Kodaikanal Obs. Bull. (1997) 13, 41-46

# Fabry-Perot Interferometric Observation of the Solar Corona in the Green Line

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## Abstract

An imaging Fabry-Perot interferometer was designed and used for coronal observations in the green line (FeXIV) 5303Å. The observations were carried out at Nim Ka Thana, Rajasthan, India during the total solar eclipse of 1995 October 24. A dielectric coated Fabry-Perot etalon with 92% reflectivity and spacing 350 $\mu$m was used to obtain the interference fringes. A liquid nitrogen cooled Photometrics CCD served as the detector. The green line emission was found to be extremely weak and restricted to the eastern and western limbs of the Sun. Emission line profiles were obtained at a few coronal locations. The average width was found to be 1.6 Å indicative of the presence of large turbulent velocities (49 kms$^{-1}$). One of the line profiles, showed line splitting, possibly due to mass motion in the corona.

**Key Words :** Total solar eclipse, Solar corona, Coronal temperature, Coronal velocity fields

## Introduction

The role of magnetic field in coronal heating is now well accepted. However, the actual mechanism by which the corona is heated to million degree Kelvin is under active investigation. A detailed knowledge of temperature, velocity field and magnetic field in the solar corona is very crucial in resolving this problem. Fabry-Perot interferometry is an ideal way of obtaining the physical quantities such as temperature and velocity fields in an extended astronomical source such as solar corona. The first successful observation of the solar corona using Fabry-Perot technique was made by Jarrett and Von Kluber during the total solar eclipse of June 30, 1954 (Jarrett and Von Kluber 1955). There have been several attempts by various groups on later eclipses (Jarrett and Von Kluber 1961, Delone and Makarova 1969, 1975, Liebenberg 1975, Hirschberg *et al.*, 1971, Marshall and Henderson 1973, Kim and Nikolsky 1975, Chandrasekhar *et al.*, 1991). With an aim to obtain the 2-dimensional distribution of temperature and velocity fields in the solar corona during the solar minimum periods, we have designed and fabricated such an instrument and used it during the total solar eclipse of 1995 October 24 from Nim Ka Thana. The emission line chosen was the coronal green line [Fe XIV]

5303Å which is usually the strongest emission line in the coronal visible spectrum. In the experimental design, we used a CCD instead of the traditional photographic film as the detector. In the following, we describe the instrument, observations and the preliminary results.

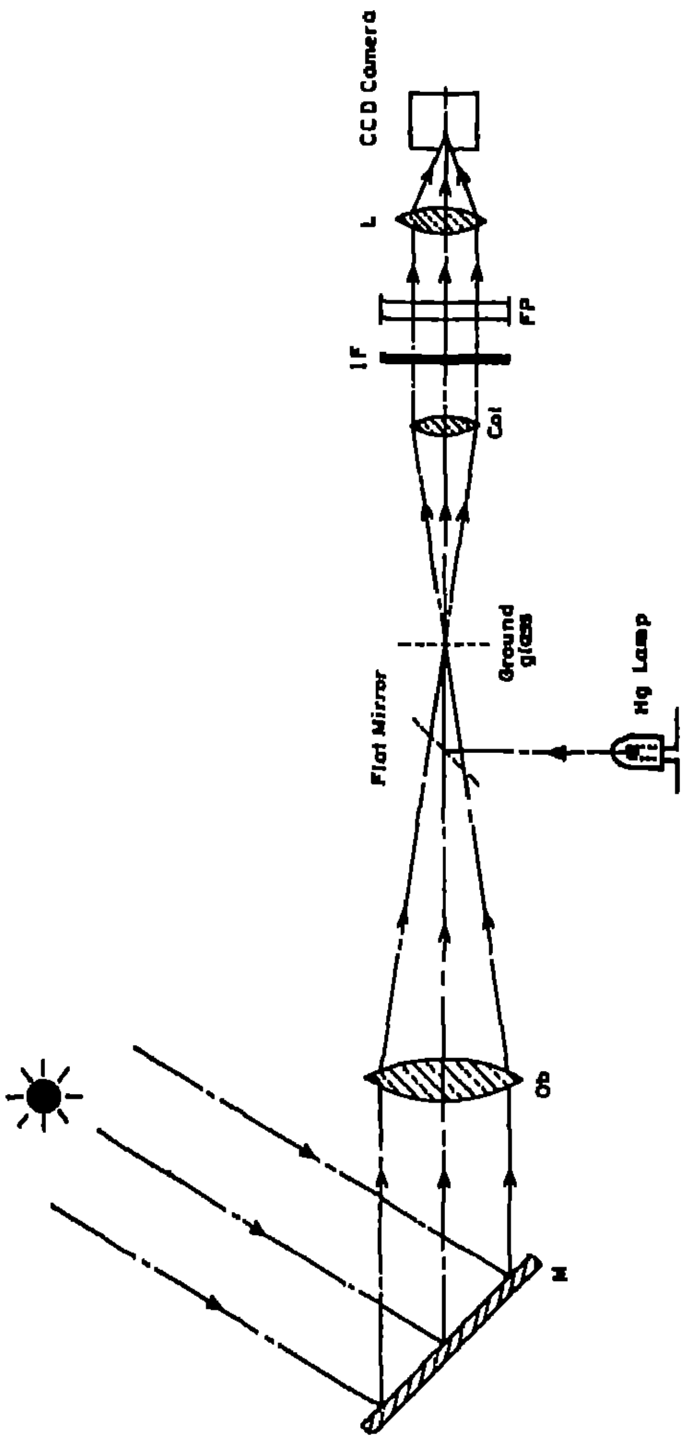


Figure 1 : A schematic diagram of the Fabry-Perot interferometer.

## Experiment

The schematic of the instrument is shown in Figure 1. A 12 inch coelostat mirror deflected the coronal light into the telescope objective of 100 mm aperture and 1000 mm focal length. The f/10 beam was collimated by a 102 mm focal length lens and then passed through an interference filter of 10 Å passband, which isolated the coronal green line. A dielectric coated Fabry-Perot etalon with 92% reflectivity and spacing 350 $\mu$m was used to obtain the interference fringes. A camera lens of 135 mm focal length was used to focus the interference fringes on a liquid nitrogen cooled CCD camera of 1024 x 1024 format with a pixel size of 24 $\mu$m. The derived parameters of the instrument are the following :-

| | | |
|---|---|---|
| Free spectral range | = | 4 Å |
| Instrumental resolution | = | 0.4 Å |
| Instrumental finesse | = | 10 |
| Image scale | = | 3.8 arcsec per pixel |

The instrument was thoroughly tested at Kavalur. A series of exposures were obtained with the Sun using different neutral density filters. This procedure was adopted to get an idea of the exposure time needed for the actual observation at the eclipse. The spectral calibrations were obtained with the mercury green line at 5461Å. The instrument was taken to the eclipse site and the trial runs were repeated. During the totality, one frame was taken with an exposure time of 40 second. The data were later transferred to Sparc workstation at IIA for detailed analysis.

## Results and Discussion

The data analysis was done in the IRAF image processing environment. The green line emission was found to be extremely weak and restricted to the eastern and western limbs of the Sun. There are about four to five fringes seen in the western limb. The radial extent of the fringes does not exceed 1.2 solar radii. The low contrast in the fringes indicates that the line to continuum intensity ratio is less than one in most coronal locations, whereas the expected value is 10 to 100 in the inner corona (Raju and Desai 1993). The fringe centre was identified in the interferogram and radial scans were made across the fringes. The line width may be obtained by converting the radial distance to wavelength units by

$$\Delta\lambda = -\frac{\lambda R \Delta R}{F^2} \quad (1)$$

where $\Delta\lambda$ is the wavelength interval from the intensity maxima corresponding to the radial interval $\Delta R$, $\lambda$ is the wavelength of the emission line, R is the radial distance to the fringe maxima and F is the focal length of the camera lens.

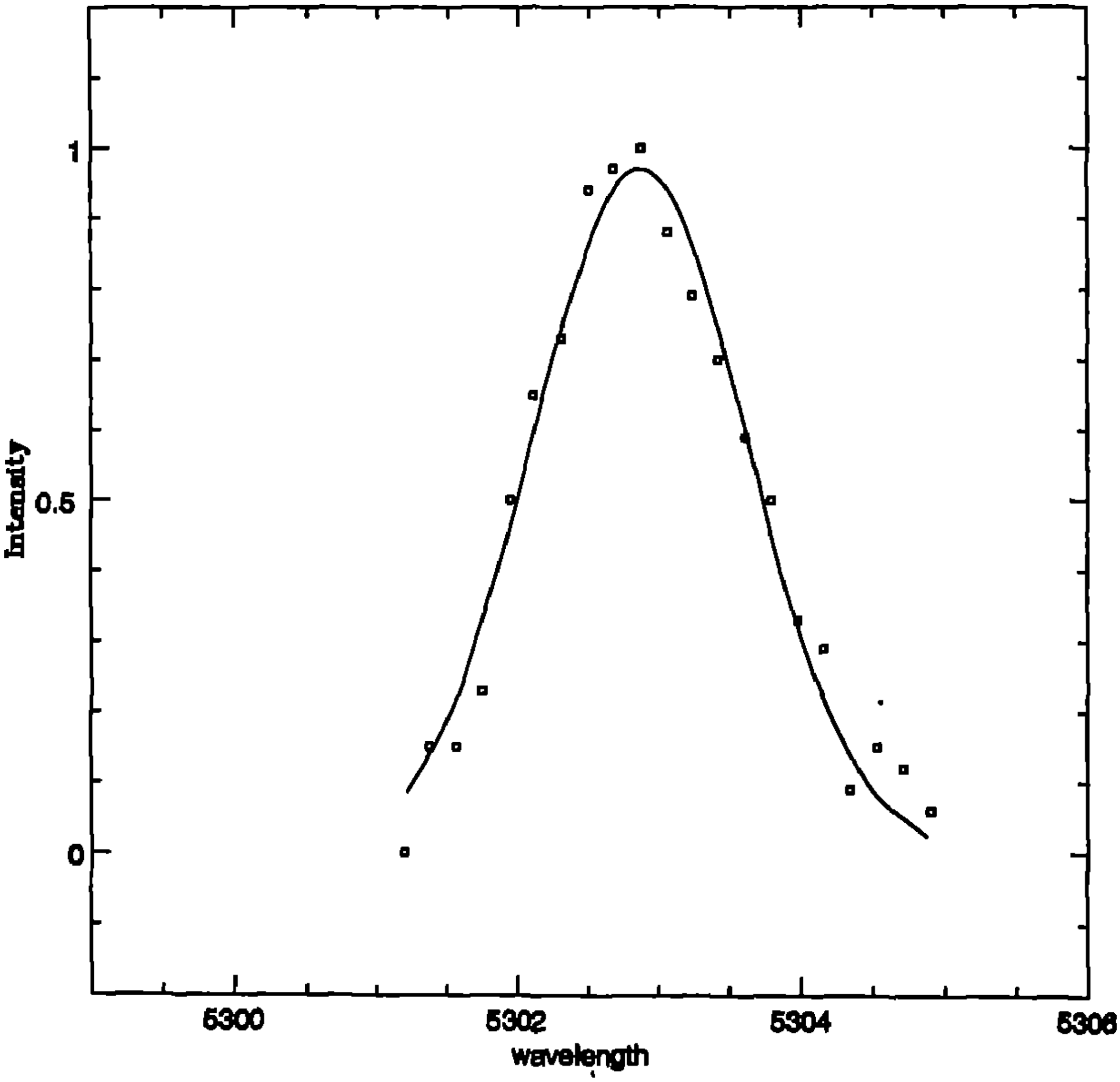


**Figure 2a :** Single gaussian fit to the observed emission line profile. The open squares represent the observational points and the solid line represents the fit. Relative intensity is plotted against the wavelength in Å units.

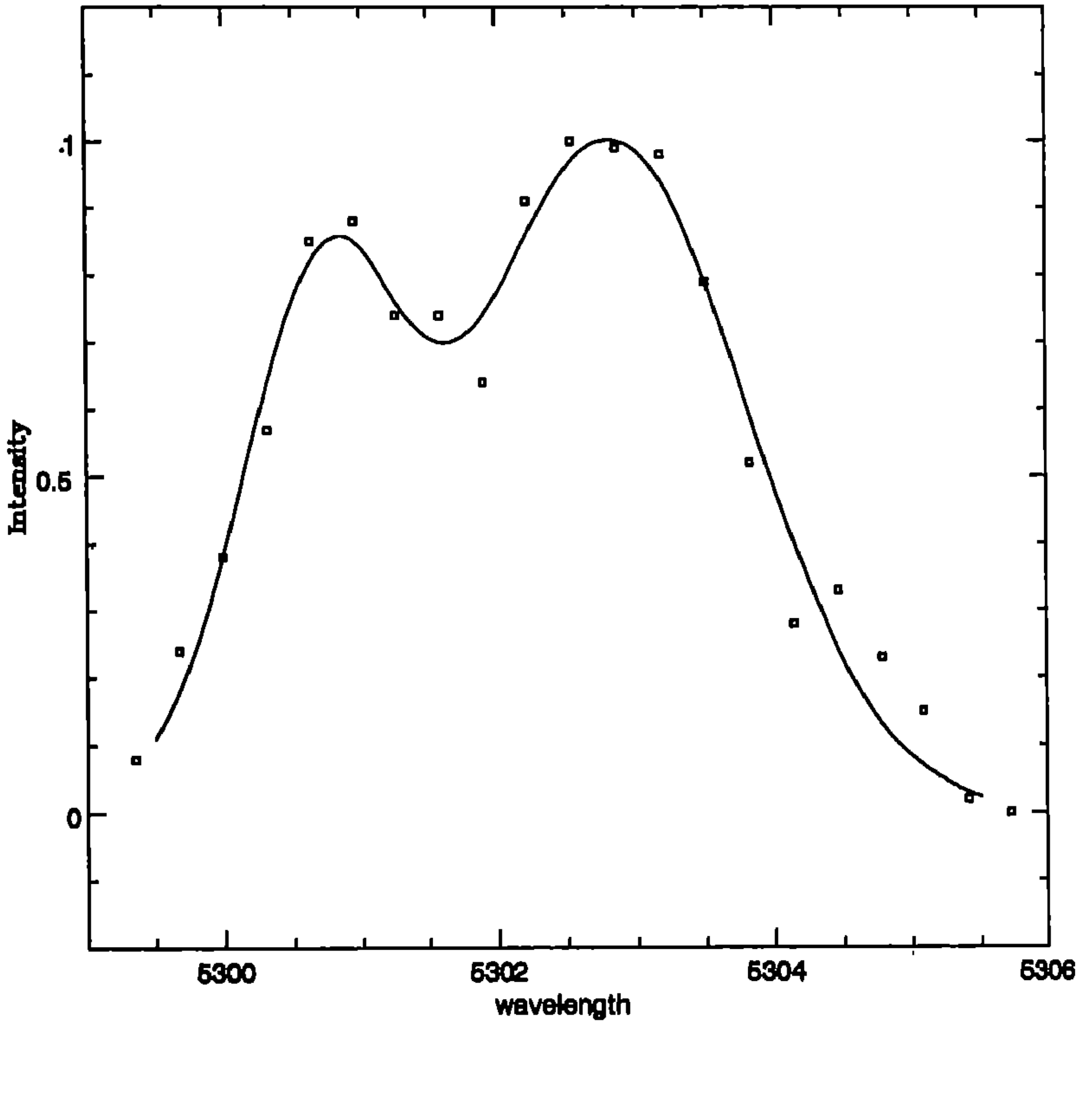


**Figure 2b** : Multiple gaussian fit to the observed emission line profile. The open squares represent the observational points and the solid line represents the fit. Relative intensity is plotted against the wavelength in Å units.

Emission line profiles were obtained at four coronal locations and one of them showed line splitting. Single or multiple Gaussian components were fitted to the line profiles (Fig. 2a, b) and the halfwidths were measured. The details of this analysis are given in Table 1. The average halfwidth was found to be 1.6 Å. If the whole width is attributed to the thermal broadening, the kinetic temperature of the solar corona comes out to be around 10 million K. At such high temperatures, abundance of Fe XIV ion will be negligible and hence this indicates the presence of nonthermal broadening. Assuming the ionization temperature of FeXIV ion around 2 million K, we obtain turbulent velocities of the order 49 km $s^{-1}$. These values are comparable with those of Singh, Bappu and Saxena (1982).

**Table 1.** Turbulent velocities in solar corona

| No. | PA | $R/R_\odot$ | FWHM (Å) | $V_t$ ($kms^{-1}$) |
|---|---|---|---|---|
| 1 | 273 | 1.12 | 1.73 | 53.2 |
| 2 | 270 | 1.10 | 1.55 | 46.5 |
| 3 | 265 | 1.16 | 1.35 | 38.7 |
| 4 | 262 | 1.12 | 1.86 | 58.0 |

One of the emission line profiles in the western limb showed line splitting, possibly due to mass motion in the corona (Fig. 2b). The velocity of the blue shifted component is 120 km $s^{-1}$ with a probable error of 10 km $s^{-1}$. A detailed analysis of this nature could not be carried out because of the limited extent of the data. The instrument will be used in the future eclipse observations and in the study of extended astronomical sources such as comets.

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