The program of the Royal Observatory of Belgium for the total solar eclipse of August 11th 1999

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Abstract. This paper briefly describes the solar physics program of the Royal Observatory of Belgium, for the total solar eclipse of 1999 August 11. We intend to set up similar experiments at two sites close to the center line, respectively in France and in Romania. In this purpose, close collaborations with local organizations are being established. The observing program will consist in two main experiments:

- Fast CCD imaging of the corona in polarized white-light, up to 2 to 4 $R_\odot$, using fully automated 24-position rotating polarizing filters and powerful computers.

- photographic observations, also in polarized white-light, using a six-position manual polarizing filter at the prime focus of 1 meter refractors.

The program may also include infrared photography of the far corona.

Key words: eclipse – corona – polarization

1. Introduction

Like many European countries, Belgium will be concerned in 1999 by the total solar eclipse. The duration of totality will approach 2 min in the extreme south, one of the sunniest place of the country. On this occasion, different amateur societies will be present in the totality zone, but also in some other locations across Belgium (even where the eclipse is partial, the phenomenon will be deep and spectacular enough), and will organize public observing sessions. The Royal Observatory of Belgium intends to take an important part in this exceptional event, and its action will concern two domains, the scientific experiments and the educational aspects.

- On the observational side, the wide-field imaging of the solar corona in polarized white-light, of which the description constitutes the subject of this paper, is a long-term solar physics program initiated in 1971 that will be continued on the occasion of this eclipse; in the domain of Earth science, two projects are planned: a multiparametric monitoring of the atmospheric response to the eclipse in relation with high precision gravimetry and a determination of the total electronic content of the ionosphere using GPS observations.

- On the educational side, a Web site is already on-line and will be further developed (http://www.oma.be/KSB-ORB). Furthermore, the Planetarium of the Royal Observatory has prepared a new show dedicated to solar eclipses. Explanatory leaflets are also planned and will be published in due time.

2. Observations of the polarised white-light corona

It is well-known (van de Hulst, 1950; Saito, 1970; Clette, Gabryl and Cugnon, 1994) that the inversion of the integral equations which describes light scattering by electrons in the corona allows the determination of the 3-D electron density distribution (Figure 1).

Therefore, since 1973, different Belgian expeditions were organized to observe the solar corona (1973-Kenya, 1980-Kenya, 1984-Java, 1991-Mexico, 1994-Chile and 1998-Curaçao). Starting in 1991, a CCD imaging program was added to the 'classical' photographic experiment. Since 1994 the CCD equipment has been upgraded to become fully motorised and computer-controlled. This allowed to increase the image cadence already in 1998, making it possible to carry out the full observing sequence within the short duration of the totality of August 1999.

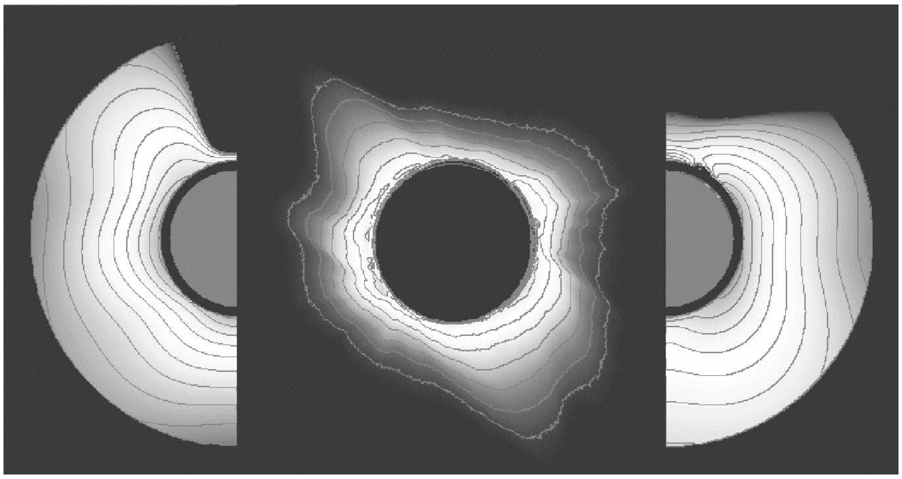

Figure 1. Polarized brightness (central picture) and reconstruction of the large scale electron density distribution for the total solar eclipse of July 11 1991: left East side, right West side.

2.1. Observing stations and teams

After considering different criteria, we have decided to establish two observing stations, one in France at the limit between Alsace and Lorraine, and another in Romania, close to the maximum duration point (Espenak & Anderson, 1997, maps pp. 41 and 44). In both countries, we have established a good coordination with national scientific institutions and amateur organizations which might lead to fruitful collaborations. We intend to perform the full program at both sites (CCD + photographic) provided that the available manpower is sufficient (6 in each team). A smaller team on the Romanian side may result in sacrificing the photographic experiment.

Figure 2. The two instruments used at the Curaçao observing station, February 1998. Left: the CCD imaging instrument showing the indexed circle of the polaroid filter. The SLR camera serves as a guiding scope as well as a counterweight and is also used to take some colour pictures of the eclipse after completion of the scientific program. Both camera's are equipped with 5-density neutral filters (calibration configuration), which are removed during totality. Right: the photographic instrument, a 1 meter focal length refractor, equipped at its prime focus with a polaroid filter with 6 indexed angular positions.

2.2. The CCD experiment

The CCD experiment which has been performed successfully in 1991, 1994 and 1998 has been described in different papers (Clette, Gabryl & Cugnon, 1994; Gabryl, Cugnon & Clette, 1997). It consists of a PULNIX video-rate CCD camera with a 200mm f/2.8 MINOLTA telelens, equipped with a motorized rotating polaroid filter with 24 equidistant positions per full rotation (then twice redundant, and 8 times oversampled). The system makes use of a lightweight equatorial mount (Figure 2, left). The image acquisition is computer-controlled. After successive upgrades it now takes only 18 s to acquire a full sample of 24 images. Based on the experience acquired during the last eclipse in Curaçao, at least 5 series with different diaphragm settings are required. A total time of 90 s (+ 15 to 20 s at the beginning for the pointing check and for the coronal brightness adjustment) is then necessary. This remains shorter than the duration of the totality (140 s in France, 144 s in Romania) with a reasonable safety margin.

The second CCD experiment will be set up at the French site, probably with one (maybe two) of the DALSA digital CCD camera (1024 x 1024 pixels) of the Solar Physics Department. Because of the physical size of the chip, a somewhat longer focal length (around 300 mm) will be required to keep the same field of view. The higher dynamics (12 bits) of the DALSA camera compared to the PULNIX (8 bits) will probably allow a smaller number of different exposures (2-3 instead of 5), compensating the longer image acquisition time. The filter mechanism will be similar to the one adopted for the PULNIX camera.

2.3. The photographic experiment

Since 1971, all the eclipses were observed using the same photographic instrument consisting in: a 1 meter focal length refractor with an aperture of 70 mm, a NIKON 35 mm camera, and a focal polarizing filter (three positions until 1984, now six positions, manual control), on equatorial mounting (Figure 2, right). The experiment was always performed by experienced amateurs. The emulsion used until 1991 was KODAK Plus-X, and has since been replaced by KODAK Tmax 400, which allowed to reduce simultaneously the number and the duration of the exposures, thanks to its high dynamic range and sensitivity. Such an equipment will be used at both sites in 1999, if possible.

3. The infrared experiment

Strictly speaking, the infrared photographic experiment is not part of the Royal Observatory program, but it has been performed on different occasions during eclipses by amateur participants at the Belgian expeditions. The aim is to observe the corona essentially through its dust F-component, up to approximately 10 $R_\odot$. The equipment should consist ideally in a refractor (or a telelens) of 500 mm focal length (instead of shorter instruments used previously), with a 24 x 36 camera. The infrared sensitive photographic emulsion chosen for the previous expeditions was KODAK High Speed Infrared, in combination with RG-610 or RG-695 filters.

4. Conclusion

Up to now, the CCD observations in polarized white-light have been successfully performed during three total eclipses. Successive upgrades of the equipment have resulted in a better polarization sampling and a faster image acquisition. Simultaneously, significant improvements were obtained in processing the images and in the numerical inversion process of van de Hulst's integral equations. We intend to exploit fully the experience acquired in these domains to optimize the observing procedure on the occasion of the 1999 eclipse.

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