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Emission lines of inner corona observed during the total solar eclipse of 1980 February 16

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Abstract. Spectrograms of the inner solar corona were obtained during the 1980 total solar eclipse. Two Ebert-Fastie type spectrographs with circular slits were used to obtain spectra on the east and the west at 1.06 $R_\odot$. These spectrographs were operated at a dispersion of 28.3 Å mm^{-1} and covered the whole of the visible spectrum. The relative intensities of the emission lines of the inner corona, chromosphere and prominences are reported here. There is an indication of the existence of a highly active isolated pocket in the solar corona with a temperature $> 4 \times 10^6$ K. We find that the ratio of the intensities of Ca^+K/Ca^+H is about 1.5 in the prominences whereas it is only 1.0 in the chromosphere.

Key words : inner solar corona—emission lines—solar eclipse

1. Introduction

In 1947 Bernard Lyot outlined his plans for an eclipse spectrograph having a circular slit that would record the spectrum of the inner corona at both limbs simultaneously between $\pm$ 60° latitude over a wide wavelength range. This experiment was carried out by M. K. Aly & B. Lyot at the Khartoum eclipse of 1952 February 25 and well exposed standardized spectra were taken. Aly & Lyot found in addition to all the well known coronal lines within the wavelength range of the plates several faint lines reported at previous eclipses. Also, they found many faint lines that had apparently never been seen before. (Aly 1953, 1955: Lyot & Dollfus 1953, Aly *et al.* 1962).

Subsequently coronal spectra were taken by, among others, Dollfus (1957), Jefferies *et al.* (1971) and Bappu *et al.* (1972) during the various total solar eclipses. The coronal spectra not only help in identifying the coronal lines but are also valuable in studying the physical nature of the corona and the coronal condensations. With a view to evaluating the temperature and the density structure of the inner corona from the total intensities of the continuum and emission lines, we planned an experiment for taking the inner coronal spectra with a moderate dispersion during the total solar eclipse of 1980 February 16.

2. Instruments

A 30 cm coelostat fed the light from the corona to a 25 cm paraboloid which formed the image of the sun and the corona on the slits. The size of the image was 23.2 mm. The optical layout of the spectrograph is shown in figure 1. The direction of the coelostat was adjusted to ensure that the axis of rotation of the sun's image was vertical. Two mirros M_1 and M_2 were kept before the focal plane of the paraboloid to separate the eastern and the western parts of the sun's image and change the direction of the respective beams by 90°. Two similar spectrographs with Ebert-Festie system were used to take the spectra of the eastern and the western corona separately. The two circular slits C_1 and C_2 of 12.3 mm radius each were located on the east and the west at 1.06 $R_\odot$ from the centre of the sun and covered a position angle of about 120°. Since the slit width was 40 μ, we obtained a spatial resolution of 3 arcsec. The 30cm spherical mirror of 55 cm focal length was used for collimating the beam and focusing the spectra. The 600-line grating, blazed at 1.1 μ, gave us a dispersion of 28.3 Å mm^{-1} in the second order. Two plate holders

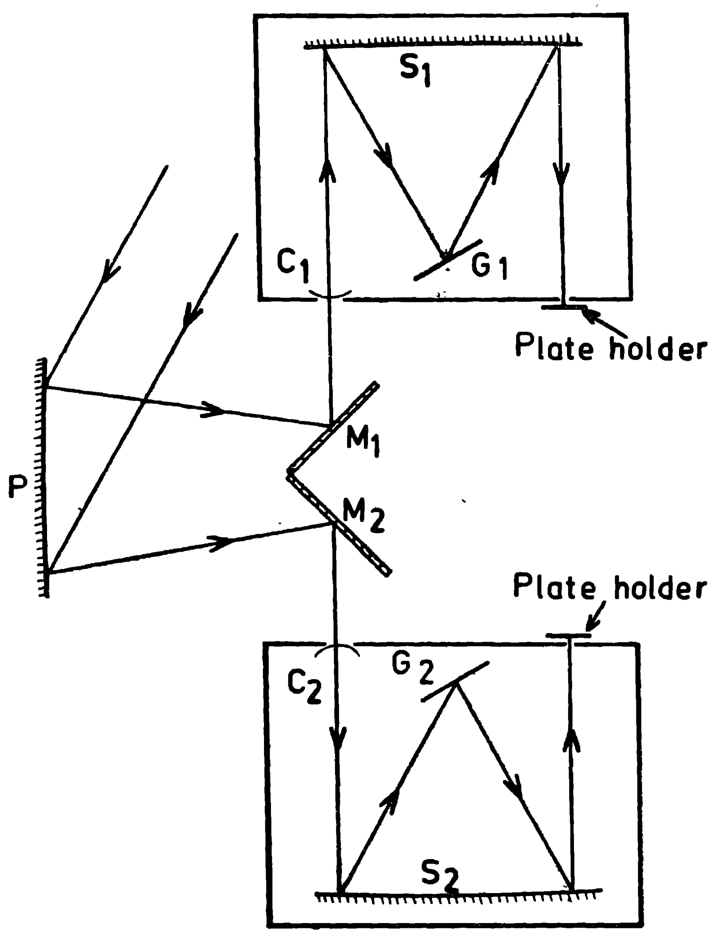

Figure 1. Optical layout for obtaining the spectra of the inner solar corona. P is a paraboloid (ϕ = 250 mm, f = 2450 mm) for imaging the corona; M_1 and M_2, two flat mirrors; C_1 and C_2, curved slits; S_1 and S_2, spherical mirrors (ϕ = 300 mm, f = 550 mm), and G_1 and G_2 gratings each with 600 lines mm^{-1}.

each with a Kodak III-F 20 cm × 15 cm photographic plate were used to record the spectra in quick succession which covered the entire visible range from 3800 Å to 6800 Å. These plates along with the calibration spectra were developed in Kodak D-19 at 20 C.

3. Observations and results

Four spectra of the inner corona on the east and the west limb were taken with the exposure time of 10, 20, 85 and 5s. The 85s spectra on the west and the east limb were found to be excellent. The spectra show all the prominent coronal lines and H-alpha line in emission. The most intense [Fe XIV] 5303 Å line is visible from position angle 215° to 290°. The extent of the other lines is indicated in table 1.

Microphotometer scans with a spatial resolution of 6 × 10 arcsec^2 were taken in a direction perpendicular to the emission lines. Three such scans were taken on the west limb corona and three on the east limb corona. Solar spectra were also taken to find the response of the photographic plate. The relative intensities of the emission lines derived from the scans were corrected for the response of the photographic plate and are listed in table 1. The Ca XV ion emission observed at the position angle of 253° indicates the presence of a highly active isolated pocket of solar corona whose temperature must be greater than 4×10^6 K. The temperature and velocity structure of the inner solar corona could not be determined because of the low resolution of the coronal spectra.

The scatter-free intensities of the lines of the chromosphere and the prominences help us a great deal in understanding the dynamics of these features. During the normal days these intensities are affected by the scattered photospheric light. In the last exposure of 5s, during the ending moments of the total eclipse, spectra of chromosphere and prominence were registered. The relative intensities of the chromospheric emission lines were determined by the same technique as applied for coronal lines and are listed in table 2. The relative intensities of emission lines in three prominences on the eastern limb are given in table 3. Only four lines namely H_α, D_3, Ca^+H and Ca^+K are recorded in these prominences. The emission in D_3 is very weak as compared to the emission in other lines. From tables 2 and 3 one can see that the ratio of intensities of Ca^+K/Ca^+H in the prominences is about 1.5 whereas in the chromosphere it is only one. The difference between the two ratios must be attributed to the different physical conditions like temperature, density and possible magnetic fields.

Table 1. Relative intensities of the coronal emission line

Sl No.	Identification and wavelength		Extent of the line in degrees	Relative intensities (E-limb)			Relative intensities (W-limb)		
				$\theta = 90°$	$\theta = 94°$	$\theta = 99°$	$\theta = 246°$	$\theta = 253°$	$\theta = 256°$
1.	[Ni XIII]	λ5116	89–92, 252–254	10.1	9.8	—	—	2.8	—
2.	[Fe XIV]	λ5303	61–132, 215–290	287.1	271.6	115.1	104.0	167.0	253.2
3.	[Ca XV]	λ5694	253	—	—	—	—	29.2	—
4.	[Fe X]	λ6374	86–108, 246–260	65.6	81.8	77.1	10.7	6.5	74.0
5.	H_α	λ6563	240–257	—	—	—	14.1	3.6	2.6
6.	[Ni XV]	λ6702	89–92, 241–256	14.2	—	—	16.9	4.0	8.9

Table 2. Relative intensities of the chromospheric emission lines

Sl No.	Identification and wavelength in Å	Relative intensity θ = 248°	θ = 250°
1.	H_α λ6563	185.4	206.5
2.	D_3 λ5876	47.4	62.8
3.	H_β λ4861	98.2	128.2
4.	H_γ λ4340	40.0	52.4
5.	H_δ λ4102	31.7	16.7
6.	Ca^+H λ3968	26.1	49.8
7.	Ca^+K λ3934	27.2	53.3

Table 3. Relative intensities of the prominence emission lines

Sl No.	Identification and wevelength in Å	θ = 89°	Relative intensity θ = 93°	θ = 95°
1.	H_α λ6563	174.6	137.1	93.8
2.	D_3 λ5876	49.2	13.6	10.0
3.	Ca^+H λ3968	153.1	103.0	79.6
4.	Ca^+K λ3934	248.3	157.4	127.4

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