



Coronal structure and flattening during total solar eclipse 2006

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Abstract On the basis of well resolved observations of the solar corona taken at Salloum N-W of Egypt during the total solar eclipse of 2006 “the descending phase of solar cycle 23”, some aspects of the physics of the corona have been studied up to several solar radii. The magnetic structures of the white light corona were studied. The flattening coefficient e characterizes the shape of the isophotes of the white-light corona and computed as a function of the distance from the disk center. The flattening index e during solar total eclipse 2006 was found to be 0.158. This result is in a good agreement with previous published results.

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1. Introduction

During the total solar eclipse, we observe the outer atmospheric layers of the sun, the chromosphere and the corona. The shape of the corona, which extends to several solar radii, depends on the sunspot cycle being more spherical around the sun at solar maximum. The structure of the corona is created

by both the global and local magnetic fields (Markova et al., 1999).

The observed fine structures of white light corona are in good harmony with the results of computed magnetic structure and the polarization analysis published by the French expedition (Koutchmy, 2006).

Pishkalo & Sadovenko observed a corona of intermediate pre-minimal type during total solar eclipse on March 29, 2006, and then had six low-latitude and mid-latitude rays of different brightness and well-developed northern and southern polar ray systems over polar coronal holes. The corona featured only a moderate E/W and N/S asymmetry. It was brighter and more active on the E limb than on the W limb, and the northern polar ray system was somewhat more extended along the limb than the southern system. In addition, the northern polar ray system is symmetric about the projection of the Sun's rotation axis, while the southern system is asymmetric (Pishkalo and Sadovenko, 2008).

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2. Observations

A set of about 314 digital photographs have been taken in white light for the partial and total phases of the eclipse, using William's top quality optics, Fluoro- star AP FLT-110, Telescope. The objective of this telescope is apochromatic triplet with oil spacing. Its diameter is 110 mm and its focal length is 715 mm. A high resolution digital camera, Canon EOS-1ds Mark II, FOV 1.9×2.8 degree (total 17.2 mega pixels) was adapted to Flouro telescope (Galal et al., 2006).

3. Observed coronal structures

The total solar eclipse of 2006 occurred at the minimum of the 23rd solar cycle.

For nearly a century the variations of structures of the white-light solar corona have been studied and were found to be related to the solar cycle (Özkan, 2007).

The best white light corona picture taken by an exposure time $1/3$ s (Fig. 1) relatively indicates the largest recorded extension of the coronal streamers.

Fig. 2 exhibits a picture taken by exposure time $1/500$ s, where we see the inner most part of the white corona during solar total eclipse March 29, 2006.

While Fig. 3 shows the processed image of the white light corona during total solar eclipse 2006, we can see all the basic coronal structures such as helmet streamers, polar streamers, etc. (see Fig. 3).

4. Coronal flattening during 2006 total eclipse

The flattening coefficient ε characterizes the shape of the isophotes of the white-light corona which can be defined as:

$$\varepsilon = \frac{r_e}{r_p} - 1 \quad (1)$$

where r_e and r_p are the equatorial and polar distances of the isophotes from the center of the solar disk respectively.

The contour map from the coronal white light image shown in the Fig. 4 is used to determine the oblateness of the solar corona (Fig. 5).



Fig. 1 Total solar eclipse image taken during solar total eclipse March 29, 2006 at Sallum with Exp. Time $1/3$ s.

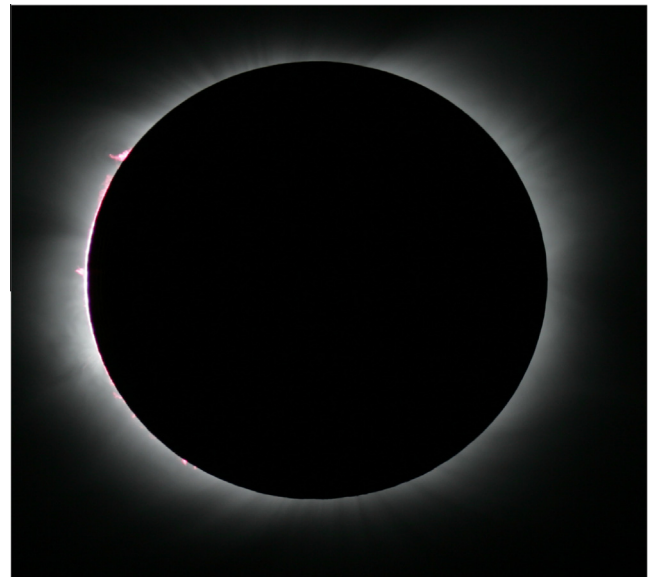


Fig. 2 The inner part of solar corona during total solar eclipse 2006.

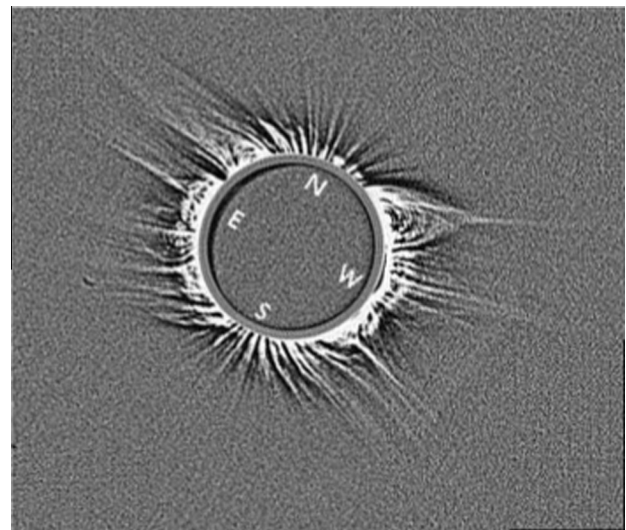


Fig. 3 Processed Image of the white light corona during total eclipse 2006.

5. Results and discussions

Fig. 1 illustrates that stalks of helmet streamers extend to about 4 solar radii from the solar limb. The existence of different zones in the observed white corona is clearly noticed. The first zone is the brightest and varies from $0.5 R_{\odot}$ to $1 R_{\odot}$. The second zone is less bright than the first one and extends to about $0.7 R_{\odot}$. The third zone is relatively fainter and extends $1.5 R_{\odot}$ on the top of the second zone. While at the inner part of solar corona we see the solar prominences at the north-east and east limb of the solar disk (Fig. 2).

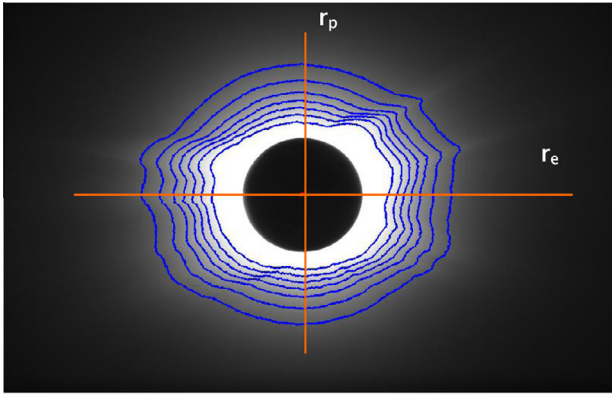


Fig. 4 The method for computing the flattening of the solar corona observed during total solar eclipse 2006.

All the basic coronal structures such as polar streamers, dome-shaped structures and helmet streamers are seen in the processed image (Fig. 3), at north and south poles, we can see that the polar streamers are well developed, while at the northern hemisphere, we can see at the northwest side closed helmet streamer rays extending up to $4 R_{\odot}$ and opened helmet stream rays seen at the northeast of solar limb. At the southern hemisphere, we can see the south border of helmet streamers near large coronal holes. Note large extended helmet stream rays at southeast sides.

According to Eq. (1) and Fig. 4, we could calculate the flattening parameters at four positions (using Matlab R2010 language program). Fig. 4 illustrates the method for computing the flattening of the solar corona observed during the 2006 total solar eclipse.

Table 1 shows the isodensity diameters derived from Fig. 4, the flattening parameter ε values calculated using this table are

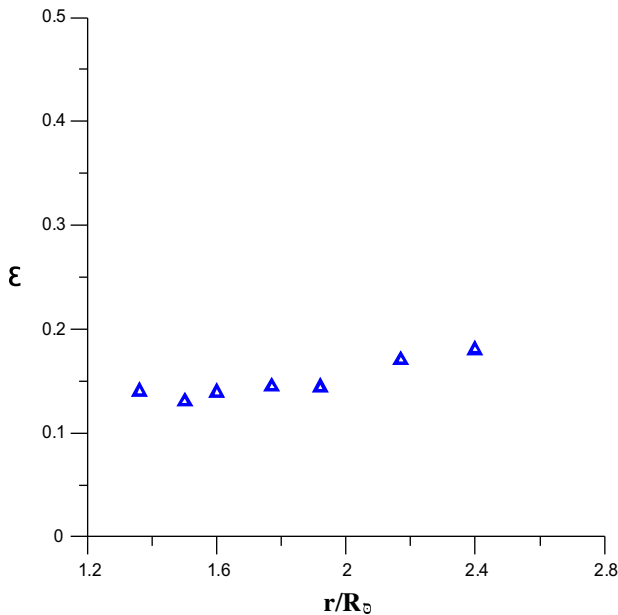


Fig. 5 Dependence of the oblateness ε of the solar corona on the radius.

Table 1 The calculated diameters of the isodensity curves.

Isodensity curves	r_e (Pixel)	r_p (Pixel)	r/R_{\odot}	ε
1	704.7	616.25	1.36	0.14
2	776.5	686	1.5	0.13
3	849.5	745.3	1.6	0.139
4	918	801.7	1.77	0.145
5	995.5	870	1.92	0.144
6	1133.4	971.5	2.17	0.17
7	1280	1084.75	2.4	0.18

displayed as a function of the distance from the solar disk center in Fig. 4.

The calculated flattening parameter ε is lying between $r = 1.36$ and $r = 2.4 R_{\odot}$. We find the flattening parameter ε equal to 0.158 at $r = 2 R_{\odot}$.

Fig. 5 shows the dependence of the oblateness ε of the solar corona on the radius, we can see that the flattening parameter increases linearly with distance from the solar disk.

Ozkan found that the flattening parameter during solar total eclipse 2006 is 0.103 at $r = 2 R_{\odot}$ (Özkan, 2007), while Stoev gives the value of the solar corona flattening $\varepsilon = 0.098$ for the STE 2006 (Stoev, 2006). Pishkalo & Sadovenko and Gloub & Pasachoff calculated the photometric flattening index ε during solar total eclipse 2006, and it was found to be 0.17 at $r = 2 R_{\odot}$ (Pishkalo and Sadovenko, 2008; Gloub, 2009). According to our secured coronal photos the flattening index ε during solar total eclipse 2006 is defined to be 0.158 at $r = 2 R_{\odot}$.

6. Conclusions

- * Our photographs in white light exhibit obvious stratified structures of the white corona up to 4 solar radii from the solar limb.
- * The most fundamental coronal characteristics (polar plumes, coronal cavities and arcades, coronal holes) are obviously seen in these photographs.
- * The flattening parameter increases linearly with distance from the solar disk, our result is in good agreement with (Özkan, 2007) results.
- * The flattening index ε during solar total eclipse 2006 was found to be 0.158. This result is in good agreement with (Özkan, 2007; Stoev, 2006; Pishkalo and Sadovenko, 2008) and (Gloub, 2009).

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