Intensity Variation of the Night Airglow in the Tropics

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ABSTRACT. In this paper the nocturnal variations in intensity of the airglow at the zenith sky at Poona obtained with a photoelectric method during the period 1954—56 have been reported. The measurements include those obtained without an optical filter and also those obtained with the monochromatic interference filters transmitting the oxygen emission line at λ 5577 Å and the nitrogen band at λ 4278 Å. The measurements without the filter and with the λ 5577 Å filter show a maximum of intensity before midnight while the blue emission does not show such a maximum but only shows a steady fall in intensity from the beginning to the end of the night. These results are wholly contradictory to those obtained by Karandikar in 1933 using photographic method. The results for λ 5577 Å emission are given in absolute units and are discussed in relation to those obtained by workers at other places in higher latitudes.

1. Introduction

The problem of the night airglow has so far received very little attention in the tropics. Ramanathan (1932) was the first to describe the spectrum of the night airglow photographed by him at Poona (Lat. 18°34′N, Long. 72° E) in 1932. Later, Karandikar (Ramanathan and Karandikar 1933, Karandikar 1934a) working under Ramanathan described in detail the spectral characteristics as recorded on his photographic plates by giving very long accumulated exposures extending over several nights. In order to study the intensity variation during a single night Karandikar (1934b) directly exposed photographic plates behind apertures covered with different optical filters selecting out rather broad spectral regions from 3000 Å to 6500 Å. He came to the conclusion that there is minimum of intensity just after midnight in all spectral regions studied and in particular in the green light around λ 5577Å. Using a self luminescent double salt of Uranium, and the same narrow band optical filter selecting λ 5577 Å Chiplonkar (1950) studied visually the internocturnal variation in the intensity of the night airglow at Poona during the clear season of 1947-48. Further he has estimated the intensity of emission of λ 5577 Å in absolute units, which varied between 690 and 3000 Rayleighs.

With a view to study the phenomenon more intensively in the tropics, we have again commenced photometric and spectroscopic observations since late in 1954, and the results of some of the photometric investigations on the variations of λ 5577 Å emission at the zenith are described here.

2. Experimental

Method I—A photomultiplier type of photometer was designed and built in the laboratory. It consisted of the photomultiplier tube 931A which is exposed through a small aperture (angular width 3° square) to the zenith sky. The output of the mutiplier was given to a four stage D.C. amplifier and finally to the vertical plates of a C.R.O. Readings were taken every 15 minutes throughout the night on all clear and moonless nights. Occasionally a monochromatic interference filter transmitting only about 180 Å around λ 5577 Å was used to verify the general trend of variation in intensity of the zenith sky. The interference filter, as is well known, severely cuts down the intensity even of the transmitted light, and therefore, in these observations no filter was used. The sensitivity curve of the multiplier tube and the intensity distribution in the night airglow automatically determined the region of the spectrum investigated. Thus present observations can safely be assumed to be those of λ 5577 Å.

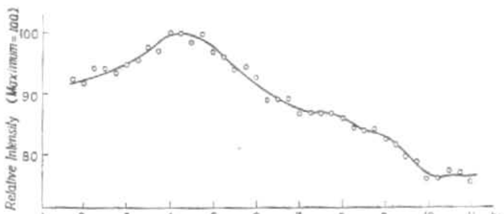

Fig. 1. Curve showing the variation of average intensity of the night airglow with time after sunset (no optical filter used)

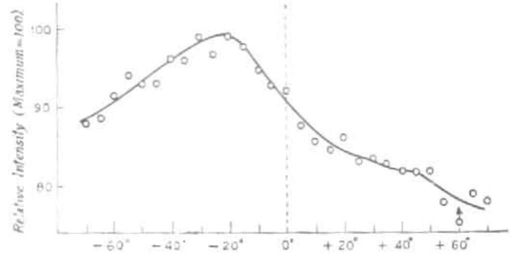

Fig. 2. Curve showing the variation of average intensity of the night airglow with the position of the sun below the horizon (no optical filter used)

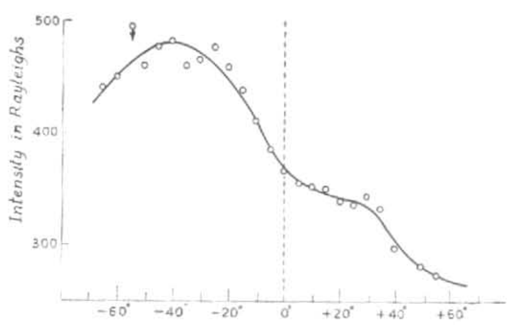

Fig. 3. Curve showing the variation of average intensity of the night airglow with the position of the sun below the horizon (λ 5577 Å filter used)

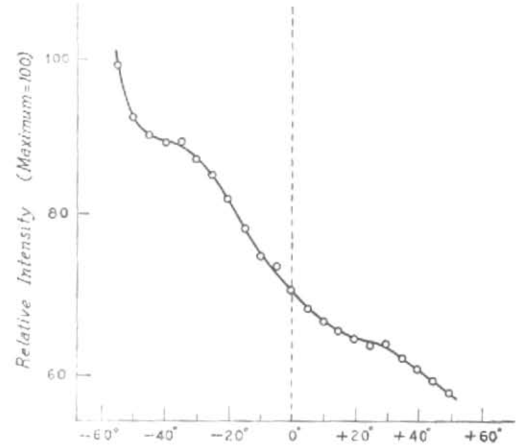

Fig. 4. Curve showing the variation of average intensity of the night airglow with the position of the sun below the horizon (λ 4358 Å filter used)

Method II—In order to completely scan the night sky the photomultiplier was mounted at the focus of a large aperture lens which itself was mounted on an alt-azimuth stand. An interference filter transmitting λ 5577 Å was invariably used while scanning the whole sky. The angle covered by the cathode of the photomultiplier was found to be about $7\frac{1}{2}° \times 3°$.

3. Results

In the first method complete sets of observations on twentytwo clear nights during the period, November 1954 to May 1955, were secured. Fig. 1 shows the average curve obtained showing the nocturnal variation in zenith sky intensity in the region of λ 5577 Å as a function of time after sunset. The same set of readings were treated in a slightly different way and the result is that shown in Fig. 2. Here the variation in average intensity is plotted as a function of the position of the sun. The maximum depression of the sun on every night is taken as zero and the positions of the sun above this point are marked in degrees negative before midnight and positive after midnight.

Using the second method in all sixtysix sets of complete scannings of the sky were obtained, using two interference filters—(1) Auroral green filter transmitting λ 5577 Å and (2) Blue filter transmitting 4358 Å on twelve clear moonless nights during the period, December 1955 to March 1956. For a comparison of the above results obtained without filter, only the zenith sky observations were selected out from these scannings wherein the λ 5577 Å and λ 4358 Å filters were used and similar curves of variation in the average intensity with the position of the sun below the horizon were obtained for each filter separately. The results are shown in Figs. 3 and 4. It may be noted that the values of intensity in Figs. 1, 2 and 4 are naturally given in arbitrary units while those in Fig. 3 are given in absolute units (Rayleigh).

4. Discussion

At the outset it may be pointed out that the average variation (which is also true to a large extent of most of the individual nights) is radically different from that observed by Karandikar (1934b) at this same place in 1933. The following points may be noted as emerging from the present investigations.

(*i*) The variations observed without the filter agree very well with those observed using the auroral green filter.

(*ii*) The intensity of airglow at first increases, reaches a maximum four and a half hours after sunset and steadily decreases till the morning twilight.

(*iii*) In Fig. 1, taking the maximum value attained during the whole night as 100, the intensity at the point one and half hours after sunset is about 80, while that attained at the corresponding morning epoch or just before the morning twilight is only about 65.

(*iv*) There is a slight tendency for a secondary maximum some time before the morning twilight as is shown best in Fig. 3.

(*v*) Fig. 3 also shows that the average value when the sun's depression is maximum is about 375 Rayleighs while at the beginning and end of the night (say $\theta = \mp 65°$, where θ is the angle as marked in Figs. 2, 3 and 4) it is 420 and 275 Rayleighs respectively. Chiplonkar's (1950) observations in 1947 were confined to the earlier part of the night and were decidedly higher than these values. The maximum average value at $\theta = -40°$ is seen to be 480 Rayleighs.

Figs. 2 and 3 have been particularly drawn to see if there is a kind of a permanent pattern of glow in space as suggested by Roach, Williams and Pettit (1953) round the midnight. Our observations at the zenith, however, do not support this view, since the maxima in Figs. 2 and 3 are well defined and are shifted away from the midnight point far too much to agree with observations of Roach, Williams and Pettit who observed their maximum one and a half hours around the midnight point.

Workers (Rayleigh 1929; McLennan 1928; Jones 1930; Roach, Williams and Pettit 1953 ; Roach and Pettit 1951 ; Davis 1951) in the temperate and higher latitudes also have reported similar variations of λ 5577 Å which show a maximum on the average round midnight ; however, there is far too great a variation from this general character from night to night in the higher latitudes while in the tropics the trend of variations is relatively more consistent.

The blue filter λ 4358 Å transmits the bright Nitrogen band at 4278 Å and the curve in Fig. 4 may be taken to represent its variation during the night. This curve, however, is radically different from all the other curves in that it has no maximum (or even a minimum as stated by Karandikar) but gradually decreases in intensity throughout the night; the average morning value being approximately 0·6 of the evening value, say, at $\theta = -50°$.

5. Concluding remarks

Although it is not proposed here to discuss the various theories (Roach, Williams and Pettit 1953) put forward in order to explain the phenomenon of the night airglow, still we would like to draw attention to certain salient points which have emerged from the foregoing investigations in the tropics. The nocturnal variation of the airglow even in the tropics has a similarity with the nocturnal variation of the incidence of aurorae in the higher latitudes. This may lend support to the view that the two phenomena are not separate but are two aspects of the same single phenomenon.

The radical dissimilarity in the behaviour of the green and the blue emissions during the early part of the night is very significant. In the case of the blue emisson the continuous fall in intensity from the end of the evening twilight to the beginning of the morning twilight shows a kind of *resulting* decaying process. But in the case of the green line emission which shows in the early part an increase in intensity, a maximum and finally a gradual fall in intensity can only be explained on the basis of two opposite processes one of excitation and the other of de-excitation going on simultaneously in the atmosphere with varying speeds (or efficiencies). The observed differences in nocturnal intensity variations from night to night would naturally mean corresponding differences in the rates of reactions.

For a complete discussion on the nature and origin of the night airglow, further information regarding the height of the emission layers and the variation in the spectroscopic character of the airglow are necessary. Such measurements, as stated above, have already been made at this place ; the results of which will be discussed in separate communications shortly.

6. Acknowledgements

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