Structure and shape of the white-light corona during March 9, 1997 and February 26, 1998 eclipses

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Abstract. Structures of the white-light corona (WLC) as were observed during last total solar eclipses on March 9, 1997 and February 26, 1998 are discussed. Both eclipses occurred in the minimum of cycle activity at the beginning of cycle 23. The WLC was a minimum type with many polar rays and extended helmet streamers, located in middle heliographic latitudes or very close to the equator, and coronal holes around the poles. Flattening index is derived, and turn out to be, $a + b = 0.27$ for 1997, and $a + b = 0.22$ for 1998, respectively.

Key words: The Sun – corona – structure

1. Introduction

Total solar eclipses provide an unique opportunity to observe different parts of the solar atmosphere e.g., prominences, different parts of the corona, etc. The March 1997 and February 1998 eclipses occurred in the minimum of solar activity at the beginning of cycle 23. These eclipses were observed by different teams from the Czech and Slovak Republic, and the main purpose of these experiments was to study structures of the WLC. Observations made close to the eclipse data are needed to make connection with disk activity, long-term (cycle) changes in coronal structures and/or short-term changes of the solar corona e.g., Zirker et al. (1994). Finally, properties of the solar wind in the vicinity of the Earth are closely connected with the WLC structure in the lower corona. Structures of the WLC are maintaned by magnetic fields of the Sun, both the local and global origins. So, structures of the WLC may give us indirect informations about distribution and intensity of magnetic fields in the corona (they cannot be directly measured).

The main topic of this paper is show structures of the WLC as derived from eclipse observations and flattening index $a + b$ for both eclipses.

2. Observations of the WLC at 1997 and 1998 eclipses

The material analysed in this work comes from two different eclipses observed in 1997 and 1998 that occurred in the minimum period of solar activity (Altrock et al., 1998).

2.1. The 1997 eclipse

The March 9, 1997 eclipse was observed at the village Eforei Pavlovich (Siberia), $\lambda = 121° 56' 51''$, $\phi = 55° 57' 31''$ N. The eclispe began at 01:08:37 UT and ended at 01:11:24 UT, the duration: 2 min and 47 s.

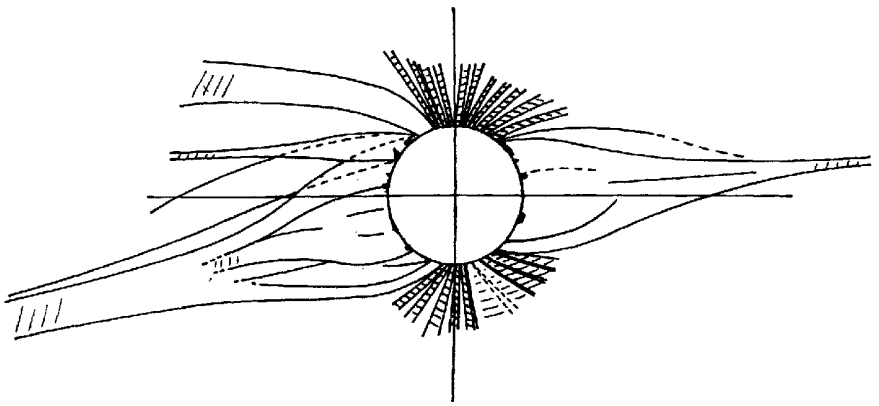

Figure 1. The structure (drawing) of the WLC on March 9, 1997. N is at the top, and E at left.

A cluster of small telescopes with different focal lengths were (MTO 1100 camera, Rubinar, a 500 mm f/8 lens, a 105 mm f/4 lens) put on stable tripods (the temperature on the eclipse site was minus 30° Celsius) by the team of Úpice Observatory. This team obtained several snapshots (Kodak Ektachrome 100 ASA and Kodad Tmax 100 ASA) available for the present analysis. The polarimetric observation was made with a 300/8 telelens through a polarized filter laid in front on the film (Kodak Tri-X Pan, 320 ASA). This polarimetric program for the 1997 eclipse was prepared by P. Kotrč from Ondřejov Obser-

vatory. Three series (0°, +60° and -60°) with the exposure time 1/16, 1/8 and 1/2 s were taken.

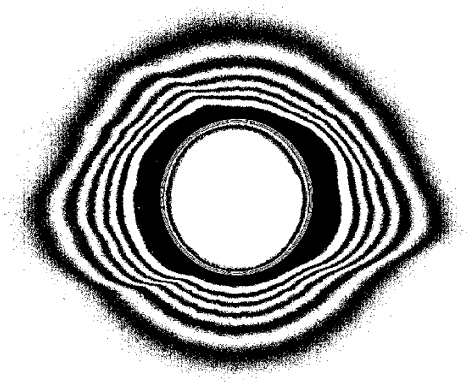

Figure 2. Isophote map (relative units) produced after recording coronal intensities of the WLC on March 9, 1997. N is at the top, and E at left.

The team from the Astronomical Institute of the Slovak Academy of Sciences, Slovakia, located in Mongolya, have had very bad weather conditions during the eclipse time.

2.2. The 1998 eclipse

The 26 February 1998 eclipse was observed in Venezuela (Don Bosco Mission) with Úpice and Tatranská Lomnica teams. Coordinates: $\lambda = 72° \; 03' \; 05''$ W, $\phi = 11° \; 03' \; 35''$ N. The total eclipse began at 18:03:01.7 UT and ended at 18:06:48.2 UT, duration 3 min 46.5 s.

Following equipments were used: (a) *Úpice team*: A 90 mm Mertz lens with 1800 mm focal length, a 500/8 telelens and a 104/4 telens. The team obtained more then 20 frames with different exposure time (from 1/250 to 2 s) on black and white, colour and slide films. (b) *Tatranská Lomnica team*: A Zeiss 100/1000 lens, a 500/8 telelens. The team also obtained of 20 snapshots with different exposure time.

3. Results and short discussion

We selected several the best pictures to perform structures and shape of the WLC. Large-scale structure of the WLC of March 9, 1997 is shown in Figure

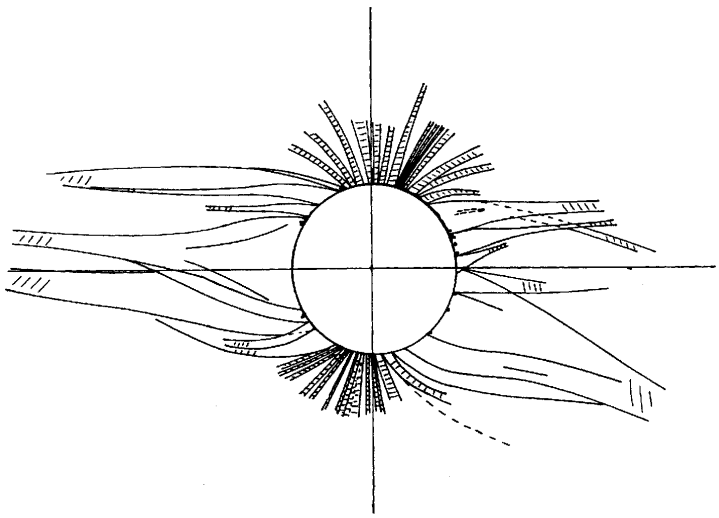

Figure 3. Drawing of the WLC structure on February 26, 1998. N is at the top, and E left.

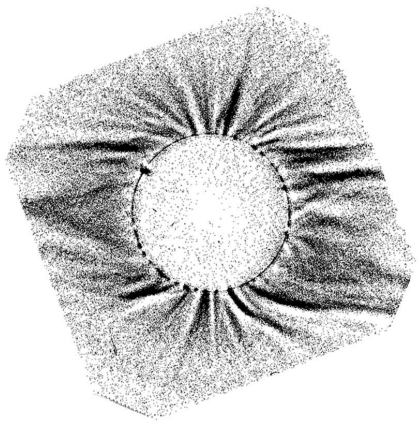

Figure 4. Image-processed structures of the inner WLC on February 26, 1998. N is at the top, and E left.

1. Figure 2 displays the isophote map (in relative units) of the 1997 WLC as derived from the snapshot of 1 s exposure time. There may be recognized three different structures in the WLC: **(a) polar rays**, located above the poles in positional angles (P.A.) 321° – 17° (the north polar region) and 171° – 217° (the southern one), located in **(b) coronal holes**. **(c) Streamers**, seen up to 6 $R_\odot$, are located above the E- and W- limbs around the equator (W-limb) and/or at mid latitudes (E-limb). It seems that streamers above the E-limb create an arcade system located above the prominence belt. One may suppose that the base of the streamers at heigh latitudes indicates that they are behind or in front of the disk. Streamers, with the height, show their deviation (mostly) from the radial direction to the equator. This is, as shown by Makarov (1994), a typical feature for the minimum corona type.

Large-scale structure of the WLC of February 26, 1998 eclipse is shown in Figure 3. Figure 4 shows an image-processed structure of the inner WLC up to 2 $R_\odot$ for the same eclipse. Figure 5 displays an isophote contour of the WLC (relative intensities) as derived from the snapshot of 1 s on February 26, 1998. Similarly as in 1997, there are seen three different types of structures in the WLC: coronal holes (P.A. 318° – 21°, the N-one, and 153° – 187°, the S-one). The holes are filled with narrow polar rays. Large-scale streamers are located around the equator (the E limb), and at mid latitudes (the W limb). The 1998 streamers show two more complicated systems in their distribution (the N- and S ones) as the same streamers in 1997. There is no doubt that this picture is connected with a development of activity on the ascending phase in cycle 23. While the 1997 eclipse occured nearly a year later the minimum (May 1996) between cycles 22 and 23 (Altrock et al., 1999), the 1998 was nearly 2 years later. The Wolf number reached its values of 90 in 1998, and only of 10 in 1997. The fourth type of structures for both eclipses are **(d) small-scale structures** seen in helmet streamers.

To go further in the analysis of the corona shape, a statistically more significant parameter, the flattening index ε is derived from Figures 2 (1997) and 5 (1998). This index, derived for the height 2 $R_\odot$, is widely used to describe the WLC variations with a solar cycle. The index for the 1997 corona is, $a + b = 0.27$, and 0.22 for the 1998, respectively. Both values of the flattening index are in the good agreement with previous results, e.g., Rušin and Rybanský (1985), the cycle related variations of the WLC.

4. Conclusion

The structure and shape of the WLC in 1997 and 1998 were of a minimum type. Polar rays, helmet streamers and coronal holes were the dominat types of the structure. Helmet streamers are mostly located, after a detail inspection, above prominences. The inner corona shows, in streamers, very complicated faint structures (loops, curved rays). Minimum type of the WLC structure was

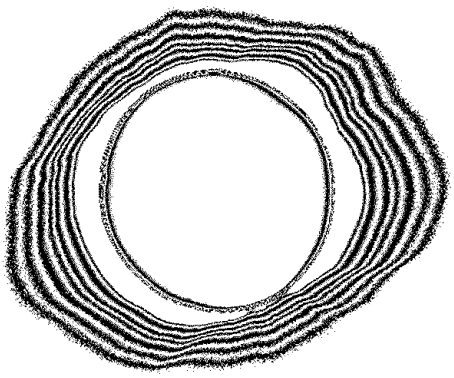

Figure 5. Isophote map of relative intensities of the WLC on February 26, 1998.

confirmed by their flattening index ε, which reached their values $a+b = 0.27$ (1997) and 0.22 (1998). The structure of the corona is created by both the global and local magnetic fields. Comparison of ground-based and SOHO (YOHKOH) observations will lead to the better understanding in coronal physics and solar-terrestrial relations.

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