*New Perspectives on Solar Prominences, IAU Colloquium 167*
*ASP Conference Series, Vol. 150, 1998*
*David Webb, David Rust, and Brigitte Schmieder (eds.)*

# Solar Prominence Diagnostics From the November 3, 1994 Eclipse

B.H. Foing [1], J.E. Wiik, L. Duvet, N. Henrich, S. Cravatte, F. David, B. Altieri, T. Beaufort, L. Ligot

*ESA Space Science Department, ESTEC, The Netherlands*

E. Maurice

*Marseille Observatory, France*

**Abstract.** We report results on solar prominences from our observations of the November 3, 1994 total solar eclipse from the North Chile alteplano. From the military base at Putre, we used our transportable CCD camera and telescope, as well as support photographic digitised observations from Putre and Parinacota volcano. The variation of density and equivalent temperature were derived in coronal holes (plumes and interplumes) and in equatorial streamers. We obtained images from the inner to the outer corona, as well as low-resolution spectra of prominences and of the inner corona. We present the analysis of images and spectra of prominences in the Balmer, He I and Ca II lines, and in the Thomson scattered continuum.

## 1. The Total Solar Eclipse of November 3, 1994 and SSD Experiments

The total solar eclipse of November 3, 1994 was observed with ESA Solar System Division (SSD) experiments from the Putre, Chile military base, situated on the central line of totality. The totality band was 173 km, and the eclipse magnitude was 1.046, due to the apparent semidiameter of the Sun of 16'07.43" and of the Moon 16'43.07". The motion of the Moon relative to the Sun was 0.446 arc-sec/s.

The aim of our observing campaign was to obtain images of the inner corona, and to measure spectra of the inner corona and protuberances on the observed limb (Foing et al. 1995, 1996a, b). The CCD experiment developed at the ESA SSD included a transportable automatic 25 cm aperture Meade LX200 telescope, used with a focal reducer from f/10 to f/6.3 in order to include a full diameter on the length of our detector, a Peltier-cooled Photometrics scientific CCD camera. The detector is a 1284x1024 pixel array of 16 micron pixels, with Multi Pinned Phase technology yielding very low dark current noise. The data were read through a controller at high rate up to 2 Mb/s, and transferred to a Macintosh memory. Automatic scripts were developed and tested before the

[1] Also at: Institut d'Astrophysique Spatiale, CNRS, France


https://doi.org/10.1017/S0252921100047588 Published online by Cambridge University Press

eclipse to be triggered 20 s before second contact of totality, in order to measure optimally different phases from last limb photospheric emission, chromospheric flash variations, and deeper exposures of the inner and middle corona.

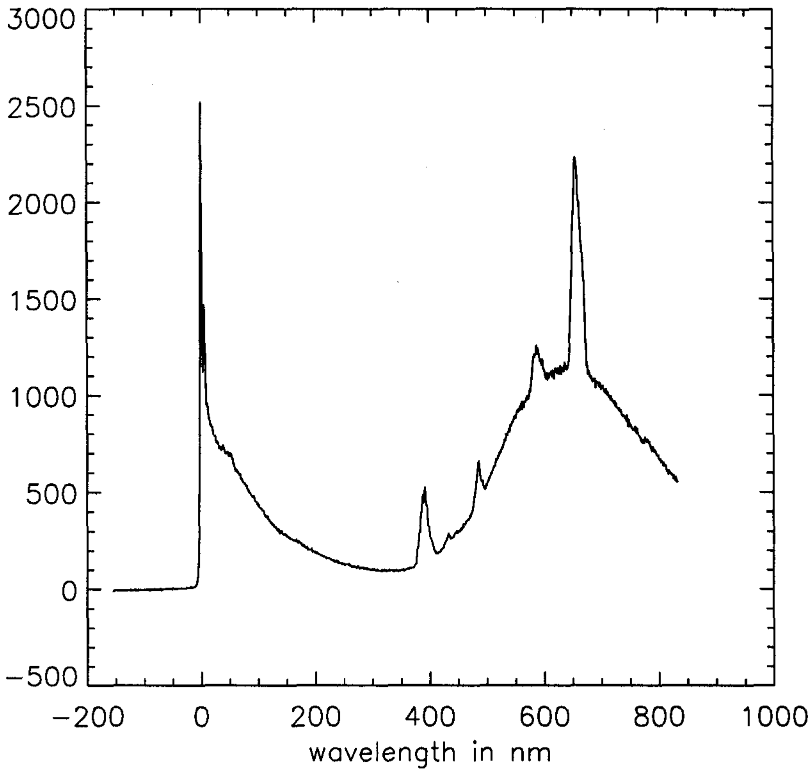


Figure 1. One frame obtained with our CCD and transportable telescope experiment. The zero order image (below) shows equatorial streamers, prominences and radial plume structures in the polar coronal hole. The objective grating first order (above) permits us to measure the spectrum of the inner corona, and monochromatic images of prominences in the lines of Ca II, H$\gamma$, H$\beta$, He D and H$\alpha$.

We used a transmission objective grating with 200 grooves/mm blazed at 10° for 476 nm. This permits us to measure simultaneously an image in zero order and a low resolution spectrum of the innner corona. The spectral dispersion was determined consistently using the constructor parameters and the distance from the spectro-imager to the detector, leading to a dispersion of 0.95 nm/pixel.

https://doi.org/10.1017/S0252921100047588 Published online by Cambridge University Press

## 2. Data Acquisition and Reduction

For the intensity calibration of the image we estimated the areas free from overlapping from the spectral orders, made corrections for the opening of the mechanical shutter at very fast exposures, made corrections for the flat field response, and estimated the straylight correction. A bias correction from a median of several biases in order to avoid cosmic rays was done. The flat field variations due to the vignetting of the optical system and the grating support were corrected for (Duvet 1996).

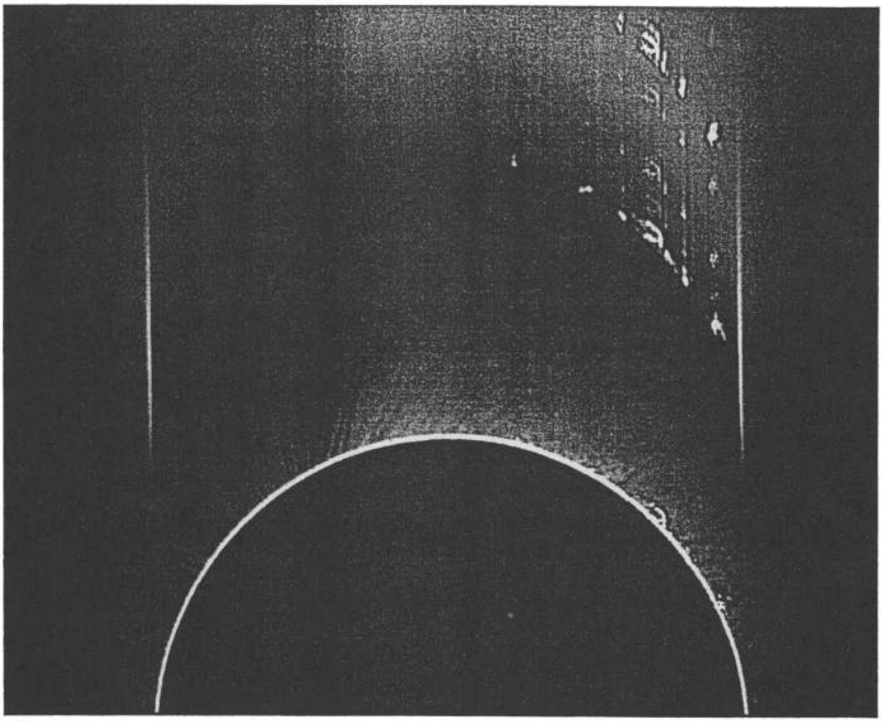

Figure 2. CCD cross section through a prominence along the axis of wavelength dispersion. The signal below 320 nm comes from the zero order image and permits mapping of the Thomson diffusion. This allows us to distinguish the vertical extent of the prominence and to measure the decay of electron density with height. The 1st order spectrum above 390 nm shows the line emission in Ca II, H$\gamma$, H$\beta$, He I D3, and H$\alpha$, respectively.

## 3. Solar Prominence Observations

A preliminary analysis of the CCD images shows several coronal characteristics. First, the respective centers and cardinal axes of the Moon and the Sun were determined. From the larger apparent diameter of the Moon and limb contour we determined exactly the moon's center. For the Sun, the parameters of the second contact were used. Also, observations of prominences in Ca II K from Meudon and Coimbra on the eclipse day (Mouradian et al. 1995) allowed us to identify and locate five prominences measurable on our frames. The second contact could then be confirmed as well as the center and orientation of the Sun. In projection we could determine for the larger arch prominence a height of 37,000 km. We also detected two other prominences, not specifed by Mouradian et al. Structures at larger scale are also visible on the image. At the pole one notices almost radial lines, which are polar plumes. A comparison with an image taken by the Yohkoh satellite shows their link with polar coronal holes. To the east one notices a streamer visible in the low corona. Large-field photographic images show at the moment of the eclipse a typical configuration of solar minimum, with polar coronal holes and two near-equatorial streamers. Spectra of the prominences show the dominate lines from Ca II, $H\gamma$, $H\beta$ and, especially, He D3 and $H\alpha$. High resolution monochromatic images of the prominences were extracted in these lines. They show different structures than the continuum (electron Thomson scattering) indicating optical thickness and 3D radiative transfer effects in the prominences.

**Acknowledgments.** We thank the Eclipse 6000 expedition team, and the Eclipse 94 Putre base staff, and the Putre international Eclipse Scientists teams for their interaction and help during our eclipse observations.

## References

Duvet, L., D.E.A. June 1996, Thesis report, ESTEC/Univ. Paris, 6

Foing, B.H. 1995, Total Solar Eclipse of 3rd November 1994: Observations and Preliminary Results, Ann. Geophys., 13, Part III, C664

Foing, B.H. et al. 1996a, Solar Eclipse and Transition Region Camera Results, Ann. Geophys., 14, Part III, C735

Foing, B.H. et al. 1996b, Results from 3 November 1994 Solar Eclipse, Proc. IAU Coll., Kluwer Acad. Pub., Dordrecht, Holland, p. 415

Mouradian, Z. et al. 1995, Solar Phys. 158, 379