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Photometry of Solar Corona to Study the Coronal Structures

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Abstract

White light images of the solar corona were taken on KODAK 2415 films using 3-inch (f/11.5) telescopes fitted with SLR cameras. Observations were made from 4 different sites spread over the totality belt by four different teams. Table 1 gives the observation sites, the teams and the positions of the places in the totality belt.

Key Words : Total solar eclipse, white light photography, coronal structures

Observation Site	Site Location	Teams
1. Gaurisar (RAJASTHAN)	28.15 N 74.69 E	Pavan Chakraborty, Sonjoy Majumder K. Sankarasubramanian
2. Fatepur (RAJASTHAN)	28.00 N 74.96 E	Rajesh Nayak, R. Sridharan A.D. Jana
3. Ambha (M.P.)	26.70 N 78.23 E	D. Suresh G. Rajalakshmi
4. Bhind (M.P.)	26.58 N 78.89 E	Ashish Asgekar, K.P. Geetha Rajesh C. Kunnumpuram

1. Objectives of our eclipse expedition

1. Scientific Observations

The scientific objective of our solar eclipse expedition was to obtain good data which would supplement the observations from Nim Ka Thana and Kalpi, covered by the main groups. Trial runs helped us to fine tune our instruments particularly the cameras. Exposures of the Moon at night helped us to find out the range of exposure times which could be used during the eclipse. In these trial runs we obtained total familiarity with the instrument so that maximum efficiency could be achieved while acquiring the data.

Apart from these trials, 36 images of the full disc of the Sun were taken for calibration purposes. In addition, pictures of the Sun were obtained using neutral density filters and a small aperture one day before the totality to confirm the exposure times to be used during the total eclipse. A maximum efficiency in acquiring the data during the short totality (about 50 sec) was obtained. Maximum number of images of solar corona (25 images) with exposures varying from 1 sec to 1/250 sec were taken from the Gaurisar observation site. After the totality, the remaining films were used for recording the partial phases of the eclipse.

2. Local awareness of the total Solar Eclipse and Astronomy in general

The second objective of the expedition was to make people aware of the facts of the solar eclipse. The observation sites as mentioned in Table 1, were located far from urban areas and people there had superstitions and fear about the solar eclipse. We were successful in making them understand the real circumstances under which a total solar eclipse takes place and remove their fear. The response was encouraging. Many villagers had come to witness the eclipse which they observed through high density filters provided by us. This created a general awareness and curiosity about Science and Astronomy, and the solar eclipse in particular.

2. Data

The data obtained in the form of images on KODAK 2415 photographic films were assembled from the four observation sites. The step-wedge calibrations for all the films with different exposure times were made at the Kodaikanal Observatory. The eclipse images along with calibrations were developed simultaneously in the same developing solution to ensure the uniformity of the data.

Due to the range of exposure time (1/250 sec to 1 sec), a large variation in emulsion densities, from underexposed to overexposed, were obtained. By adding the calibrated images of different exposures, a large dynamic range is expected to be obtained.

Most of the images have been digitised using the PDS machine at Bangalore. The photographic characteristic curves obtained using the digitised step-wedge data used to convert the density values to the intensity values. The flux values at the various locations in the solar corona would be computed using these intensities and the photospheric values obtained on the previous day.

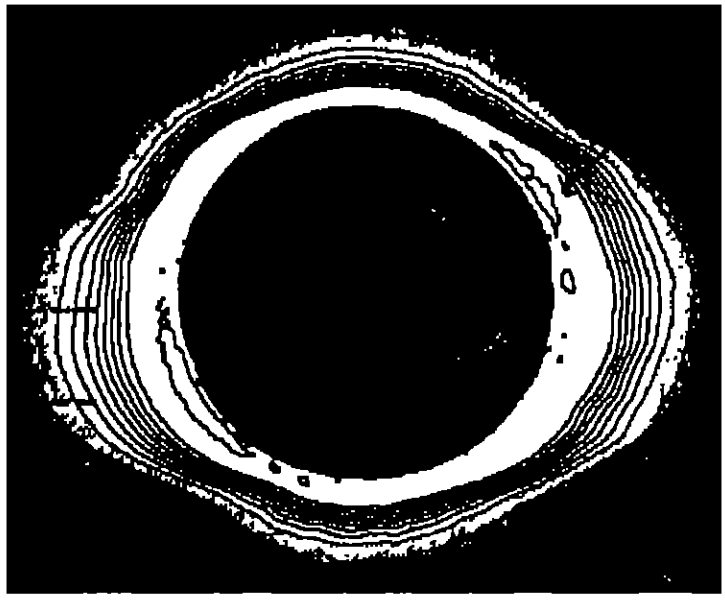

Figure 1 : Iso-density contours superimposed on a 1/4 sec exposure coronal image.

3. Preliminary Results and Conclusions

We show our preliminary results in the form of four figures. The images are digitized and the counts are proportional to the emulsion density. Figure 1 shows one of the coronal image obtained during the eclipse with exposure time of 1/4 sec and the iso-density contours. A larger density gradient is observed in the North (top) and South (bottom) compared to the East (left) and the West (right).

A structure was observed on the North-West limb of the Sun. The details of this structure close to the limb are seen better in shorter exposures. Though the region close to the limb is saturated in longer exposures, the extension of this structure is seen extending to a greater radial distance. Figure 2 and Figure 3 are the magnified section of the corona close to the limb of the Sun, showing the observed structure. Super position of iso-density contours on the images clearly shows the presence of enhanced density in this structure. Figure 2 is a shorter exposure (1/60 sec), while Figure 3 is a longer one (1/4 sec). This structure might be a prominence.

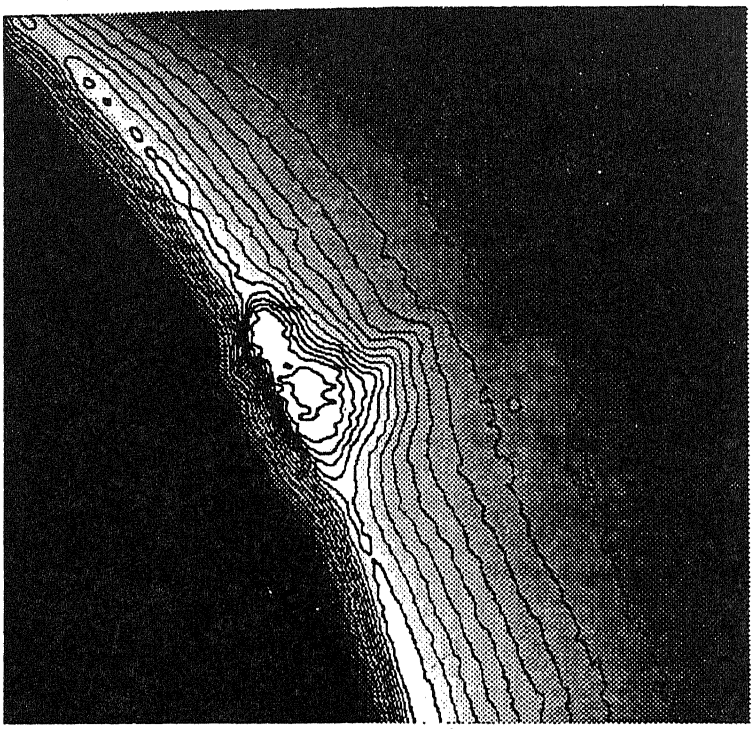

Figure 2 : The structure on North-West limb of the Sun. Exposure time 1/60 sec.

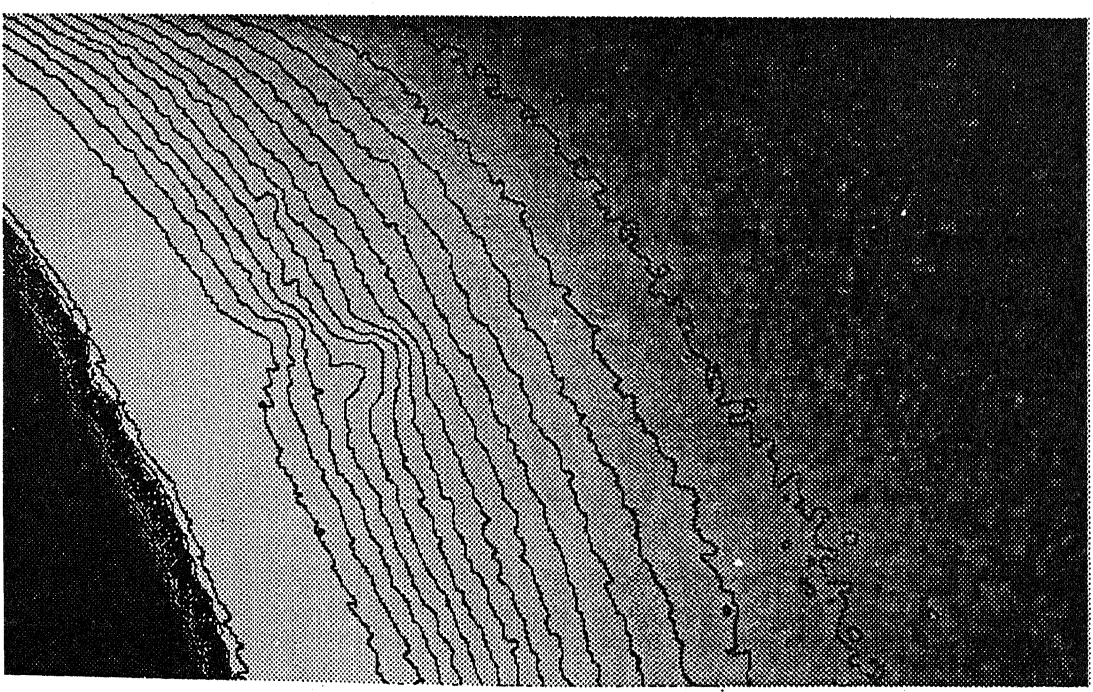

Figure 3 : The structure on North-West limb of the Sun. Exposure time 1/4 sec.

In Figure 4 we plot the coronal profile, emulsion density versus the radial distance from the sun's centre in units of radius of the occulting lunar disc. The profile cuts have been obtained at the North, South, East and West of the coronal image. The top plot in Figure 4 is from the image in Figure 2 while the lower plot is from the image of Figure 3. Note that in the lower plot, the profile is saturated up to R = 1.2 for the North and South direction and up to R = 1.4 in the East and West direction. A combination of the upper and lower plot, and the profile from other images would give us a large dynamic range and permit to construct the coronal profile to a large distance (R ≈ 2.5).

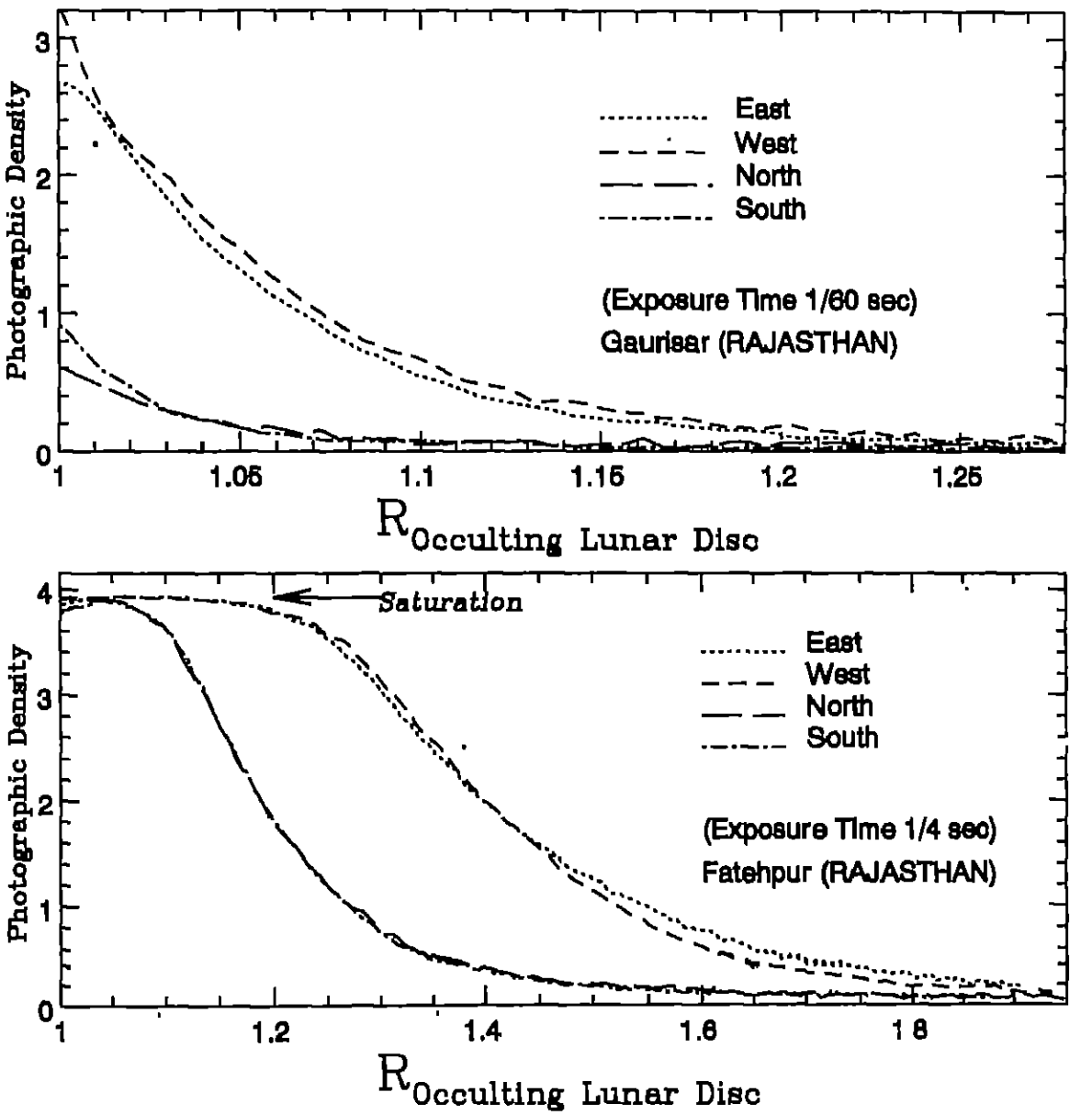

Figure 4 : The intensity variation in the solar corona with solar radii.

With proper calibration of the data with the photospheric intensity value for all the exposed images, it would be possible to study the large extent of the corona. The intensity variation with the radius can be fitted to a general formula and from that the temperature structure with the radius can be studied. The feature observed in the limb may be due to the enhancement of the electron density in that part of the corona. This quantitative analysis and the position of the feature can be compared with several other observations taken on the same day in different wavelength regions. This would give information about the kind of phenomenon involved. The polarisation data taken by other teams would be compared to study the electron density enhancement.

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