Observations of total solar eclipse of 29 March 2006 and related atmospheric measurements

Wahab Uddin*, Bhuwan Joshi, T. S. Kumar, Saurabh Sharma and Ram Sagar

Aryabhatta Research Institute of Observational Sciences (ARIES), Manora Peak, Nainital 263 129, India

We report preliminary results on short-period oscillations in the corona and changes in the earth's atmospheric parameters, observed during a total solar eclipse of 29 March 2006 from Manavgat, Turkey.

Keywords: Atmospheric parameters, coronal imaging, total solar eclipse.

OBSERVATIONS of total solar eclipse are valuable to understand the physical processes occurring in the solar corona as well as in the earth's atmosphere. One of the unresolved problems concerned with the solar corona is its enormously high temperature, $\sim 10^7$ K, in comparison to the photospheric temperature of the Sun, ~5700 K. It has been recognized that the magnetic field plays an important role in heating up the solar corona, but identification of the mechanism involved is still unclear[1]. The existence of fast- or slow-mode magneto-hydrodynamic waves has been identified as a source of coronal heating. These waves are expected to cause intensity and velocity oscillations in the solar corona in the frequency range ≤ 1 Hz. Koutchmy *et al.*[2] reported Doppler velocity oscillations with periods near 300, 80 and 43 s, but found no prominent intensity fluctuations from the measurement of the green coronal line at 5303 Å, using a coronagraph. Singh *et al.*[3] performed fast photometry of solar corona during the total solar eclipse of 24 October 1995 and observed coronal intensity oscillations of period ranging from 5.3 to 56.5 s. Their analysis further pointed out that if these oscillations are considered in fast magnetosonic mode, they provide enough flux for the heating of active regions in the solar corona. Cowsik *et al.*[4] confirmed the existence of short-period oscillations in the frequency range 0.01–0.2 Hz in coronal brightness observed during the total eclipse of 26 February 1998 and detected three prominent periods at 90.1, 25.2 and 6.9 s.

In order to study the response of the earth's atmosphere during the solar eclipse, measurements of different atmospheric parameters, viz. temperature, pressure, relative humidity, wind speed, solar intensity, etc. have been made earlier by several authors[5–7]. These studies indicate that the atmospheric temperature and pressure decrease rapidly during a total solar eclipse, which produces meteorological anomalies. However, the various processes occurring in the earth's atmosphere and their variation during the eclipse are not well understood.

In the light of the above discussions, we carried out some observations during the total solar eclipse of 29 March 2006 from Manavgat, Antalya, Turkey (lat. 36°49′N, long. 31°18′E). During the event, the path of the moon's umbral shadow began in Brazil and extended across the Atlantic, northern Africa, Turkey and Central Asia. The eclipse ended at sunset in northern Mongolia. The longest eclipse occurred around Chad, a place near the border of Libya in Sahara, at 10:11:18 UT, with maximum duration of 4 min and 7 s. The totality duration at our observation site was 3 min and 45 s. The observing site was on the central line of totality (Figure 1).

A description of the instruments used during the eclipse observations are given below.

Imaging the total solar eclipse: We installed a 12.5 cm f/5 refractor equipped with red coronal line 6374/2 Å filter at the observation site for fast imaging of the solar corona. The detector was a 12 bit, 512×512 pixel, 15 μm square Photometrics CCD camera at a plate scale of 4.95 arc s/pixel. The CCD has a field of view of $2.8R_0 \times 2.8R_0$, which covers the inner corona. During the totality period of 3 min and 45 s, we obtained 250 images with a temporal resolution of 0.9 s.

Measurements of atmospheric parameters: We installed a mini weather station at the observation site, manufactured by Weather Technologies (India) Private Limited, Pune. There were four sensors mounted on the weather station to measure solar radiation, ambient atmospheric air temperature, relative humidity, wind speed and its direction. The silicon pyranometer has sensitivity in the range 400–1000 nm. The sensing device for temperature sensor is standard platinum RTD element, while the humidity sensor uses a solid-state capacitor. The temporal resolution for each sensor was 5 s.

Figure 2 shows our instrumental set-up at Manavgat, Turkey.

Figure 3 shows some images taken during the totality period. The eclipse started with first contact at 09:38:06 UT,

Figure 1. Map showing location of central line of totality (in red colour). In Turkey, the central line passes close to Manavgat, the observation site shown by an arrow.

*For correspondence. (e-mail: wahab@aries.ernet.in)

Figure 2. Photograph shows our experimental set-up. (Left panel) Telescope used to make observations of the solar eclipse. The data logger for the mini weather station placed on a tripod is also shown. (Right panel) Different sensors of the mini weather station.

Figure 3. Snapshots of the solar eclipse of 29 March 2006. (Middle panel) Eclipse image at the time of maximum totality. Near the east limb of the sun, the loop region is marked by an arrow.

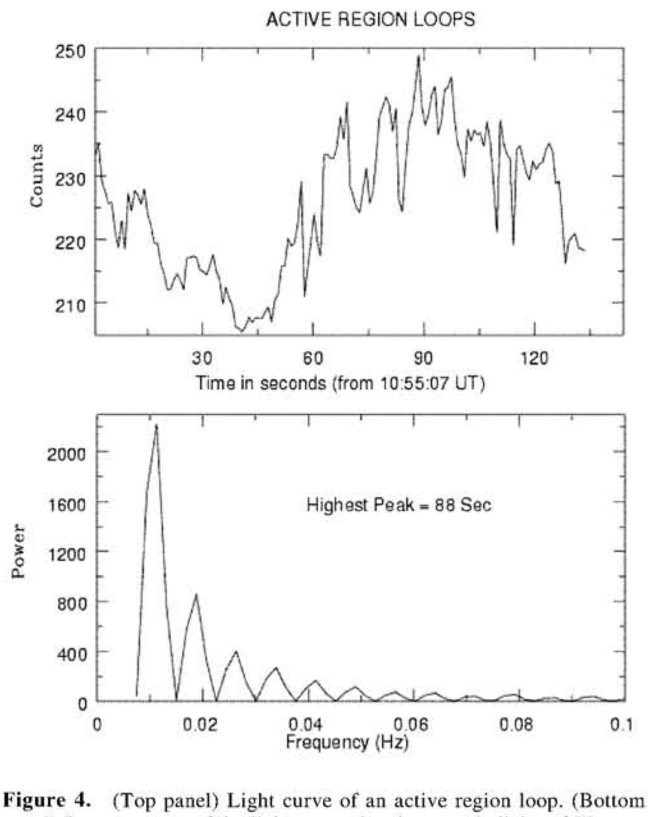

Figure 4. (Top panel) Light curve of an active region loop. (Bottom panel) Power spectra of the light curve showing a periodicity of 88 s.

when the elevation angle of the sun was ~56°. The second and third contacts occurred at 10:54:42 and 10:58:26 UT respectively, while the longest eclipse was observed at 10:56:34 UT. The eclipse ended with fourth contact at 12:13:17 UT, when the solar elevation angle was ~44°. The sky conditions were also conducive for carrying out such observations.

Figure 4 shows the time profile of a selected region at the solar corona which is at the top of an active region loop system. This light curve was constructed by plotting the mean intensity inside a square region of size 10 × 10 sq. pixel. The lower panel of Figure 4 shows the power spectrum of the light curve presented in the upper panel. From this power spectrum, a peak at 88 s is evident. A peak of 90 s was detected in coronal intensity in the eclipse data earlier[4]. Our analysis shows similar periodicity and confirms the earlier results[4]. Detection of such periodic variation may be associated with the oscillations of magneto-hydrodynamic waves that are likely to be responsible for the high temperature of the solar corona.

In Figure 5, we plot the various atmospheric parameters recorded by the mini weather station. The topmost panel shows that the solar radiation started decreasing from the first contact onwards till the eclipse maximum. At the time of first contact the sky was clear, but with the progress of the eclipse clouds started to appear that produced dips in the solar radiation curve (mostly after the eclipse maximum). At the time of totality, the solar radiation reached almost zero value. After third contact, there was again a gradual increase in the solar radiation. The profile of air temperature (second panel, Figure 5) also shows a gradual decrease in the ambient air temperature, with maximum decrease of ~2.5°C. However, the minimum temperature did not occur at the eclipse maximum, but ~8 min latter. Fernadez *et al.*[5] found in their 1991 eclipse observation, that the surface air temperature decreased by 2–5°C in general, with lowest values occur-

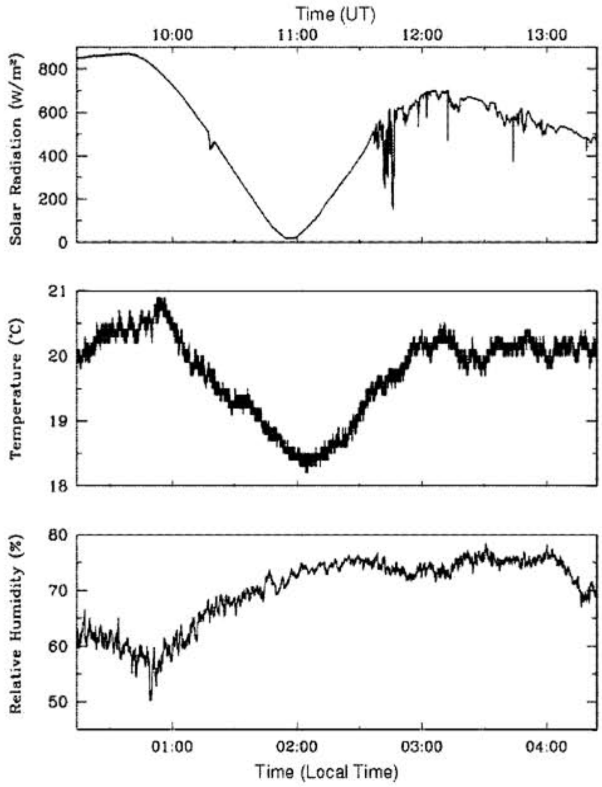

Figure 5. Plot showing variation of solar radiation, temperature and relative humidity (top to bottom) in the earth during the eclipse, covering the whole event duration from its first to fourth contacts.

ring 10–30 min after totality. However, Fernadez *et al.*[6] in their 1994 total eclipse observations found a surface temperature decrease of 3°C, with the lowest value occurring about 7 min after totality. The present observations also confirm similar changes in the atmospheric parameters. The time lag between the temperature minimum and the time of totality may be interpreted in terms of the thermal inertia of air and ground[6]. Due to its dependence on temperature, relative humidity increases as a consequence of decrease in temperature (third panel, Figure 5).

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