THE FINEST WHITE-LIGHT CORONAL FEATURES.

Serge Koutchmy, Olivier Bouchard, Jean Mouette
Institute d'Astrophysique de Paris
CNRS, 98 bis Bd Arago
F-75014, Paris
France

Olga Koutchmy
Laboratoire d'Analyse Numérique, Université Pierre et
Marie Curie,
Tour 55-65,
4 Place Jussieu,
F-75230 Paris (France)

ABSTRACT
An attempt to detect the finest white-light coronal features observed with a large optical telescope was made at the July 11, 1991, total solar eclipse. A few selected results taken from the video-CCD high speed observations obtained at the prime focus of the Canada-France-Hawaii Telescope (CFHT) with a red coronal interference filter are presented. The smallest (sub-arcsec) detected and/or resolved coronal features are shown. The methods that were used to extract them from the noisy and seeing-limited images taken from video frames are described.

1 INTRODUCTION
The total solar eclipse of July 11, 1991, was observed at the prime focus of the 3.6 m aperture, Canada-France-Hawaii Telescope (CFHT), the largest optical telescope ever used to study the solar atmosphere. The main objective was to look at the smallest possible scale where coronal heating and ejection phenomena are supposed to take place. Thanks to the efforts of a rather large consortium of scientists and engineers (Koutchmy et al. 1993; Koutchmy, Monnet and Sovka 1992), seeing limited images were obtained with different high-speed photographic and video-CCD cameras during the four minutes of totality. Here we report on a preliminary analysis and an attempt to measure the cross-section of the smallest sub-arcsec truly coronal feature (instead of a low-excitation-line emission features). Images of \(135 \times 105 \text{ arcsec}^2\) were taken with a 60Hz video-CCD camera using a 756 \(\times\) 581 px chip. The camera was put at the prime focus of the CFHT – i.e. after the b gonette. A 7nm FWHM interference coronal filter centered at 637nm was used (pure WL and FeX coronal line emission). Figure 1 gives the typical full widths of the instantaneous smearing function measured on the best frames, analyzing the silhouetted limb of the Moon. Only the last video-frames were analysed as the totality ended. The FWHM of the smearing function is estimated assuming that it corresponds to the width of the derivative of the limb profile at selected locations.

2 LOOP STRUCTURE
Different parts of the inner corona were taken with the camera because the focal-plane set-up was rotated by an angle of 32° thirty-six seconds after the second contact. Then a 205 sec long sequence over the same field of view containing the image of a plasmoid was obtained (Vial et al. 1992). During the rotation, the field of view of the camera crossed a region near the lunar limb where coronal loops were captured. We picked up the video images showing these loops and processed a few digitized frames. The first images were recorded on a video-disc and then digitized using the 8-bit video-grabber (512 \(\times\) 512 px) of the NSO/SP Sun computer. We superposed 10 single video full-frames after removing the small shift in odd and even frames, that had been produced by the motion of the telescope (processed by Andrea L. Cox, summer student at NSO/SP). The signal/noise ratio was then sufficient to further process the resulting frame using our OMC or “Mad Max” operator (Koutchmy et al. 1988). The resulting image (Figure 2) shows very thin and irregular coronal loops with a cross-section of about 1 to 2 arcsec; blobs are also seen, sometimes at sub-arcsec size.
(Vial et al 1992). The aspect ratio of the loops is certainly ≥100. Irregularities in the loops strongly suggest that some kind of coronal heating is going on along it. As only a single snapshot of the loops was taken, we cannot comment on the dynamics of the phenomenon. However, the usual models of loops with a cool or hot core and hot or cool envelope seem too oversimplified to represent these observations; models with inhomogeneities along the loops should be considered.

3 THREAD STRUCTURE
To look at the finest structures, namely short lived coronal threads seen on the 6000 frames time sequence, we produced a compressed 237 single image version of the movie which indeed uses only 35 of the sequence (0.2 sec integration time every sec). Then we selected the best images by visual inspection of the pictures. A small part of each single image shows the background corona displaying several features: a plasmoid (see Vial et al 1992) and threads barely detected. We used analog compositing and processing methods (correlation-compositing and unsharp-printing) to obtain the best possible image. The result of integrating 8 images (2.4 sec total integration time) taken from a 38 sec long subsequence was used to perform measurements. Note that the thread moves rapidly in the field of view along its ‘axis’ — as a spicule does. This image was subsequently cleaned using the “brush” program at NSO/SP (FITS-LIB code by L. November).

Figure 3 is a “Madmaxed” version of that picture, showing the contour of the sub-arcsec thread. Note that the thread (and its motion) follows approximately the radial direction. We used a few photometric scans across the thread to measure its cross-section, giving an (uncorrected) FWHM of about 0.7 +/- 0.05 arcsec. When correcting these values for the average smearing, as shown in Figure 1, we ended up with a corrected estimation of the FWHM (corr) of approximately 0.4 +/- 0.1 arcsec, which seems to be the first measurement of the size of a typical coronal thread ever obtained.

4 CONCLUSION
We used high speed imaging at the focus of a large aperture telescope to measure the cross-section of a small size truly coronal feature. On individual video frames, the signal/noise ratio is not sufficient to perform the analysis. So we used a specific method to improve the image, taking advantage of the form of the object. No doubt this kind of observation will not be repeated in the near future, so the deduced measurement is probably unique; note that the value is affected by a rather small error.

REFERENCES


Figure 2 – Left: superposed video frame showing the part of the image representing loops. Note the radial gradient. Right: image processed with Mad Max to show irregularities along the loops. Note the position of the true solar limb (dotted line).

Figure 3 – Selected part of the field of view showing the coronal thread (arrow), after processing the integrated image.