Changes in the surface UV radiation and sferics over Kalyani (West Bengal) during the solar eclipse on 22 July 2009

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The present study was mainly confined to the investigation of the responses of downwelling solar radiation fluxes in ultraviolet wavelengths to the partial solar eclipse event on 22 July 2009 besides an investigation on sferics at 27 kHz. The measurements were done at ground-based station of Kalyani (22°58'N, 88°28'E) where the maximum solar coverage was more than 90%. The optical properties and associated meteorological parameters are simultaneously examined. During the partial solar eclipse, UV components of sunlight reaching the Earth’s surface were found to decrease significantly in addition to luminosity. The surface air temperature was dropped but relative humidity was increased. A characteristic short period fading was also recorded at 27 kHz. The results have been interpreted by considering the impacts of solar eclipse on UV radiation and ionospheric propagation.

Keywords: UV radiation, Solar eclipse, Ionospheric propagation

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1 Introduction

The solar eclipse is a mere natural phenomenon that can provide an opportunity to study the changes of solar UV radiation on the surface of the earth under varying conditions$^{1-3}$. Investigation associated with solar eclipse has further interest for examining solar and ionospheric behaviour as well as meteorological parameters at such times$^4$. The possible changes in the stratospheric composition caused by natural processes have been an interesting subject$^5$. However, the number of observations exploring the effects of solar eclipse on surface UV radiation and its precursors is relatively small. The purpose of this paper is to investigate the variation of the shortwave downwelling solar ultraviolet radiation in both open sky and under a nearby tree when UV irradiance is further covered. In addition, the sferics data being reflected from the ionospheric layer have also been taken into consideration in relation to the eclipse event. The main objective of the paper is to examine the optical properties as well as determine meteorological parameters during eclipse hours. It is also planned to observe sferics variations, if any, at such times.

2 Observations

Some of the observations carried out in India and abroad during earlier solar eclipses have been presented in Tables 1 (a and b), respectively showing explicitly their scientific values.

During the solar eclipse on 22 July 2009, the penetrating solar radiation was observed on the ground of Kalyani University Campus (22°58'N, 88°28'E). The UV radiation during the partial solar eclipse was measured by a calibrated ultraviolet meter for three days centering the day of eclipse. The sensor had an extremely precise structure with UV photodiode and UV colour correction filter. The direct solar irradiance was measured in the bandwidth 290-390 nm with sample time 0.4 s approximately. The details of the UV Light Meter have been presented in Table 2. The ‘hi range’ of the UV sensor is designed to measure UV light values up to 19,990 µW cm$^{-2}$. As the dendritic structure of trees might significantly modulate the UV environment at the ground under its shade, the impact of a tree on UV radiation had also been recorded simultaneously. The observations of UV irradiance were thus taken during a period of three days in open sky and under an isolated tree centering the eclipse day. The luminosity under both the conditions has also been measured using a sensitive Lux Meter. The measurements were taken at 60 s interval on an average to evaluate the impact of a transient solar eclipse on radiative fluxes. Table 3 presents the details of the Lux
During observation, the photo detector was faced to light source in a horizontal position and the value of illuminance was taken from the LCD display. Stability of optical properties of atmosphere over the site was checked with measurements of luminosity before and after the three-day period of actual record. Some meteorological parameters interlinked to the UV radiation were also recorded at the same site of observation with a view to note the corresponding changes, if any. Measurements of integrated field intensity of atmospheric noise, also called sferics, were taken for noting the ionospheric irregularities by a sensitive tuned radio frequency receiver at 27 kHz.
3 Results and Discussions

The solar eclipse started at 05:28:48 hrs LT on 22 July 2009 at Kalyani, reached the maximum solar coverage (90.2%) at 06:26:24 hrs LT and ended at 07:30:54 hrs LT, thus lasted for a total duration of 2 h 2 min and 6 s. The local sunrise on that day was at 05:04:00 hrs LT. The sky was almost obscured by dense clouds in the morning hours with scattered cloud distribution occasionally on the normal day while on eclipsed day, the sky was clear since early morning from 05:00:00 to 06:52:00 hrs LT and thereafter, a partly cloudy over Kalyani. Figure 2 shows the mean variations of UV intensity on non-eclipse days (normal days) and on the solar eclipse day under open sky condition. It was seen that during the period of solar eclipse, the ultraviolet components of sunlight reaching the ground decreased significantly as compared to non-eclipse days. A similar characteristic variation was also noted when the UV intensity values are plotted under an isolated Alstonia scholaris tree (local name Chatim) with a hemispherical canopy having 6.74 and 8.12 m canopy width and height, respectively; 1.8 m trunk height and leaf area index of 4.7. The UV surface irradiance values under tree shade condition recorded simultaneously with the UV irradiance under open sky have been shown in Fig. 3. The irregularities in some portion of the curves are mainly caused by the appearances of the overhead clouds and hence a low transparency of the atmosphere with haze was experienced and has been reflected in the figure. A plot of luminosity in lux considered under the two conditions exhibits a similar behaviour (Fig. 4). It appears that the obscuration of solar disc is responsible for temporal reduction of solar radiation fluxes or a temporal dimming in the light measured at the Earth’s surface. However, some asymmetry in the shape of the curve related to the non-eclipse day is apparent which may either be due to sunrise effect at the early morning hours or may be due to sudden appearance/disappearance of clouds in the atmosphere. In addition to the UV irradiance and
luminosity on the Earth’s surface, some related meteorological parameters were also measured. The variations in surface temperature, relative humidity and pressure have been plotted in Fig. 5. The variations in temperature and relative humidity are remarkable during the limb darkening in comparison to before and after the eclipse. The air temperature was dropped and the relative humidity values were increased as evident from the figure. Round-the-clock records of sferics data at 27 kHz in the laboratory at the same time showed a fading pattern presumably caused by ionospheric irregularities \cite{8,20}. The record of the sferics, when carefully examined, exhibits a typical short period fading in the sferics level during eclipse. The VLF sferics recorded at 27 kHz is presented in Fig. 6. For the purpose of comparison of sferics variation on a normal (locally clear) day, sferics variations on 21 July 2009 have been documented at 27 kHz (Fig. 7). The record exhibits all regular variations, viz. the sunrise effect (A), first minimum (B), recovery effect (C), morning minimum (D), afternoon maximum (E), late afternoon minimum (F) and night maximum (G). On the eclipse day, as evident from Fig. 6, just after the sunrise effect, variational characteristics of the sferics totally differ, particularly after its onset when large numbers of short period fadings were produced in the sferics level. The figure also reveals that there are a number of fade-outs in the sferics level prior to the pick activity of the eclipse. The short period fading pattern vanishes and sferics level returns to the normal value at the end of the eclipse almost within an hour. The decrease of electron density at the lower ionosphere caused by the occurrence of the eclipse appears to be associated with the short period fading pattern in the sferics level. King & Eccles \cite{20} also reported that the structure of the ionosphere returns to normal value within two hours at the end of the eclipse. The decrease in ultraviolet component at sunlight is significant as the ionosphere was eclipsed for an important part of the developmental phase and it is possible that during this period, the behaviour of the ozone layer might be abnormal as reported by Bhattacharya et al. \cite{8}, from their early observations during 24 October 1995 solar eclipse and it was supported by other investigators as well \cite{10,11}. The measurements of meteorological parameters revealed

![Figure 5](image_url)

**Fig. 5**—Fluctuations of: (a) surface temperature; (b) relative humidity; and (c) surface pressure on 21 July (---), 22 July (----) and 23 July 2009 (-----), respectively

![Figure 6](image_url)

**Fig. 6**—Sferics at 27 kHz on the eclipse day (intensity of noise level in dB above 1µV m⁻¹)
that parameters like temperature and relative humidity were affected by the solar eclipse but reasonably not so for the air pressure. The near ground air temperature dropped during the eclipse event at Kalyani while the relative humidity was increased reaching a maximum value at the end of the eclipse. It is interesting to note that after the end of the eclipse all the parameters showed a tendency to regain their normal behaviour

4 Conclusions

In the present study, the response of downwelling solar radiation fluxes in the covered UV wavebands 290 - 390 nm to the solar eclipse events is interesting particularly when the optical properties are cross-examined with the meteorological parameters. The investigation clearly indicates that the UV component of the sunlight reaching the Earth’s surface diminishes together with luminosity, when there is a reduction of surface air temperature but an enhancement of the relative humidity. An analysis of sferics data also exhibits a short period fading instead of its regular variations. The effect of cloud cover on the amount of solar ultraviolet exposure under tree canopies in the present investigation was remarkably different in variational pattern exhibiting a reduction of one-tenth from that under clear skies. Multi waveband solar irradiance on tree-shaded surfaces during cloud free and partly under clouded skies may be considered elaborately as a future problem to verify how far the climate change affect UV exposure.

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References