THE WHITE-LIGHT, FAR-RED (600-700 nm) AND EMISSION CORONAE AT THE JULY 11, 1991 ECLIPSE

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Abstract. Preliminary results of the analysis of the white-light, emission (green and red), and far red (600-700 nm) corona during the July 11, 1991 eclipse are given. Even though the corona is of nearly-maximum type, four different principal coronal structures are seen, combined with faint, small-scale structures (loops, arches, cavities, voids or plasmoids). Scattered light is seen up to 10 $R_\odot$ in helmet streamers. The Ludendorff index of the corona shape turns out to be $a + b = -0.02$, and the estimated brightness of $J_K = 1.47 \times 10^{-6}$ $B_\odot$. Some aspects of multiwavelength observations are discussed.

Key words: eclipses – Sun: corona

1. Introduction

Total solar eclipses provide a unique opportunity not only to observe all parts of the solar corona (*E, K, F, T* (?)) under optimum conditions, but to study other aspects of solar activity in a wide range of wavelengths, and heights above the solar surface. The combination of eclipse and non-eclipse observations, both ground-based and from space, should provide one of the best opportunities for developing multispectral models of the solar corona. This opportunity occurred on July 11, 1991, when many observers located around the world were able to observe the Sun and its surroundings both in the eclipse path and outside it. In this article we present some preliminary results of the white-light, far-red, and emission coronae as observed on July 11, 1991.

2. Observations

2.1. The white-light and far-red (600-700 nm) coronae

Classical pictures of the white-light corona were obtained in observations made at La Paz (Baja California Sur, Mexico) with two telescopes: a 3-meter focal length telescope as a part of the MICE experiment (Zirker *et al.*, 1992) and a 1-meter focal length telescope . To find coronal streamers or *F*-corona properties very far from the Sun in the interplanetary space, an 80-mm camera was used (with Fujichrome film). The far-red corona was imaged with video recording (Panasonic) during the whole eclipse (more than 6 min). The blue and green components of the camcoder record were separated electronically from the video record and digitized for storage.

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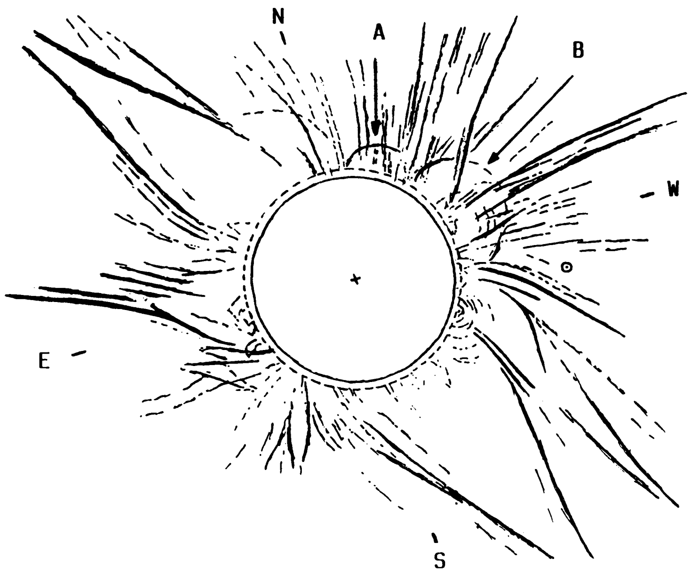

Fig. 1. Large-scale stuctures of the white-light corona (Zirker *et al.*, 1992). Notable features in the NW-quadrant are denoted by the letters A, B.

2.2. The green (530.3 nm) and red (637.4 nm) corona, and prominences (non-eclipse observations)

Standard limb observations (of about 40″ above the solar limb with a lag of 5° from the north solar pole towards east) of the green and red corona during the eclipse day and around it, were made at Lomnický Peak coronal station.

3. Results and Short Discussion

The eclipse occurred after the maximum of cycle 22 – mid-1989 according to the sunspot number, however increased activity on the Sun was observed for three months, from June 1991 to August 1991, when it reached values comparable with the maximum values (see Solar Geophysical Data for 1992). Four different principal large-scale types of coronal structures were found in the white-light corona (Figure 1) during the eclipse.

(a) Helmet streamers are located in the NE-quadrant in P.A. (at the moon's limb) 14°–60°, and in the SW-quadrant in P.A. 155°-260°. These streamers represent multiple systems located above the quiet filamentary channels of both north and south hemispheres (some small prominences in the NE-region were observed at P.A. 37° and 41° on July 9, 1991). A separation of helmet streamers with height above the Sun enables us to reach the conclusion that they have different bases above the photosphere with regard to heliographic longitude. Nevertheless, some of them are seen up to 9-10 $R_\odot$ (Figure 2),and their orientation above the Sun in

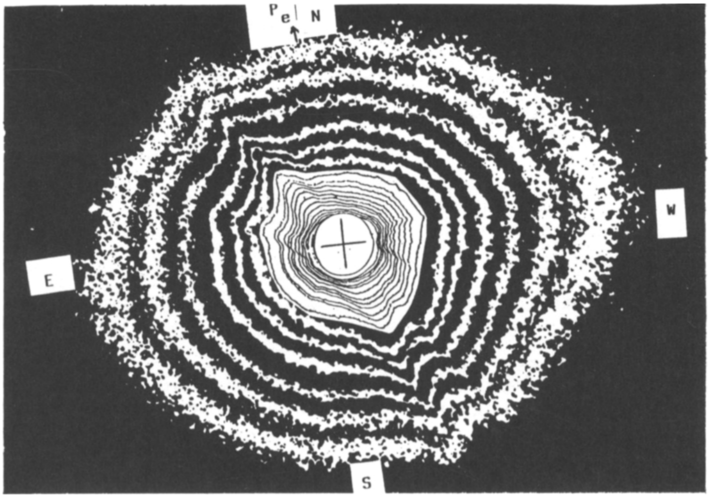

Fig. 2. Isophotes (arbitrary units) of the inner and outer solar corona.

nearly radial with height.

(b) Narrow polar rays are mainly extended above the north solar pole, and should be seen up to 3-4 $R_\odot$. Such narrow rays are not seen above the south solar pole. Different types of coronal structures above both poles confirm a temporally-shifted development of solar activity between individual hemispheres over the solar cycle as has been observed earlier.

(c) A typical coronal hole was localized above the north solar pole, between P.A. 315°-15°, where a decrease in coronal brightness (Figure 2), is clearly seen. Similar cases are found in the NW-quadrant at P.A. 265°–278° and in the SW-quadrant at P.A. 130°–155°. It may be supposed that both these regions should be good candidates for coronal holes too (equatorial and high altitude), and a good location for searching for the F-corona or T-corona. We note that the angular size of these coronal holes is smaller than for the comparable north coronal hole, and faint, narrow streamers are localized there.

(d) Thin coronal rays which were mostly non-radial (especially very close to the solar limb) are found to be located above the active regions, which should be centered above the P.A. 70°-120° and 280°-310°.

Thin coronal loops, arches, cavities or voids (*e.g.*, Koutchmy, 1977) may be found at nearly all the principal coronal structures mentioned above. The ellipticity is one of the basic parameters of the coronal shape for a given eclipse (the coronal shape is closely connected with the prominence distribution). The ellipticity of the isophotes (as derived from Fig.2) amounts, even in the innermost corona, to 0.1 only and decreases outward to 0.01. The Ludendorff index of the coronal shape turns out to be $a + b = -0.02$ ($a = 0.144$, $b = -0.164$), and the white-light corona is a maximum type. Using a relation between the total brightness of the white-light corona and ellipticity (Rušin and Rybanský, 1985), we found that the

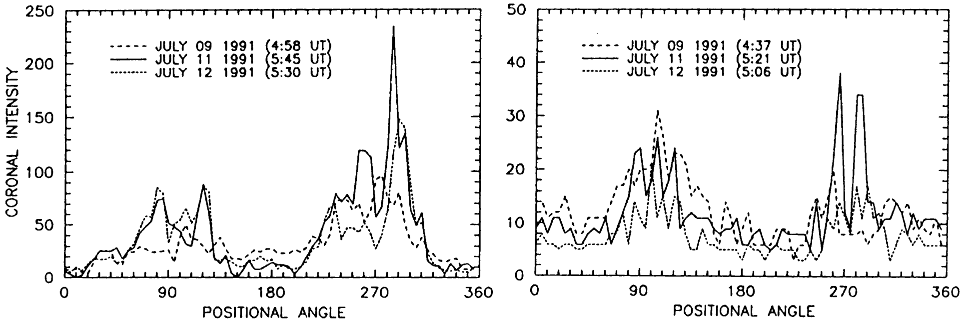

Fig. 3. The green (left) and red (right) spectral limb intensities at Lomnický Peak coronal station (40″ above the solar limb). Intensities are expressed in absolute coronal units ($\times 10^{-6} B_\odot$). The day of observation is shown in the Figure.

integral brightness reached $J_K = 1.47 \pm 0.15 \times 10^{-6} B_\odot$, and the white-light corona was one of the brightest observed at an eclipse at this phase of a cycle $\Phi = 0.41$ (preliminary value for cycle 22). We note that a strong excess in favour of the southern hemisphere is clearly seen in the inner-most corona ($K + F$). Moreover, one of the SW-streamers overlaps the south solar pole. Both these features may perturb the Ludendorff index. Nevertheless, the 11 July corona is of the maximum type. We also note that, during the July 22, 1990 eclipse, the corona was also of the maximum type, even if a remarkable coronal hole was observed above the south solar pole (Marková *et al.*, 1992). The video recording and small camera images extended the coronal isophotes up to $9 - 10 R_\odot$. We see $3 - 4$ helmet streamers (created by scattered light) in the NE- and SW-quadrants (see Figure 2). The distribution of the $K + F$ corona above 3 $R_\odot$, with an excess of the F-corona, is non-spherically symmetry around the Sun. Its maximum values do not lie in the E-W solar direction, but are tilted to the solar equator by 10° (the direction in P.A. 100°-280°) – that is, along the ecliptic plane. A similar result was obtained for the infrared corona by MacQueen *et al.* (1993). The green and red line coronal intensities are shown in Figure 3. Rapid changes in their intensities were seen in the equatorial regions above both the E and W hemispheres.

These changes are too great to be caused by solar rotation over 4 days, and must result from rapid changes connected with photospheric activity in the active regions. In Figure 4 we present a comparison between the green corona and the NIXT experiment for the eclipse day (Golub, 1992). No typical coronal mass ejection (CME) was observed during the eclipse passage from Hawaii to Brazil, even if such could not be excluded for the days before or after the eclipse day. Prominences above the active region showed high dynamical activity over these days. Moreover, two very interesting features, which resemble a head of CMEs or a plasmoid in the solar corona were found in the Hawaii and Mexico pictures in the NW-limb (their central positions are at P.A. 290° and 330°). However, they remain at nearly the same height above the solar surface over the 1.5 hours between the Hawaii and

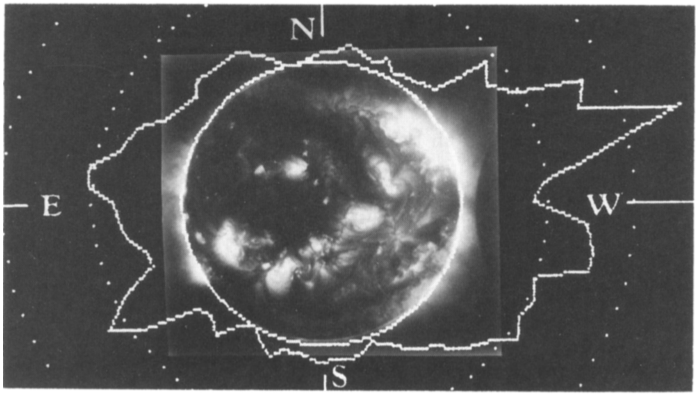

Fig. 4. Comparison of the July 11 1991 green coronal intensity with the NIXT (4-6 nm) corona (Courtesy L. Golub). Inner circle: 100×10^{-6} $B_{\odot}$; outer circle: 200×10^{-6} $B_{\odot}$.

Mexico totalities. No notable changes were found between the far-red and white-light coronal images but we do not exclude differences showing up in a detailed study. The intensity distribution of the F-coronal spectrum is generally assumed to be the same of that of the photosphere both in the visual and the infrared. A brief comparison between the results given by Macqueen *et al.* (1993), and our white-light, F-coronal data, showed nearly the same picture of the intensity distribution, which may be taken as a partial confirmation of that assumption. The F-coronal intensity distribution around the Sun does not depend on solar activity, except for transitory events (CME's), but mat well be connected with the distribution of asteroids or sun-grazing comets, see, *e.g.*, Chocol *et al.* (1983).

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