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High Resolution Multislit Spectroscopy of Solar Corona in two lines during the Total Solar Eclipse of Oct. 24, 1995

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Abstract

Two coronal emission lines 5303Å (Fe XIV) and 6374Å (Fe X) corresponding to ionization temperatures of 2 and 1 million degree kelvin respectively were used to obtain the high resolution coronal spectra using multislit spectrograph. The experimental setup provided a spatial resolution of 11 arcsec and spectral resolution of 70 mA corresponding to a velocity of about 4 Kms^{-1}. The spectra were recorded on 70 mm kodak 4415 film using Hamamatsu image intensifiers. For the first time we were able to obtain the high resolution spectra in these two emission lines simultaneously at various locations in the solar corona.

Key Words : Coronal temperature, Emission lines, Ionization and kinetic temperatures, Turbulence.

Introduction

A detailed knowledge about the temperature and velocity structure in the solar corona is of crucial importance for understanding the coronal heating mechanism and origin of solar wind. Jarrett and Von kluber (1955, 1961) were the first to successfully record the interference fringes in the coronal green line during the total solar eclipse of June 30, 1954 and to derive the temperature at various locations in the solar corona. Subsequently number of observers have employed this technique during the eclipses (Kim and Nikolsky, 1975, Desai *et al.* 1982) and Raju *et al.* (1993) reported large scale mass motions in the solar corona at some locations. The Fabry – Perot experiment has the advantage of simultaneous registration of interference fringes over most of the corona; the disadvantage is the uncertainty of the contribution by Doppler shifted elements to the line profile derived from the interference fringes, which is inherent in a slitless mode. Such limitations are absent in a slit survey, since the finite width of the slit samples limited extent of the corona. On the other hand, the slit permits the acquisition of information only along the coronal emission regions intercepted by its length. Procedure to minimize this handicap is to use properly spaced number of slits along with an interference filter to cut off the unwanted spectra. This technique can be used to provide a good twodimensional coverage of the corona by judicious choice of instrumentation and has all the advantages of standard slit spectroscopy over its slitless counterpart.

Livingston *et al.* (1982) have used multislit technique to study the temperature structure of solar corona and to investigate the existence of outflow or inflow of plasma in the polar regions. Singh *et al.* (1982) used this technique during the total solar eclipse of 1980 February 16 and from the observations in red coronal emission line concluded that turbulent velocities of about 30 kms^{-1} need to be invoked to explain the observed line widths and corona does not show any localized differential mass motion. Further, the ratios of line to continuum intensities indicated that the average temperature of solar corona was about 1.6×10^6 k during that period (Singh 1985). It was realised that observations in two coronal emission lines will give a better clue to the turbulent velocities and help in estimating the differences in 'open' and 'closed' field structures in terms of density, temperature and turbulence. With this view, an experiment was conducted during the total solar eclipse of October 24, 1995 to obtain the spectra in 5303Å (Fe XIV) and 6374Å (Fe X) coronal emission lines simultaneously.

Experimental details

The optical layout of the experiment is shown in Figure 1. A two mirror coelostat system of 20 cm aperture collected the solar / coronal light and fed it to a horizontal fixed telescope. The first mirror of the coelostat was driven by a stepper motor through a worm – wheel assembly at a frequency of ~ 200 Hz. The frequency was adjusted by a small amount to get almost zero drift of the image in the E – W direction in 5 minutes time. The drift of the image in one minute in the N – S direction due to change in the declination of the Sun was negligible. An objective of 10 – cm aperture and 100 cm focus formed the solar image of 9.1 mm diameter on the multislit of the spectrograph. Five entrance slits, each separated by 5 mm from its neighbour, together formed the multislit. The 80 – micron width of each slit provided a spatial resolution of ~ 16 arcsec on the solar corona. The field lens behind the multislit focused the objective onto the spectrograph lens. The Littrow spectrograph with the f/10 lens of 140 – cm focus and 600 grooves per mm grating (blazed at 1.2 micron in the first order) provided a dispersion of 4.7 A/mm in the second order red. Thus 5303Å and 6374Å, two coronal emission lines were separated by 228 mm in the second order. To filter the required spectra around these lines interference filters with 5Å pass band were kept in the respective light beams after the diffraction. Hamamatsu 1366P image tubes were used to intensify the spectra. The gain of these tubes was adjusted to obtain intensified spectra without image tube back ground. Motorized 70 – mm film magazines enabled rapid change over of the emulsion. An arrangement was made to press the film against the image intensifier while recording the spectrum and avoid the contact between film and image tube while moving the film after exposure. The spectra were recorded on 70 mm kodak 4415 emulsion. 25 mm diameter of the image intensifier allowed us to obtain coronal spectra upto 2 solar radii from the sun's center. The spectrograph yielded over all spectral resolution of 70 mA. A pellicle beam splitter was mounted in front of the multislit to enable recording of neon spectra in addition to coronal spectrum.

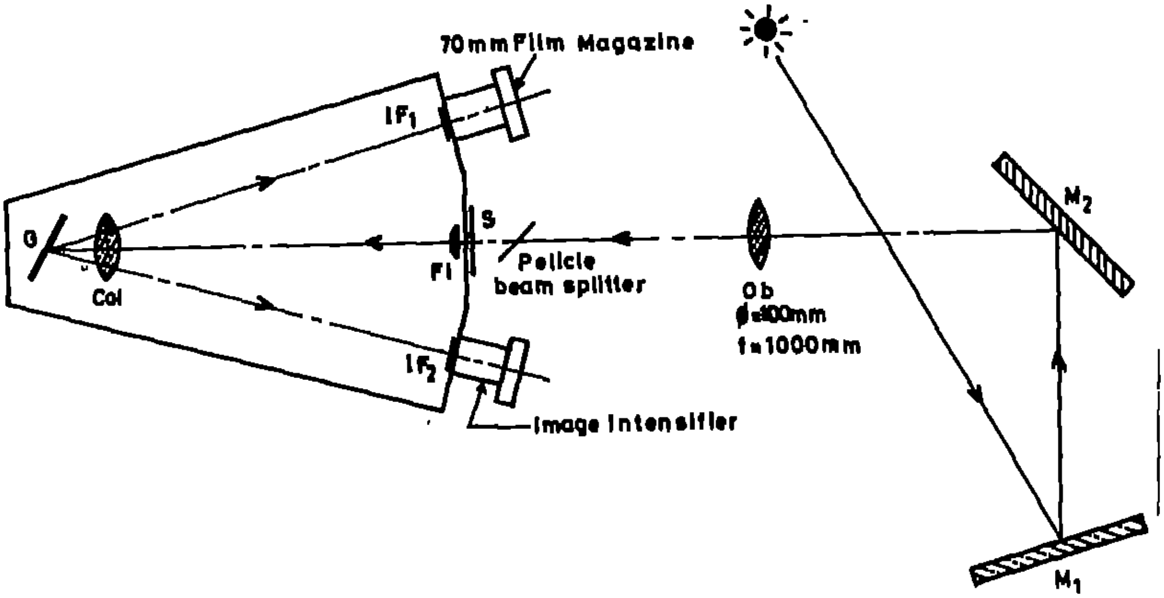

Figure 1 : Experimental layout of the multislit spectrograph.

Observations and Results

Spectra on the solar disc were obtained using neutral density filters on one day before and one day after the eclipse at the epoch as that of eclipse to convert the measured coronal intensities to the standard value of intensity at the sun's center. These spectra will also help to estimate the instrumental modulation of intensities as a function wavelengths. Neon light spectra were also obtained to determine the instrumental line profiles.

Five spectra of the corona covering 5303Å and 6374Å emission lines were obtained during the totality with exposure time ranging between 1 – 10 secs. The spectra at the disc center using a step wedge were also recorded after the totality to compensate for the film response. All these films taken between Oct. 23 – 25, 1995 were developed together in D19 at 20°C. The spectra recorded with 10 sec. exposure are shown in Figures 2 and 3. These spectra have been scanned with PDS machine to get the line profiles of emission lines using standard photometric technique. The initial look at the data indicates some differences in the 'open' and 'closed' field structures. The detailed analysis will yield information about turbulence and in making realistic modelling of coronal structures.

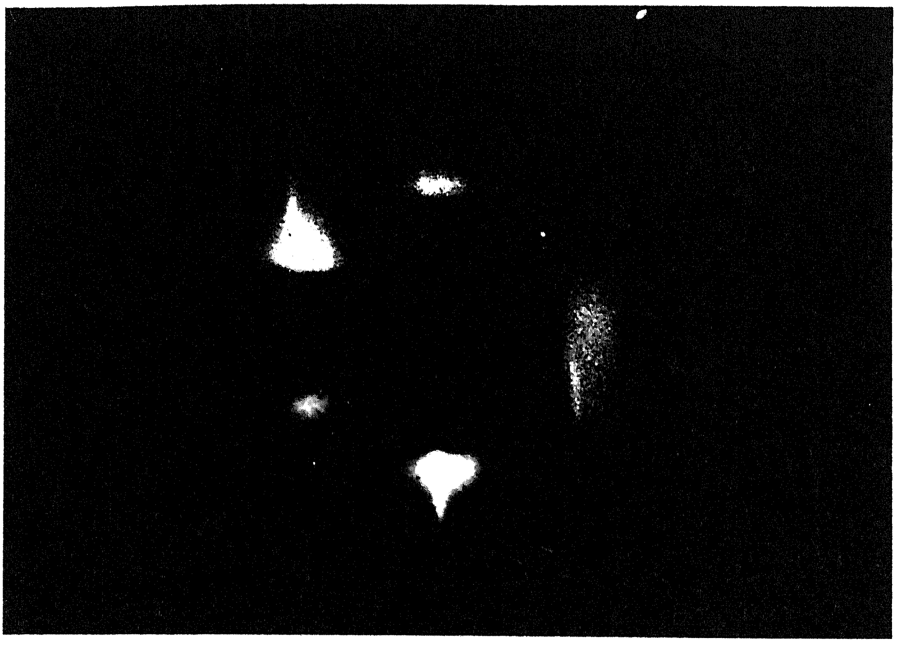

Figure 2 : Multislit spectrum in 5303Å (Fe XIV) coronal emission line obtained during the totality on Oct. 24, 1995 with exposure time of 10 sec.

Figure 3 : Multislit spectrum in 6374Å (Fe X) coronal emission line obtained during the totality on Oct. 24, 1995 with exposure time of 10 sec.

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