White-light coronal structures during the 1988 – 1998 eclipses

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Abstract. Large-scale coronal structures (helmet streamers), observed in the white-light solar corona during total eclipses, are mostly seen above prominences. These streamers are supported by the global magnetic field of the Sun. However, the distribution of prominences over a solar cycle shows both the poleward and equatorward migrations. The location of observed white-light coronal streamers during total eclipses in the period 1988 –1998 will be compared and discussed with that of prominences. It seems that the distribution of the above mentioned streamers matches the distribution of pominences and shifts together with prominence belts to the poles. A possible scenario for a such development is described and discussed.

Key words: The Sun – corona – magnetic fields

1. Introduction

Solar eclipses provide a unique possibility of observing the uppermost part of the solar atmosphere – the corona. It is generally accepted that the corona consists of three different parts: *E-corona*, *K-corona* and *F-corona* according to the nature of radiation they produce. The most conspicous and impressive part of the corona is, visible during a total solar eclipse, the white-light corona (WLC). It is created by scattering of the photospheric light on electrons and dust particles around the Sun. Long-term observations show that the WLC consists of many structures, with different shapes and sizes, and physical conditions in them. These coronal structures are sustained by magnetic fields of the Sun. As emphasized by Bagenal and Gibson (1991), there are systems of magnetic fields in the solar corona responsible for its structure. The large-scale global coronal structure of the corona is related to the very low order structure in the magnetic field that is poorly determined by photospheric measurements. These low order magnetic field structures originate deep in the dynamo region, while the small-scale structures - dominating photospheric magnetograms - arise from distortions of the dynamo field by small-scale motions in active regions. On the

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other hand, a structure of the inner corona is a very important parameter for the properties of the solar wind around the Earth.

While small-scale coronal structures are observed only temporary above active regions, streamers could penetrate around the solar surface with a solar cycle similarly to a distribution of the green corona brightness and prominences (Minarovjech et al., 1998). It may be also supposed that the life-time of these streamers will be longer in comparision with smaller ones. Observations of WLC helmet streamers at a different cycle phase could help us study a distribution of a low order structure of magnetic field around the solar surface. As we stated above, helmet streamers are located above some type of prominences that divide large-scale structures of magnetic regions on the solar surface.

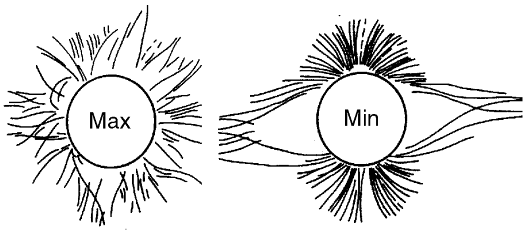

Figure 1. Distribution of helmet streamers in cycle maximum (left) and minimum (right).

In this paper we will deal with a distribution of helmet streamers over 1988 – 1998 with regard to the distribution of prominences, and a possible development of helmet streamers over the cycle 22.

2. Data exploited

To this end, we have used our own observations performed on July 22, 1990 (Fig. 3), July 11, 1991 (Fig. 4), November 3, 1994 (Fig. 5), October 25, 1995 (Fig. 6), March 9, 1997 (Fig. 7) and February 26, 1998 (Fig. 8). The August 13, 1988 eclipse structures (Fig. 2) were drawn from a picture given in Golub and Pasachoff (1997). These observations were made at the different phase of cycles 22 and 23, starting in 1988, shortly before the cycle maximum (1989), and ending up in 1998 at the beginning of cycle 23. The minimum between cycles 22 and 23 occurred in May 1996 (Altrock et al., 1999). Derived positional angles of individual helmet streamers, passing their centres, as well as positional angles of prominences located at their bases, are shown in Table 1. Positions of helmet streamers were checked by observations of the WLC from Mauna

Table 1. Positional angle of prominences and axis of helmet streamers as observed during 1988 – 1998 eclipses for both the northern (N) and southern (S) hemispheres.

Date	Streamers N/S [°]	Eclipse Prominences N/S [°]	Prominences from SGD N/S [°]
March 18, 1988	49/50	52/50	47/52
July 22, 1990	82/66	80/66	79/64
July 11, 1991	57/75	60/75	55/68
November 3, 1994	42/35	40/40	40/37
October 25,1995	36/35	40/42	38/35
March 9, 1997	55/40	55/55	52/44
February 26, 1998	50/45	00/00	55/50

Loa and/or C2 coronagraph aboard SOHO, when available. The distribution of 'eclipse' prominences were compared with the positions of prominences from observations at Lomnický Štít coronal station and/or from SGD.

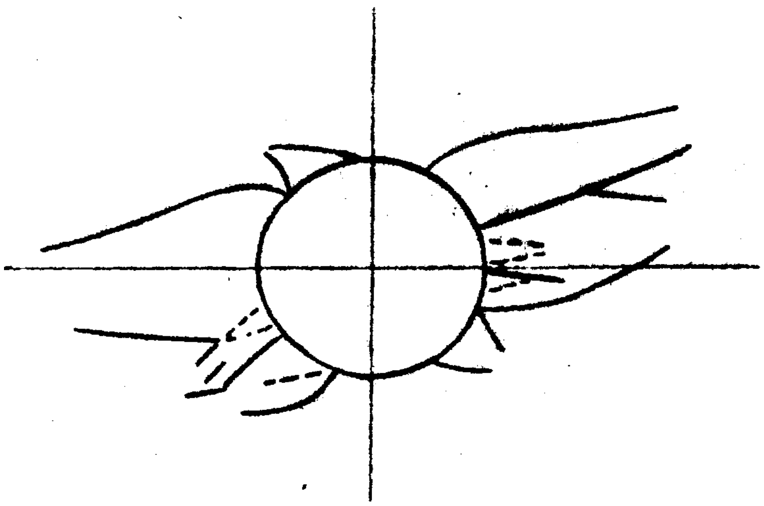

Figure 2. Structure of the WLC on August 13, 1988. N is at the top, and E at left.

3. Discussion and conclusion

As it may be discerned from Table 1, prominences are located mostly at the base of each helmet streamer. While around the miminum these streamers are found only in the equator vicinity, during the maximum they are distributed around the whole Sun. There are streamers in intermediate heliographic latitudes between the maximum and minimum, which slowly change their position.

Let us discuss a possible scenario for the variation of helmet streamer distribution over a cycle. Prominences around the minimum (Minarovjech et al.,

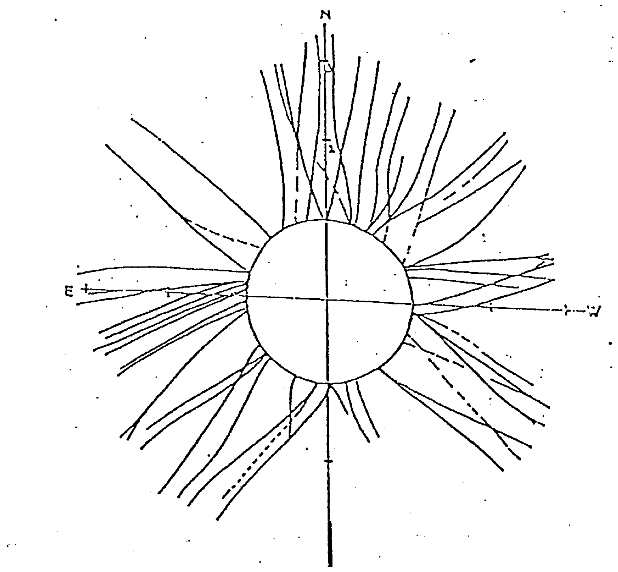

Figure 3. Structure of the WLC on July 22, 1990.

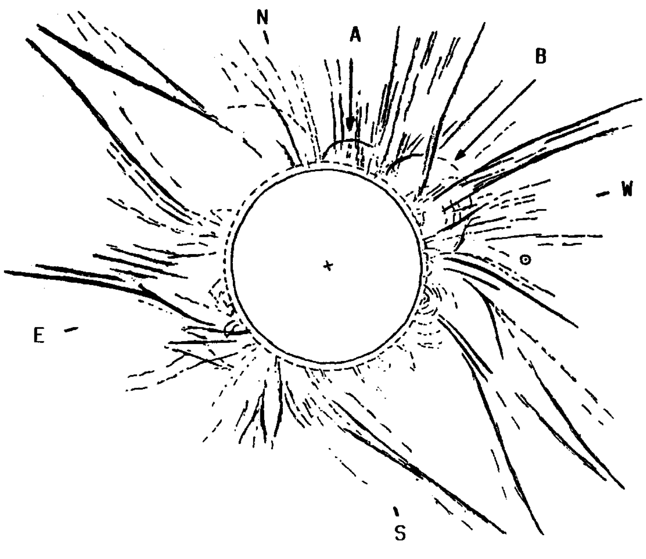

Figure 4. Structure of the WLC on July 11, 1991.

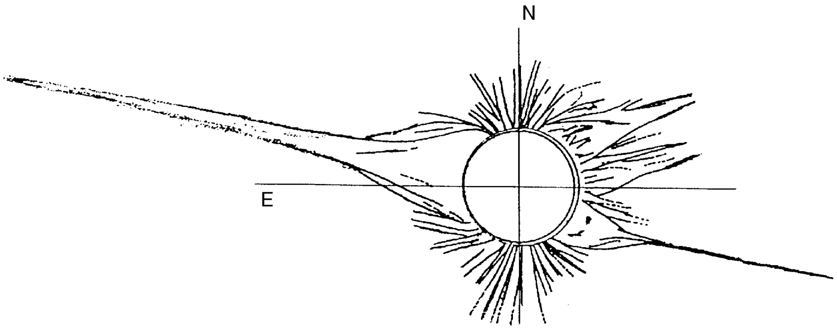

Figure 5. Structure of the WLC on November 3, 1994.

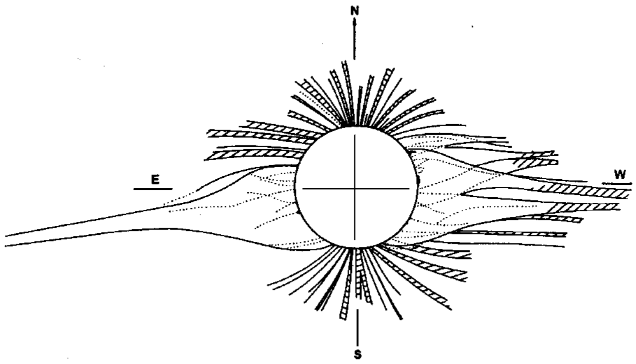

Figure 6. Structure of the WLC on October 24, 1995.

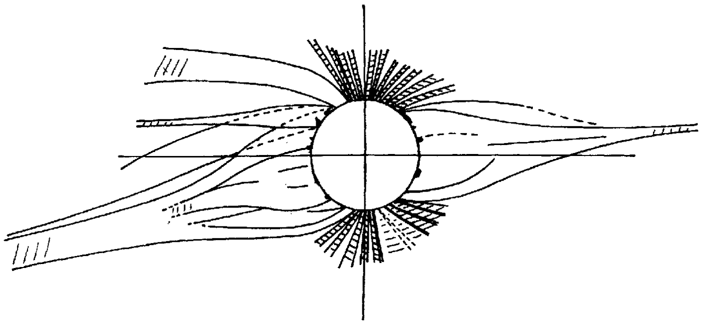

Figure 7. Structure of the WLC on March 9, 1997. N is at the top, and E at left.

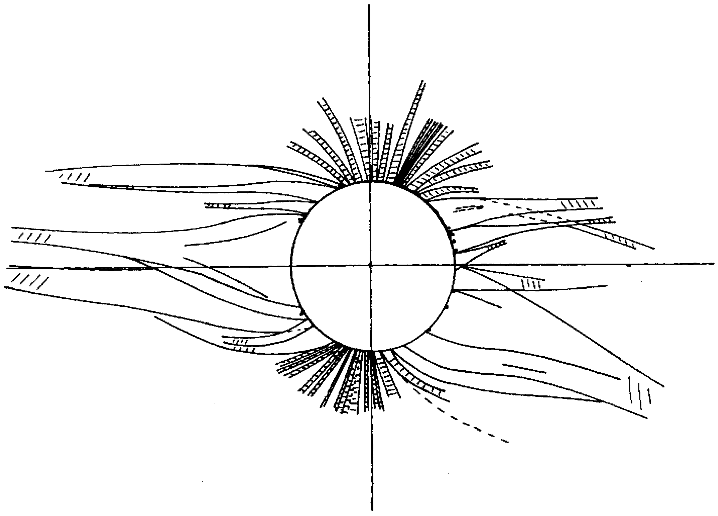

Figure 8. Structure of the WLC on February 26, 1998. N is at the top, and E at left.

1998) are mostly localized around the equator up to 40°. A picture of the corona, resembling closely this state may be seen in 1995 (Fig. 6). Shortly after the minimum, the prominence belt went splitting into two separate belts. The first one shifts slowly to the poles where it disappears around the pole in the cycle maximum. The second one shifts to the equator, where it vanishes at the next cycle minimum. A similar phenomenon may be observed also in the distribution of the streamers in 1997 and 1998 (Figs. 7 and 8). There may be continuously seen two independent helmet streamer systems, the north and south ones. The edge of streamers, closer to the poles, are shifted to higher heliographic latitudes. The 1988 eclipse (Fig. 2), which occurred a year before the maximum, showed at least 6 streamer systems, located almost around the whole Sun. The same case was observed in the 1990 eclipse, a year after the cycle maximum in 1989. The 1991 eclipse occurred two years after the maximum, when polar prominence belts were observed at poles, and decayed to the end of the same year (the N-one) or early in 1992 (the S-one). There are seen very well developed streamers above these polar prominence belts in Figure 4. Nevertheless, other less developed streamers are observed in mid-latitudes or around the equator. We suppose that streamers observed around poles in cycle maximum, decay together with the prominence belts. Later, several system streamers are observed in mid-latitudes or around the equator (see Fig. 5). They slowly shift to the equator or decay together with their parent photospheric regions. The corona appears again very simple in the cycle mimimum.

The development of helmet streamers would be very closely connected with development of coronal holes. This process, as shown by e.g. Bumba, Klvaňa & Rušin (1994), is a global process, depending of many physical conditions on the

Sun. Daily observations of the corona and solar surface aboard SOHO will help to solve this question.

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References

Altrock, R.C., Rybanský, M., Rušin, V., Minarovjech, M.: 1999, *Sol. Phys.* , in press

Bumba, V., Klvaňa, M., Rušin, V.: 1994, in *Solar Coronal Structures*, eds.: V. Rušin, P. Heinzel and J.-P. Vial, VEDA, Bratislava, 65

Bagenal, F. and Gibson, S.: 1991, *J. Geophys. Res.* **96**, 17 663

Minarovjech, M., Rybanský, M., Rušin, V.: 1998, in *New Perspectives on Solar Prominences*, eds.: D. Webb, D. Rust and B. Schmieder, ASP Conference Series **150**, San Francisco, 484

Discussion

Comments:

(Filippov): After the 1991, your Fig. 3, seems to be not absolutely correct. The corona during the maximum of solar activity is not obliged to be axisymmetrical and the corona on July 11, 1991 is an excellent example of this. The corona looked like a solar minimum corona only not oriented along the equator plane but approximately perpendicular to it along the N-pole - S-pole line. This problem was studied by Gulyaev and Sýkora and was connected to the dicrepancy of the planes of the heliographic and magnetic equators.

(S. Koutchmy - to the comment of dr. Filipov): We know that the generation of the solar magnetic field by dynamo mechanism should be linked to the axis of the Sun rotation. It is not easy to imagine the nature of the tilted solar rotator. The interpretation of the corona on July 1991 can be not unique and we need more observational data.

(P. Cugnon): We have tried 3-D reconstruction using the rotation axis and the supposed magnetic axis for 1991. It seems that reconstruction was slightly better than that one with the 'magnetic axis'.