Total Solar Eclipse - Guadeloupe 1998

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Abstract. Experiments carried out during the total solar eclipse on February 26, 1998 observed at Guadeloupe are described in the paper. Preliminary results obtained by processing the observational material are presented.

1. Introduction

The Slovak Central Observatory (SCO) in Hurbanovo organized expedition to observe the eclipse on February 26, 1998 from the archipel Guadeloupe in Lesser Antilles. Experiments performed during the eclipse were as follows:
I. Structure of the white-light corona (T. Pintér)
II. Polarization and structure of the white-light corona
(J. Sýkora)
III. Distribution of intensity in the spectrum of K-corona,
colour of the solar corona (B. Lukáč)
IV.Intensity and structures of the corona in the infrared part of the spectrum,
T-corona (I. Dorotovič)

2. Structure of the W-L corona

The telescope 110/1500 mm was used to realize this experiment. White-light solar corona was photographed on KODAK T-MAX 100 sixty millimetre roll-film by the Pentacon-Six Camera with different exposures. This experiment was performed from Basse-Terre (western part of Guadeloupe) near Saint Rose, at the observational site with geographical coordinates: $\varphi = 16°21'20''$N, λ=61°43′15″W. Here, duration of totality was $2^{\rm m}\ 54^{\rm s}$.

Experiment should be considered as more or less classical one. It was intended to determine some basic parameters of the solar corona at this eclipse. Among them were identification and description of the individual coronal structures, classification of the global shape of the corona and realization of the coronal photometry. Any contribution to the statistics of the parameters mentioned

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above and measured during previous eclipses is still very valuable, namely from the point of view of their behaviour throughout the solar cycles.

Altogether five images of the unpolarized white-light corona were taken during totality. The following exposures were used: 1/250, 1/30, 1/8, 1/2 and 1 s. Obtained images of the corona were digitized and are successively analysed.

3. Polarization and structure of the white-light corona

Measurement of the white-light corona polarization belongs to the main sources of information about physical conditions in distances above 1.3 solar radii, i.e. in the middle and outer corona. Polarization measurements give additional information to that obtained by photometric investigation of the solar corona. Polarized brightness pB does not depend on the brightness of the F-corona and so these measurements are used for separation of the K- and the F-corona. Polarized radiation, pB, represents an unique tool for estimation of coronal density along the line of sight and polarization measurements enable us, for example, to determine the 3-D geometry of coronal streamers.

Polarized and unpolarized white light corona were photographed using the telescope 100/1000 mm from Grande -Terre near the settlement Gros Cap (geographical coordinates are $\varphi = 16°22'20''$N, $\lambda = 61°24'10''$W). Duration of the totality at this point was $2^{\rm m}31^{\rm s}$. The combined data enable us to determine the degree and direction of coronal polarization all around the solar disk and to study the global shape of the corona in relation to the solar cycle phase.

The corona was photographed on KODAK T-MAX 400 Pro sixty millimetre roll-film by the Pentacon-Six Camera with exposures 1/60 s and 1 s for each of three position of polarization filter. The white-light corona was taken with 1/2 s exposure. Original images have been already digitized. Computer processing of the digitized images included successive application of the 2-D Fast Fourier Transform, digital filtration of the images and application of the so-called unsharp masking method. Example of the resulting structure of the corona is presented in Figure 1. It is evident that coronal structures obtained by applying this computer processing can be identified to considerably greater distances from the Sun than could be estimated from the unprocessed images where contrast of the structures is considerably lower.

Figure 1 shows that the solar corona observed during the February 26, 1998 eclipse is strongly flattened, much more than one could expect at the rising phase of the 23rd solar activity cycle (this cycle began in May 1996). Corona has clearly minimum-like shape, expressive coronal structures are near to the heliographic equator (which is still approximately identical with the heliomagnetic equator) and the thin coronal plumes dominate at polar regions. According to the classical imaginations such form of the corona is rather unusual for the advanced rising phase of the cycle. However, we have shown that the traditional Ludendorff's definition (Ludendorff, 1928) of the flattening of the corona has

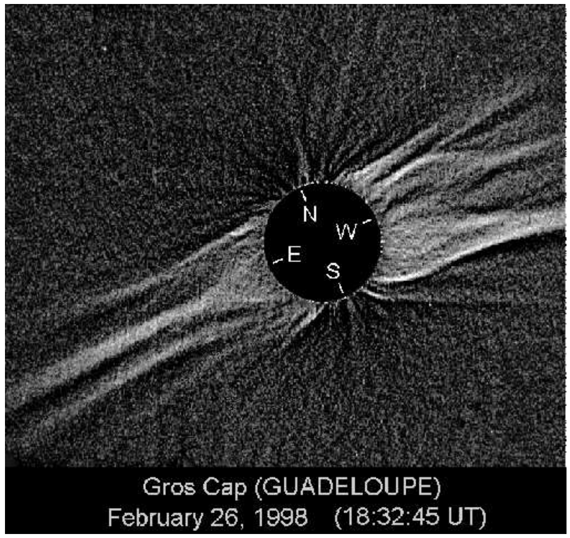

Figure 1. Computer-processed image of the corona photographed during the total solar eclipse on February 26, 1998.

serious drawbacks as reported for instance in Sýkora et al. (1995), Sýkora and Ambrož (1995). According to this definition we obtained the flattening of the 1998 corona $\varepsilon = 0.208$. Such a value is typical at the deep minima of solar cycles only. However, under ideas presented in the quoted papers, very high values of the flattening (up to $\varepsilon = 0.3$) are, in fact, possible at any phase of the solar cycle (including the solar maxima), depending only on the line of sight geometry of the actual global magnetic field topology.

4. Distribution of intensity in the spectrum of K-corona (colour of the solar corona)

Observation of the coronal spectrum was repeatedly carried out during this eclipse with aim to investigate colour of the solar corona. This experiment represents continuation of a long-term program which was described in detail in the paper by Dorotovič et al. (1998). The program is concentrated to verify presence of the neutral (unionized) matter in the corona. Presence of the neutral matter should be manifested in a slight difference between the colours of the solar disc centre and the corona.

Experiment included recordings of the coronal spectrum by using the CCD ST-7 camera equipped with a low-dispersion prism spectrograph with objective 50/540 mm. Simultaneously, image of the sun together with the slit of the spectrograph were recorded by using TV CCD camera with video output (construction of the device was realized by M. Vanya). Observation was carried out from Grande-Terre (eastern Guadeloupe), near Pointe-a-Pitre, at the site with geographical coordinates: $\varphi = 16°13'20''$N, $\lambda = 61°31'30''$W.

Spectrum of the photospheric light, depleted by using a neutral filter, was recorded prior to and after the eclipse. These images have two different purposes. Firstly, they enable us to estimate intensity of the coronal light with respect to the intensity of the solar disc centre and, secondly, they allow us to estimate the non-uniform sensitivity of the individual pixels, i.e., to determine the so-called flat field. Dark frame was recorded to each image.

Data related to the individual records are presented in the Table 1., where c and s indicate corona and solar disc, respectively.

Table 1. List of the spectra records.

Image	UT	Δt [s]	h [°]	Slit/PA	Δh
1s	17:56:49	1	55.32	-	-
1c	18:31:39	2.5	48.84	radial 122.5°	8.0″
2c	18:32:06	2.5	48.76	radial 302.5°	60.4″
3c	18:33:00	5.0	48.58	tang. 212.5°	-
2s	19:34:08	1.0	35.72	-	-
3s	19:39:05	1.0	34.63	-	-

Here, Δt is the exposure time, h is the altitude of the Sun and Δh is the hight covered by the Moon.

The obtained images can be used, first of all, to estimate a course of the coronal colour with height, i.e., to estimate the relative colour. Colour of the corona is defined by the ratio of intensities between the red (673.6 nm) and the blue (465.2 nm) parts of the spectrum. These regions of the spectrum were chosen to avoid spectral parts occupied by emission lines of the corona and chromosphere. The $i_r(l)$ (673.6 nm) is an average of 16 pixels in the row of the CCD camera and the $i_b(l)$ (465.2 nm) is an average of 51 pixels in the row of the CCD. Resulting values of the colour, as derived from the 1c image, are depicted in Figure 2.

Figure 2 shows considerable scattering of the estimated colours. We carried out a test to estimate contribution of the real colour variability and contribution of the instrumental origin. We estimated the mean square deviation between the images 2s and 3s and we obtained the value 0.83×10^{-2} was obtained. Considering this, one can say that colour variability for more than then 1% may be real. Vertical lines in Figure 1 separate the regions where signal of the CCD camera is not sufficient to obtain results with accuracy of 2%. In any case, the real changes of the colour are much larger than the change in the case of presence of neutral matter in the corona (Dorotovič and Rybanský, 1997). No monotonous variations of the coronal colour with height in the solar corona was detected.

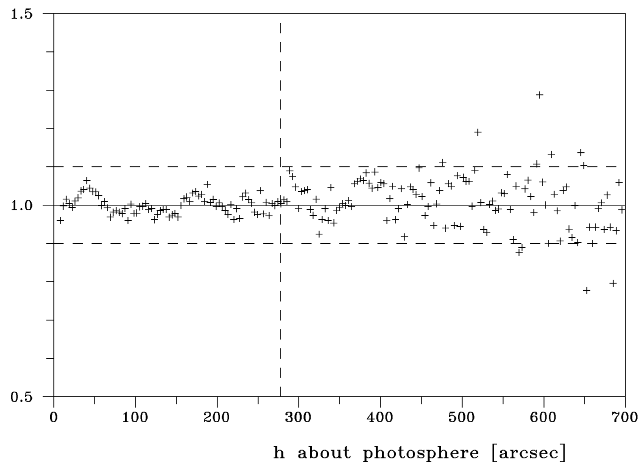

Figure 2. Relative colour of the corona as a function of the height above the photosphere.

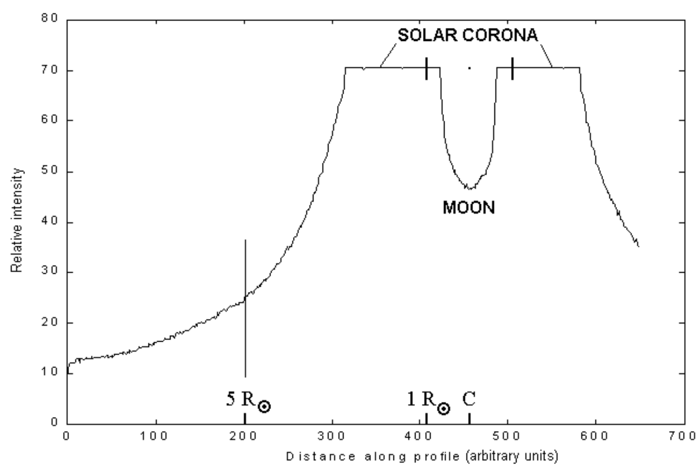

Figure 3. Intensity profile along the Sun's center.

5. Intensity and structures of the corona in the infrared part of the spectrum, T - corona

It is theoretically expected that at about 5 solar radii there is an inner border of solid dust particles present around the Sun (Leinert, 1975). Our experiment was realized to reveal this border observationally.

Images of the corona in the infrared part of spectrum were recorded by using the CCD ST-7 camera and a camera lens 2.8/80 mm. Red RG 8 filter, which transmits the spectral region (> 750 nm, was placed in front of the objective. Camera was most sensitive at 850 nm and its sensitivity ended at 1100 nm. Two images with exposures 15 s (18:31:05 UT) and 5s (18:32:36 UT) were recorded during the eclipse. Dark frame was recorded as well to each image. Observation was performed at the same site as the experiment listed under I.

Most of the corona was overexposed, but the main purpose of the experiment was to record the outer faint part of the corona and to find the border of the dust particles. For a verification of the existence of this border we made an intensity profile along the line drawn in this image. This profile is shown in Figure 3. No evidence of any remarkable intensity change at the distance of 5 solar radii was found. Therefore, we decided to continue our investigations by using another intensity profiles and/or repeat the experiment during one of the future total solar eclipses.

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References

Dorotovič, I. and Rybanský, M.: 1997, Solar Physics **172**, 207.

Dorotovič,I., Lukáč,B., Minarovjech,M. and Rybanský,M.: 1998, in *Solar Jets and Coronal Plumes*, ed.: T.-D. Guyenne, , ESA SP-421, 263

Leinert, Ch.: 1975, Space Sci. Rewiews **18**, 281.

Ludendorf, H.: 1928, Sitz. Ber. Preuss. Akad. Berlin, **16**, 185.

Pierce, A.K. and Slaughter, Ch.: 1977, Solar Physics **61**, 25.

Sýkora, J. and Ambrož, P.: 1995, in *Proc. 24th Int. Cosmic Ray Conf.*, ed.: , Roma, 4, 509

Sýkora, J., Pintér, P. and Ambrož, P.: 1995, in *Proc. of the Int. Symp. on the Total Solar Eclipse of November 3, 1994*, ed.: M.S. Raljevic, F. Zaratti and J.M. Pasachoff, La Paz, Revista de la Academia National de Ciencias de Bolivia 69, 23