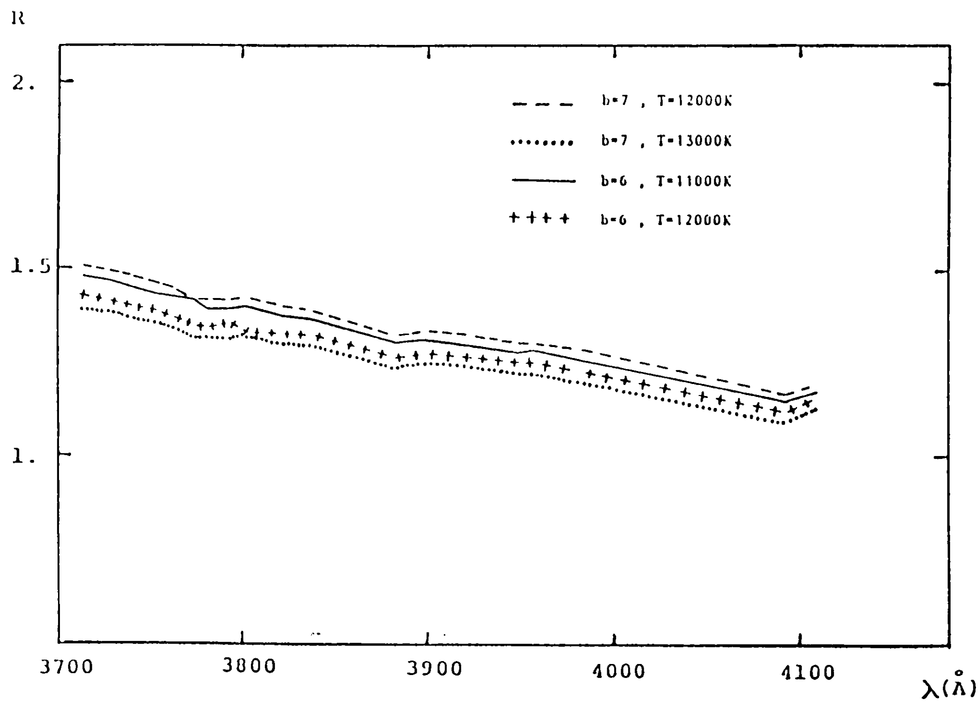

FIGURE 3

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