

Comparison of defined features of solar corona at different locations on the track during total solar eclipse 2006

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Accepted : December 12, 2014

Abstract: The track of total solar eclipse March 29th, 2006 started in Brazil at local sunrise (8:36 UT) and ended in northern Mongolia at local sunset (11:48 UT). It was seen and observed at the Salloum city (Lat. = 31° 34' 3.23"N, Long. = 25° 7' 39.35"E) near the west border of Egypt, beginning at 10: 40 UT with a duration of 03m 56.5s.

We select the observations at six locations which the time started from sunrise to sunset to compare their imaged detected features on the track of the eclipse. We find that the details of our processed image are more distinct and show more features than other secured images along the track of the examined eclipse.

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Keywords: solar eclipse, solar corona

Introduction:

The umbra path of the total solar eclipse began on the coast of Brazil at its local sunrise and swap across the Atlantic to the north of Africa and the central of Asia where it ended at the local sunset of northern Mongolia.

Pasachoff et al. (2006) observed 3min of totality on 29 March 2006 in three places in Turkey. One of their observations was in the green emission coronal line, emitted by Fe XIV (530.3 nm) due to the high temperature in the solar corona (around 2×10^6 K) locating at coronal loops. The other observations were in the red emission coronal line that is emitted by Fe X (637.4 nm) at temperature around 1×10^6 K. Both observations are determined from among the theories of coronal heating and continue earlier reports of excess Fourier power in the 1 Hz rang. Their set of observations used a very narrow-band filter, with 1/6 angstrom resolution, to make velocity (Doppler) images of the same coronal loops.

Rusin et al. (2008) studied the structures observed during the last few total solar eclipses, mainly those of 2001 and 2006. Thier study showed that the white light corona is highly structured not only in the sense of a variety of different types of its classical "objects" e.g. polar plumes, helmet streamers, ...etc, but also within these objects themselves.

Galal et al. (2008) studied the fine structures of the white light corona during total solar eclipses 2006, and remarked evident stratified structures of the white light corona up to 4 solar radii from the sun's center.

Pishkalo and Sadovenko (2008) investigated the structure and shape of the solar corona during solar total eclipse 2006. They found that the corona was one of the intermediate pre-minimal types. It had northern

and southern polar ray systems above the polar coronal holes and six streamers of different brightness in the middle and lower heliographic latitudes. The corona's photometric index was 0.17.

Koutchmy et al. (2010) reported the results obtained in the frame of the French – Egyptian scientific cooperation program organized at the occasion of the total solar eclipse of 29 March, 2006. By comparing simulations with the observations of the white-light corona, they indicated that in all cases the predicted images from the model did not have as much high-resolution structure as the observations. The authors attributed these differences to the fact that their simulations are averaging models over a full rotation, while the eclipse coronal images are snapshots of few second exposure times.

Galal et al. (2012) studied the basis of well resolved observations of the solar corona taken at North-West of Egypt (Salloum city) during the total solar eclipse of 2006. They showed that the stalks of helmet streamers extend to about 4 solar radii from the Sun's center and described that the existence of different zones in the observed white light corona was clearly noticeable. At the inner part of solar corona they noticed solar prominences at the north-east and east limb of solar disk. Their observations also showed all the basic coronal structures such as polar plumes, dome-shaped structures and helmet streamers.

In this work we will compare the defined features of solar corona at different observing locations (six locations) along the track from sunrise to sunset of the total solar eclipse 2006. The aim of this investigation is to show the differences of the observed various features phenomena due to the different locations and methods of processed images.

Data Used:

We selected 6 locations along the track of the total solar eclipse 2006. Table (1) shows the parameters of the observing locations along its track from sunrise to sunset.

Image of the solar corona from Niger was sent by Dr. V. Rušin, Astronomical Institute of the Slovak Academy of Sciences, Slovakia; prof. Pasachoff used this picture. Prof. Pasachoff from Hopkins Observatory, USA sent us the image taken from Kastellorize-island (Greece), while Dr. Stovea from institute of Solar-Terrestrial Influences "Acad. D. Mishev", Bulgaria sent us image taken from Manavgat, Turkey, finally Dr. Druckmüller from Institute of Mathematics, Faculty of Mechanical Engineering, Brno University of Technology, Czech Republic sent us images taken from Libya and Near Göreme, Turkey.

Figure 1 shows the processed image of the white light corona taken from Niger. It is composed of 26 frames with different exposure times from 1s to 1/250 s, which were taken by a 10 cm, F/4, focal length 100 cm Zeiss Telescope, equipped with a canon EOS 7 and Fuji color Superia Realta ISO 100 film.

Using this image, Pasachoff et al. (2007) reported that some discontinuities in helmet streamers are clearly visible.

The processed image of white light corona from Libya (figure 2) is composed of 60 images with different exposure times from 1/1000 s to 4 s. These images were taken using a 16.4/1640 mm (Takahashi 100 mm ED), focal length 820 mm, canon EOS 5D digital camera (TSO 100).

Pasachoff et al. (2007) showed that the shape of the loops adjacent to the north-east helmet streamer is suggestive of the propagating wave. This work also reported a large number of polar rays above the north solar pole as shown in Figure 2.

Figure 3 shows the processed image of white light corona, which is resulted from original images taken in Salloum, Egypt had very excellent-clear sky. The python processing program was used to process one of the images, which was taken by William top quality optics telescope, Fluoro-Star AP FLT-110 with Canon EOS-1DS Mark II digital camera.

In figure 3 one can see the polar plumes at both north and south poles, and closed helmet streamers at the north-west side.

Figure 4 shows the processed white image taken from the Kastellorizo-island (Greece) of the William Collage eclipse expeditions, using a Nikon focal length

Table 1. Selected locations in the track of Total Solar Eclipse 2006

Place	Longitude	Latitude	Eclipse time	Eclipse Duration
Niger	12° 42.2' E	18° 34.56' N	09:37 UT	3min 54s
Libya	24° 14.3' E	30° 56.946' N	10:11 UT	4min 07s
Salloum, Egypt	25° 7.65' E	31° 24.05' N	10:40 UT	3min 56.5s
Kastellorize-island, Greece	29° 35.6' E	36° 8.9' N	10:51 UT	2min 58.9s
Manavgat, Turkey	31° 27.24' E	36° 45.46' N	10:54 UT	3min 11s
Near Göreme, Cappadocia, Turkey	34° 52.147' E	38° 39.39' N	11:02 UT	3min 06s

600 mm f/4 lens with a 2x Nikon doubler and Nikon D200 digital camera.

Figure 5 shows the processed white light image taken near the town of Manavgat, Turkey. It is composed of 16 images with different exposure times ranging from 1/2000 s to 5 s, using a large aperture camera (200/100 mm) and two (150/2250 mm Meniskas - Cassegrain) and (63/840 mm) refractor telescopes. A black and white professional photographic film, Kodak T-AMX 200 pro, with a unique structure, was used.

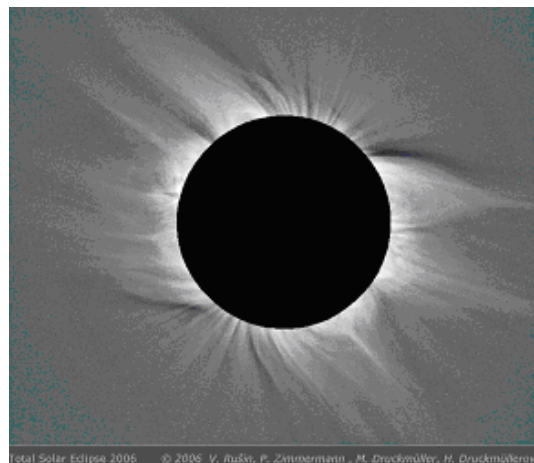


Figure 1. The processed image of white light corona in which their original images were taken in Niger during the total solar eclipse 2006.

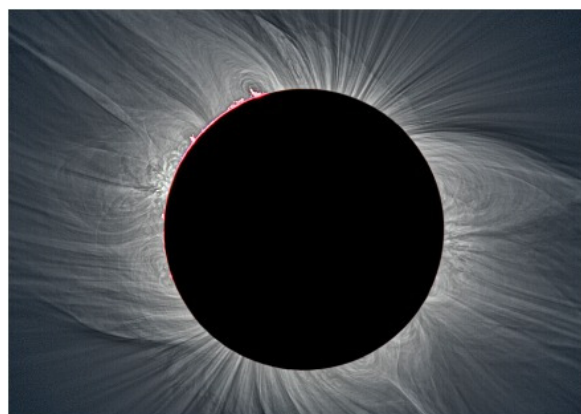


Figure 2. The processed image of the white light corona that is combined from 60 images taken in Libya during the total solar eclipse 2006.

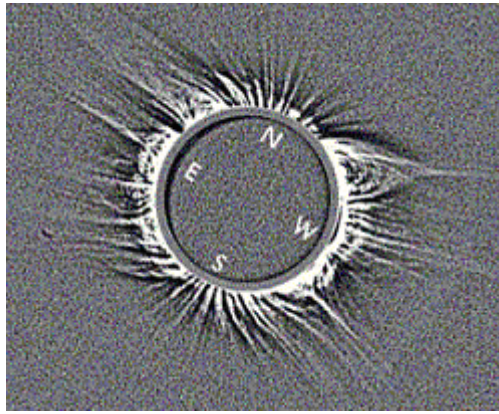


Figure 3. The processed image of the white light corona. This image is based on one frame taken in Salloum, Egypt during the total solar eclipse 2006.

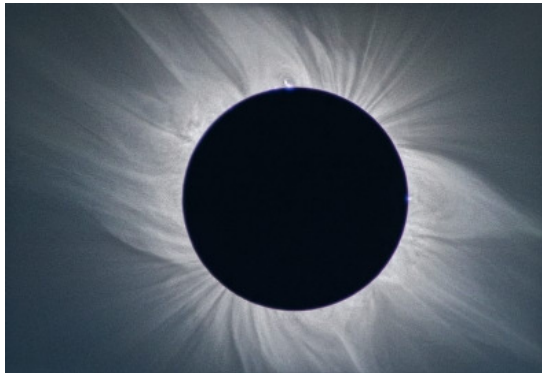


Figure 4. The processed image of the white light corona, which is original from observations taken in Kastellorizo-island (Greece) during the total solar eclipse 2006.

Stoev et al. (2008) concluded that the helmet-type streamers of the corona are tilted towards the solar equator and the deviations from a radial direction in the western hemisphere are greater than those in eastern one ($21^{\circ}/8^{\circ}$). Comparing their image with the images of the solar corona taken by LASCO C2 SOHO, they claim that the basic streamer structures are identical.

Figure 6 shows the processed image of white light corona taken from Near Göreme, Cappadocia, Turkey, with good, thin cirrus clouds out of the solar disk, and strong wind. It is composed of 63 images at different exposure times ranging from 1/1000 s to 8 s, using Maksutov-Cassegrain MC 3M-5CA, 8/500 mm with a Canon EOS 1D Mark II (ISO 100).

Ambroz et al. (2009) applied a numerical processing method on the Salloum images of the total solar eclipse 2006. Their method was based on the application of adaptive filters and described in detail by Druckmüller et al. (2006). The processed image (Figure 7) allowed them to study both small and large scale coronal structures.

Discussion:

The previous Figures (1- 6) taken along the track of the total solar eclipse 2006 show the basic coronal structures such as polar plumes, dome-shaped structures and helmet streamers type structures.

At north and south poles, we can see that the polar plumes are well developed, as exhibited in all processed images. Narrow streamer near south pole is seen in the processed images of Niger; Egypt; Turkish sites in Manavgat and near Göreme, Cappadocia.

In the northwest side of northern hemisphere, closed helmet streamers rays extended up to $3.5 R_{\odot}$ can be seen and our processed image (figure 3) agrees with the previous processed one taken in Libya (figure 2) and the two Turkish (figures 5,6) sites. The same feature can be seen, but less extended, in the processed images taken in Niger (figure 1) and the Kastellorizo-island, Greece (figure 4) sites. At the northeast side, the opened helmet stream rays extended to $3.5 R_{\odot}$ can be seen in the processed images from Niger; Libya; Egypt and Manavgat, Turkey but is not that far extended in the processed image from the Kastellorizo-island, Greece site. On the other hand, this extension in the processed image taken in near Göreme, Cappadocia, Turkey reaches up to $5 R_{\odot}$.

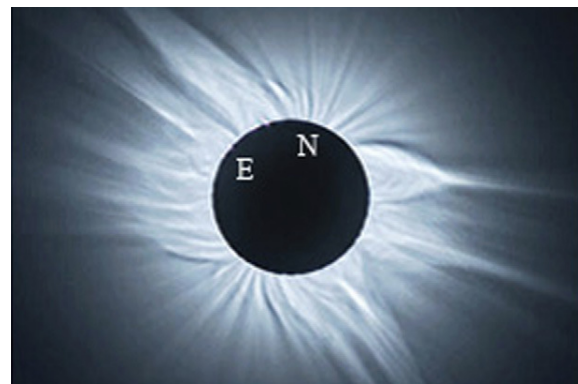


Figure 5. The processed image of the white light corona, which combined from images taken in Manavgat, Turkey during the total solar eclipse 2006.



Figure 6. The combined image of the white light corona, which resulted by adding 63 images taken Near Göreme, Cappadocia, Turkey during the total solar eclipse 2006.

At the southern hemisphere we can see a south border of helmet streamers near large coronal holes. There is no large extension in the helmet stream rays at southeast side in all processed images studied here. While a good similarity of large extension at northwest can be seen in the processed images from Niger; Egypt; the two Turkish sites and with less extension in the processed images taken in Libya and the Kastellorizo-island, Greece sites.

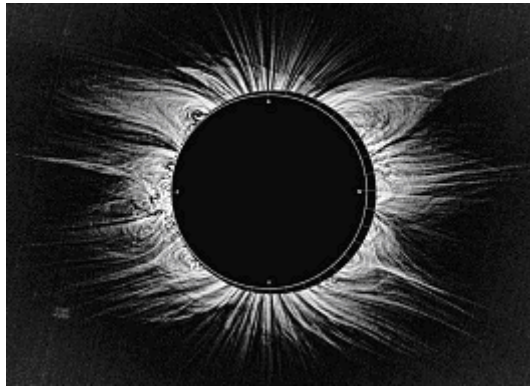


Figure 7. Processed image of the white-light corona for the total solar eclipse on 29 March 2006 observed at Salloum, Egypt (Ambroz et al. 2009).

Prominences originating and developed at middle heliographic latitudes (25° - 45°) are well outlined at the bottom of some large dome-shaped structures in the processed image of Manavgat, Turkey (Stoeva et al. 2008).

Pasachoff et al. (2007) found a small knot near the top of a very pronounced prominence in the helmet streamer at northeast in the processed image from Libya site.

Small prominence at northeast was seen in the processed image taken from Egypt; the Kastellorizo-island, Greece and Near Göreme, Cappadocia, Turkey sites, while no prominence activity appear in Niger site.

Our processed image (Figure 3) is in a good agreement with Ambroz et al. (2009) processed image (Figure 7) where they have the same open magnetic field lines at northern and southern poles. There is also a good similarity of closed magnetic field lines at the north-west side, south-west and near the equator. At east north side, we can see open magnetic field lines in both of our processed image and Ambroz et al. (2009) processed image. At east limb, we can see closed magnetic field lines.

Conclusion:

It is generally known that coronal magnetic structures are created and maintained with solar magnetic fields, however, these fields can be observed at the present on the solar surface only, not in the solar corona. The white light coronal structures are mirrors of the solar surface magnetic fields and play very important role in studying solar wind and its influences in the heliosphere.

Comparison of the solar corona observed from 6 locations along the track of the total solar eclipse 2006 shows the following:

- 1- Basic coronal structures such as polar plumes, dome-shaped structures and helmet streamers type structures were seen in the secured pictures.
- 2- The observed features of the solar corona in our processed image (figure 3) are in a good agreement with those features in the published images especially in the following phenomena:

a- At north and south poles, we can see that the polar plumes are well developed.

b- At northern hemisphere, we can see at north-west side closed helmet streamers rays extended up to $3.5 R_{\odot}$.

c- At northeast side we can see that the opened helmet stream rays extended up to $3 R_{\odot}$.

d- At southern hemisphere, south border of helmet streamers near large coronal holes can be seen.

e- Small prominence at northeast which is appeared in the processed images taken from the sites of Egypt; the Kastellorizo-island, Greece and Near Göreme, Cappadocia, Turkey, while no prominence activity appears in the site of Niger.

Our processed image is in a good agreement with published one by P. Ambroz et al. (2009). In both images we can notice similar open magnetic field lines at northern and southern poles, closed magnetic field lines at west north side, west south and near the equator. The open magnetic field lines can be seen at east north side.

Acknowledgment:

We would like to express our deep appreciation and gratitude to all who sent us the images used in this work; Prof. Pasachoff from Hopkins Observatory, USA, Dr. Stoev from institute of Solar-Terrestrial Influences "Acad. D. Mishev", Bulgaria and Dr. Druckmüller from Institute of Mathematics, Faculty of Mechanical Engineering, Brno University of Technology, Czech Republic. We also thank the editor and the anonymous referee for the valuable comments and suggestion that improved the paper.

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