Features of sodium emission in nightglow

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ABSTRACT

The average diurnal variation of Na emission in the nightglow is discussed from the observations during November 1964 to April 1967 at Mt. Abu (24.6° N, 72.7° E). Mainly the Na intensity was found to vary linearly with time and on some occasions the oscillatory nature in it was also detected. In the sets of linear diurnal variations an anti-covariation is found in the initial intensities of the linear variations and the associated rates of their variations. This inter-relationship in the initial intensities and the rates of variations is related with the tendency for appoaching an equilibrium value in the night time sodium emission.

1. Introduction

The atmospheric sodium has been studied by the ground based observations of the twilight sodium glow and the nightglow. The twilight observations have been mainly useful to determine the abundance on the daily and the seasonal basis and also to determine the level and the shape of the atmospheric sodium layer. The nightglow observations of sodium emission on the other hand are useful to study the diurnal and the seasonal variation of sodium emission. The diurnal variations of sodium emission in nightglow usually have been found to show only small intensity variations. In this text the diurnal variation of sodium emission at Mt. Abu (Geog. Lat. 24.6° N, Long. 72.7° E, altitude 1 219 m) has been discussed. It will be shown in Section 2 that the sodium emission at this station showed different types of diurnal variations with considerable intensity changes. Section 3 contains analysis of the observations which give only the linear diurnal variations of intensity. A brief discussion on the mechanisms of sodium emission and the night time model of the sodium layer is included in Section 4.

2. Observations

A photoelectric photometer pointing to the constant star background around the north celestial pole was operated during 1964–1967 at Mt. Abu. With the help of interference filters of about 100 Å half width the intensities of nightsky radiations at 6 300 Å (OI), 5 893 Å, 5 577 Å (OI) and the background at 5 350 Å were recorded every five minutes, on clear moonless hours of the night, between the end of the evening twilight and the beginning of the morning twilight. Only the results of the sodium emission in nightglow are discussed in the present work. At Mt. Abu the skies have been consistently clear, during the period from October to May, while no observations were possible during monsoon months from June to September. The observations were frequently calibrated with a C^{14} radioactivated phosphorescent light source supplied by the United States Radium Corporation (this standard source was kindly recalibrated by Dr. M. Gadsden of ESSA, Boudler, USA). The observations were reduced to absolute units of Rayleighs by the usual 'two-colour method' (Roach & Barbier, 1950; Smith & Alexander, 1963). The OH(8,2) contamination in sodium filter was not corrected. It may be mentioned that the small contribution due to OH(8,2) in Na intensity will not affect the type of analysis followed in Section 3. This is so because of the covariation in OH and Na emissions (Barbier, 1954; Berthier, 1954).

The lunation-wise averages of nocturnal intensity variations, the average diurnal curves of Na emission, are presented in Fig. 1. (Indian

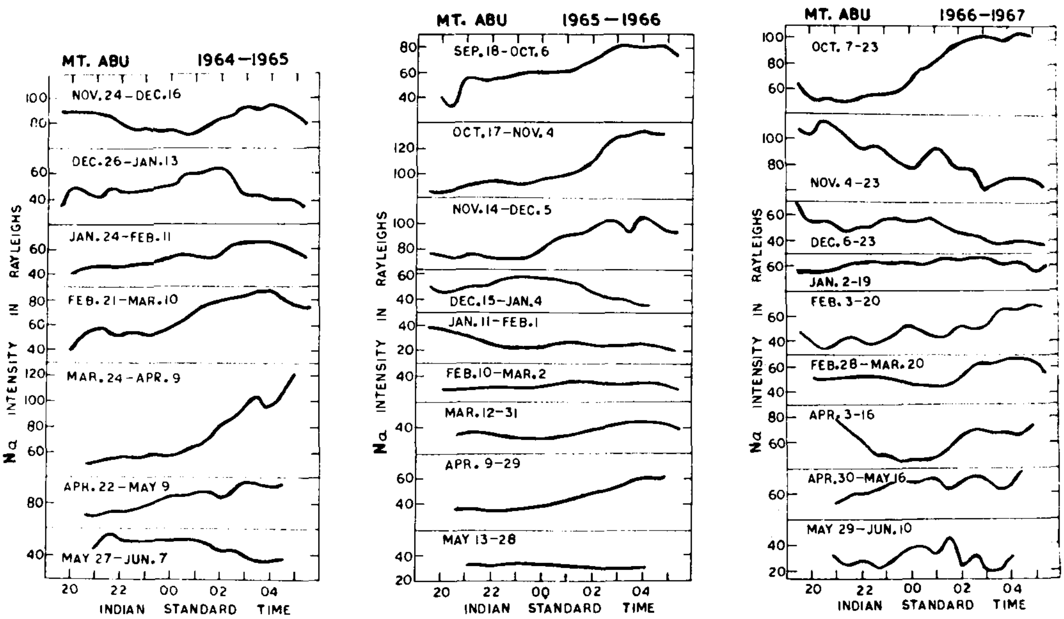

Fig. 1. The average nocturnal variation of Na emission in different lunations.

Standard Time = 82.5° EMT). From these curves and other individual nocturnal variations the following general points are noted:

(1) Nocturnal sodium emission at Mt. Abu does not show any obvious regular features (like the midnight maximum of green line of atomic oxygen or predawn enhancement as observed in red lines of atomic oxygen). There is not as much intensity variation in the Na emission as the variation in atomic oxygen lines.

(2) At Mt. Abu, in about 50 % of the cases (Fig. 1) the sodium intensity, I_{5893}, rises gradually throughout the night. In the remaining cases the intensity remains either constant or decreases gradually. A continuous rise in intensity has also been reported from the other observations, at other stations (Dufay & Tcheng, 1946; Roach, 1955; Steiger, 1967).

On the majority of the nights the sodium intensity was found to vary linearly for a considerable period of time; irrespective of whether it showed an increase or decrease. It is thought worthwhile to illustrate a few diurnal variations which showed a contrast in the increasing and the decreasing intensity trends. Fig. 2 presents some typical nights where the dotted lines through the intensity curves show that for a

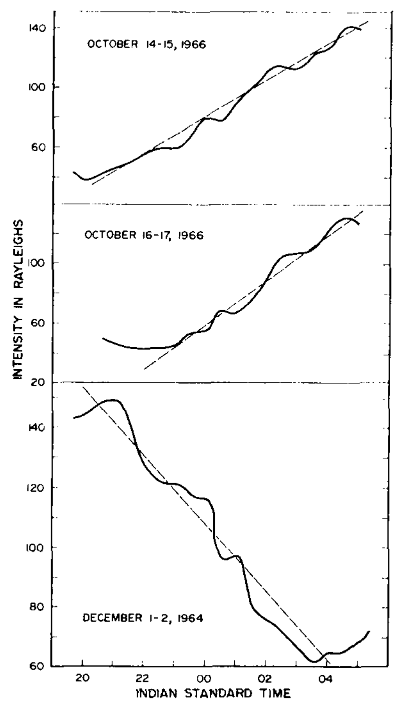

Fig. 2. The nocturnal variations on typical nights showing linear increase and decrease in Na intensity.

considerable period of time the mean growth or a fall in intensity is along a linear slope. In section 3, a relationship of this linearity and the rate variation of intensity is discussed.

(3) On many occasions periodic intensity fluctuations are observed for a considerable length of the night. The fluctuations can be seen in individual nocturnal curves but not in the lunation-wise avarages where they are smoothed out due to averaging. On these occasions a periodicity of the order of one to five hours has been observed in these fluctuations. However, the cases of intensity variation with the periodic fluctuations are not very frequent. Some peculiar trends and the occurence of maxima–minima in intensity are illustrated in Fig. 3*a*, *b*. To see the behaviour of nocturnal variation on successive nights some curves of January 1967 have been presented in Fig. 3*a*. A trend of intensity decrease is seen from the successive nights of January 7–8, 8–9 and 9–10. This trend has increased towards the latter date. Such a trend is disturbed in the successive nights from January 12–13 to January 14–15; with fluctuations of intensity on January 12–13, 1967 found to set in after midnight. The curves of October 24–25, 1965 and November 22–23, 1965 (Fig. 3*b*) being on a reduced scale, actually show large intensity fluctuations. The February 4–5, 1967 started with the large intensity fluctuations which died down during the course of the night. Also the separation between the maxima decreased continuously towards the end of the night, while in case of the curve of January 7–8, 1965 it is found to increase.

The internal atmospheric gravity waves could well be the source of these fluctuations of the period 5 to 1 h; in the sodium emission which is largely from 75 to 95 km region above the earth. Prof. C. O. Hines (in private discussions) also suggested that the gravity waves were very much responsible for these oscillations in sodium intensity. The gravity waves being responsible for the oscillations in the air density and consequently in the atomic oxygen density could be responsible for the oscillations in Na intensity as the atomic oxygen is the main constituent governing the variation in Na excitation rate (Ballif & Venkateswaran, 1963). Recently from the radar observations of the zonal wind, Revah (1969, 1970) has detected gravity waves having periods from 8 to 2 h in the altitude range between 80–105 km. As the sodium emission was observed as integrated intensity in a fixed direction, no reliable calculations could be done to bring out clearly the effect of gravity waves on the sodium emission.

The observations at Poona (Chiplonkar & Ahashe, 1961), at Haute Prevence (Barbier, 1956) and the observations at Haleakala (Steiger, 1967) also show linearity and the intensity fluctuations discussed above.

3. Relation in $I_{(5893)i}$ and m

$I_{(5893)i}$ represents the initial value of soduim intensity in Rayleighs from which the linear variation of intensity will be considered with m as its rate variation. The analysis shows that the process of Na emission had a tendency to acquire equilibrium obeying a definite relation in $I_{(5893)i}$ and m. This point has been brought out clearly in the following.

Two excitation mechanisms for Na emission in nightglow, governed respectively by O_3 and O_2^* the vibrationally excited molecular oxygen have been extensively discussed by Potter & Del Duca (1960) and Ballif & Venkateswaran (1962, 1963). For discussing the relationship in $I_{(5893)i}$ and m let us assume that the O_3 mechanism is operative. In the normal course of chemical kinetics, such as in Earth's atmosphere, the ozone concentration would tend to acquire its equilibrium concentration. Three cases may arise for ozone concentration to tend towards its equilibrium concentration. The ozone concentration at anytime was (i) *less* than its equilibrium concentration. This would cause an increase in ozone concentration. The control of ozone on I_{5893} would cause a similar effect on Na emission; (ii) *more* than its equilibrium concentration. In this case the temporal variation of ozone and therefore of I_{5893} would show a decrease. (iii) in its *equilibrium* concentration. This causes I_{5893} to remain steady. All these three cases are necessary for the observed diurnal variations at Mt. Abu showing rise, fall and the steadiness.

The consequence of this is that for the curves having positive slopes, the $I_{(5893)i}$ values will be less than an equilibrium value $I_{(5893)eq}$ and for those having negative slopes, the $I_{(5893)i}$ values will be greater than $I_{(5893)eq}$. As the atmosphere tends to acquire equilibrium condition, a value

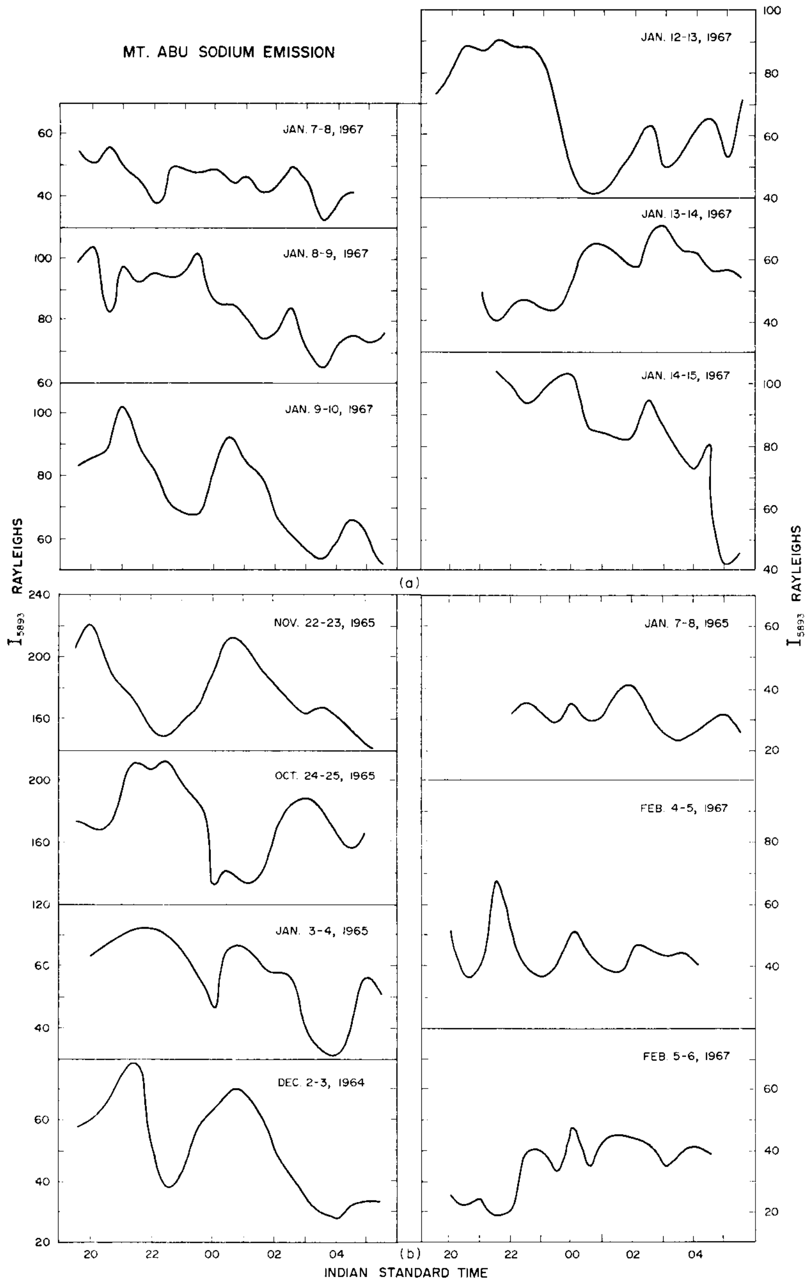

Fig. 3. (*a*) The nocturnal variations of Na emission compared in the sets of successive nights. (*b*) Shows the occasions when large scale oscillations in the diurnal variations of Na emission were observed. Some of the nights also show the development and the decay of amplitudes of intensity oscillations as the night progresses.

of $I_{(5893)i}$ very small compared to $I_{(5893)eq}$ is expected to cause a fast rise of I_{5893} curve and vice-versa. Also, when I_{5893} curve of one day with negative slope (e.g. see Fig. 2) is compared with I_{5893} curve of another day having positive slope, the former will have higher $I_{(5893)i}$ than the latter. Thus, if one consideres a set of Na intensity curves in a reasonably short period during which the region of interest has not suffered with the seasonal changes in its properties one infers an antivariation in initial values, $I_{(5893)i}$, and the slopes, m, of the intensity curves. The correlation analysis supports this hypothesis in general and very spectacularly in a considerable number of sets.

At first glance, this hypothesis may look like a random one (as was commented by one of the referees on this paper). A discussion on this point is considered necessary here.

Let us consider a nocturnal variation of sodium emission which started at time $t=0$ with intensity value $I_{(5893)i}$. Given this much, can one predict how the following intensity variation is going to be? One cannot predict this variation if (*a*) the sodium variation night after night was found to vary randomly and if (*b*) $I_{(5893)i}$ did not control, in a well known way, the rest of the intensity variation. The random variation of Na intensity, if existed, require that after $t=0$, the intensity values I_{5893} would be higher and lower than corresponding $I_{(5893)i}$ values and a set of several nights would show a random relation between $I_{(5893)i}$ and the rate variations m; but certainly not a definite antivariation between the two. The randomness requires that if a $I_{(5893)i}$ is noted at $t=0$, the slope m of the rest of the intensity curve could have a positive or a negative value.

The present hypothesis on the other hand suggests that the intensity variation after $t=0$ is not random but is definite and related to $I_{(5893)i}$. As will be noted later, the $I_{(5893)i}$ is noted and m estimated. The estimate of m does involve all the values of I_{5893} after $t=0$ but not the magnitude of $I_{(5893)i}$. This maintains an independency in $I_{(5893)i}$ and m for subjecting the two to a correlation analysis.

A restatement of the hypothesis is that if the two nights, (1) and (2) were considered with $I^{(1)}_{(5893)i} > I^{(2)}_{(5893)i}$ their corresponding rate variations will hold the inequality $m^{(2)} > m^{(1)}$. Also if $I^{(1)}_{(5893)i} \gg I^{(2)}_{(5893)i}$, then relatively $m^{(2)} \gg m^{(1)}$ is also true. This cannot be a random hypothesis, rather it points out for the first time from the observations that the Na intensity variations in the atmospheric Na layer has a tendency to tend to its equilibrium value.

(a) Selection of data

This hypothesis, establishing antivariation in $I_{(5893)i}$ and m presumably exists in non-linear variations of Na intensity also, but no attempt has been made in this paper to investigate the nature of relationship in $I_{(5893)i}$ and the rate of variation, because in a non-linear case the intensity curve is changing m, with continuously establishing a new $I_{(5893)i}$ value. Therefore, the hypothesis that the rate of increase or decrease of Na intensity is controlled by the relative initial intensity is discussed for the linear variation only. In this case, the data selection was straightforward as discussed below.

For deciding the linearity, all the individual nocturnal variations in each lunation were plotted. The visual examination of the different curves indicated the disturbed nights. By disturbed nights is meant the nights on which short term, irregular fluctuations were present causing nocturnal variation not of a regular or linear type. For a normal night, thus selected from a lunation, the linear phase of variation was considered up to a time after which either the slope of the curve changed sign or it showed a disturbed nature. The significance has been attached to those linear variations which lasted for at least $2\frac{1}{2}$ hours or more. Then the regression lines were fitted to determine the slopes of the curves. For the further analysis the slopes were noted. For an assessment of the linear cases, the correlation co-efficients of the linearity were also noted.

To examine the anticovariation in $I_{(5893)i}$ and m the analysis has been divided into two main parts: (*a*) dealing with the sodium intensity variations having linearity from the beginning of the night (i.e. time $t=0$, which is the end of evening twilight at Mt. Abu) and (*b*) dealing with the linearity in sodium intensity in later parts of the night. In the case (*a*) the initial value $I_{(5893)i}$ is at $t=0$. As the observations were usually started from a convenient time, though very close to, but after the end of evening twilight, the first observation in many cases may not be exactly at $t=0$. The extrapolation of the regression lines therefore were made to note the initial values of Na emissions. This extrapolation was in no case more than for half an hour and was necessary only for the cases falling under the category (*a*). In category (*a*), the assumption that $I_{(5893)i}$ was at $t=0$ could be a source of error. However, the results were found quite encouraging, as will be shown later (Table 2).

In the case (*b*), $I_{(5893)i}$ is the value correspond-

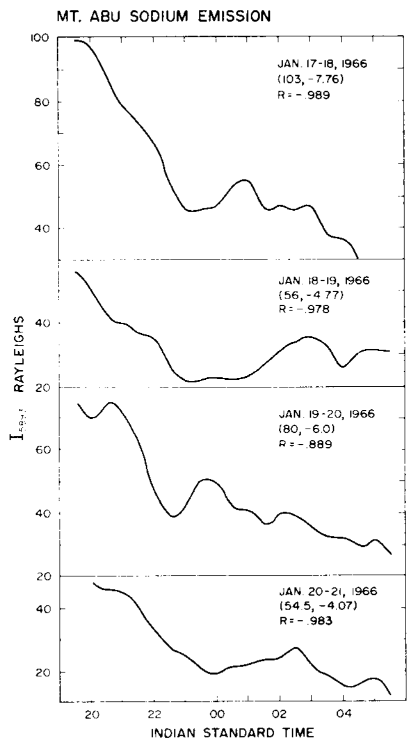

Fig. 4. An example of the nights showing linear intensity decrease in the initial phase of variation. R, the correlation coefficient for the linearity in this phase is shown with each curve. $I_{(5893)i}$, the initial value of the sodium intensity at $t=0$ (1932 IST), and m the rate of intensity variation in the linear phase as expressed in the brackets show on intercomparison that higher $I_{(5893)i}$ causes intensity to fall with a greater slope m.

ing to a maximum or a minimum any time of the night ($t \neq 0$) after which the linearity of the intensity has been considered. Thus in case (a) there can be only one value of $I_{(5893)i}$ per night while in case (b) there could be more than one depending on the times by which the intensity curve changed slopes in a night. For example on January 9–10, 1967 (Fig. 3a) one gets $I_{(5893)i} = 103$ Rayleighs at 2 100 ($t=0$) and the related linearity from 2 100 to 2 300 hours and also other values of $I_{(5893)i}$ at 2 300 and 0 030 hours for the linearities respectively between 2 330 and 0 030 and 0 030 and 0030 hours. Those nights after new-moon, when the presence of the moon in the beginning of the nights did not allow nightglow observations from within one hour of $t=0$, were not included in the case (a) because of uncertainty in the value of $I_{(5893)i}$ at $t=0$.

In Fig. 4 the successive nights of January 1966 exemplify the inter-relationship in their $I_{(5893)i}$ and m parameters. It is seen from Fig. 4 that after sunset the curves show a linear fall of intensity till around 2 300 and 0 000 hours. To examine the linearity in this phase of variation the correlation coefficient R were determined between intensity values and the time at 6 min intervals. The correlation coefficients depicted with each curve prove a very good linear variation of intensity. The end of evening twilight or the beginning of the nightglow observations is at 1932 IST. The initial values of sodium intensity are those where the regression line to each curve intersects the intensity axis at 1932 IST. These initial values and the slopes of the regression lines, i.e. $I((_{5893})_i$, m have been listed on individual curves. An intercomparison of these brackets confirms the inference that the curves with initial high intensity value would fall faster and vice-versa.

(b) *Discussion*

From the nightglow observations of sodium emission over three years (November 1964 to April 1967) at Mt. Abu a number of night time variations were examined for their linearity. Only those cases of linear variations were arbitrarily retained which had the correlation coefficient between I_{5893} and time greater than 0.7. Thus from different lunations of these years, we had as many as 219 cases to analyse. In this number are included the categories (a) and (b) mentioned before. It is worthwhile to have an idea of the predominantly present linearity in the initial phase as well as between maxima–minima of sodium emission variation. The Table 1, therefore, has been prepared wherein are shown the ranges of R and the percentage of cases falling in them.

The anticovariation between $I_{(5893)i}$ and m is exhibited in Fig. 5a, b. Except for the departure in a very small number of points a remarkable point to point anticovariation can be seen from these figures. It can be remarked here that: in a phenomenon like Na emission from the upper atmosphere the emission at some time of the night is independent of the emission at the time of sunset. Therefore $I_{(5893)i}$ and the rate by which I_{5893} should change later are not necessarily tied in a relation. But if $I_{(5893)i}$ and m

Table 1. *The correlaton coefficient R for the linear variation of Na intensity. The total number of 219 linear variations fall in different degrees of linearity as shown by the number of cases and the range of R*

Range of R	No. of cases falling in the range	% of cases falling in the range
0.95–1.0	141	64.1
0.9–0.949	45	20.5
0.85–0.899	21	9.6
0.8–0.849	6	2.7
0.75–0.799	3	1.4
0.7–0.749	3	1.4

of an intensity curve of one day are anti-related with those of the other days, it is an existing phenomenal relationship in them to which attention has been drawn for the first time in this text.

For showing better antivariation the present analysis requires a period short with consistent observations. The analysis therefore, for the categories (*a*) and (*b*), was limited to the separate lunations. To see an average picture, the data from (*a*) and (*b*) have been mixed to form a category (*c*) and the covariation studies have been followed.

In Table 2 are listed, all the lunations from November 1964 to April 1967, the number of points N used for determining the correlation coefficient in $I_{(5893)i}$ and m and the correlation coefficients. Only those lunations which could not give at least 5 points for the category (*c*) are absent from the Table 2.

In all the lunations the correlation coefficients are negative in the category (*a*). The correlation coefficients of category (*b*) are negative in all the lunations except for the lunation of March 1966 when it is insignificantly positive. The correlation coefficients in the category (*c*) are negative in all the lunations. The histographic representation of the occurrences of $R(I_{5893)i}, m)$ in different ranges has been done in Fig. 6.

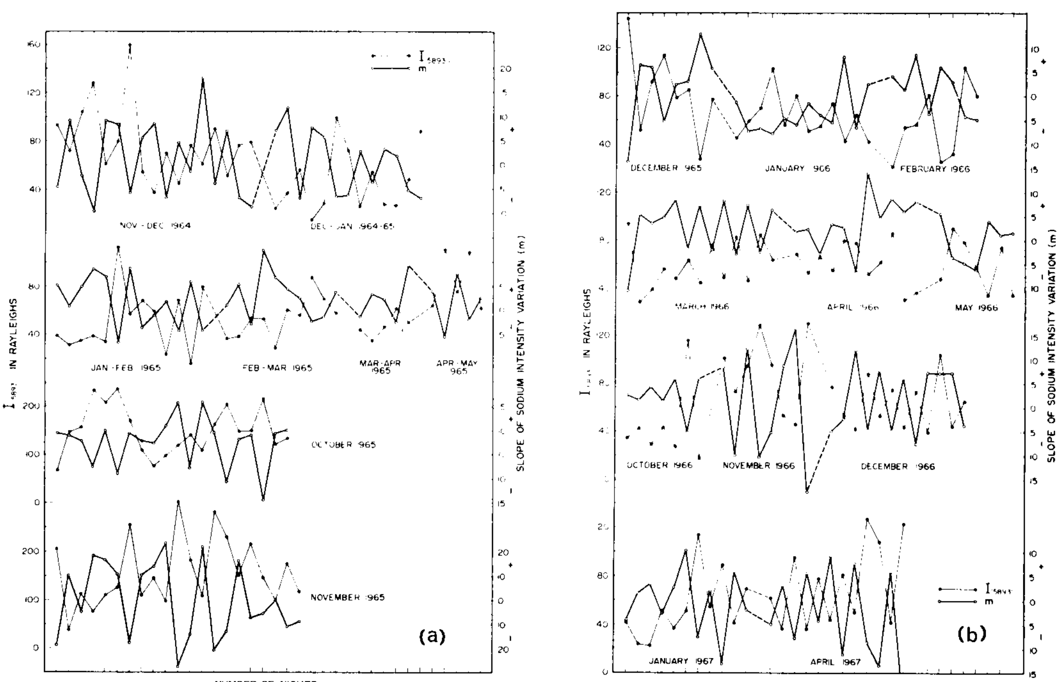

Fig. 5. Showing that the initial sodium intensity $I_{(5893)i}$ day after day oscillates around a mean value. m, The rate of change of sodium intensity also oscillates around a mean value corresponding to roughly $m = 0$. $I_{(5893)}$ and m show an antivariation when compared day after day. Each division on the base line of these figures gives the position of a night.

Table 2. *Correlation coefficient between* $I_{(5893)i}$ *and* m

	Category					
		(*a*) $t=0$		(*b*) $t\neq0$		(*c*) $t=0+t\neq0$
Lunation	N	R	N	R	N	R
November–December 1964	7	−.787	10	−.432	17	−.610
December–January 1964–65	5	−.936	8	−.790	13	−.801
January–February 1965	6	−.786	7	−.827	13	−.752
February–March 1965	6	−.532	5	−.679	11	−.526
March–April 1965	3	– –	2	– –	5	−.278
April–May 1965	4	– –	1	– –	5	−.720
October 1965	10	−.638	10	−.766	20	−.629
November 1965	8	−.748	13	−.832	21	−.758
December 1965	8	−.931	—	– –		
January 1966	7	−.747	5	−.866	12	−.714
February 1966	7	−.947	1	– –	8	−.777
March 1966	6	−.877	7	+.250	13	−.340
April 1966	7	−.548	4	– –	11	−.406
May 1966	5	−.473	2	– –	7	−.635
October 1966	7	−.957	—	– –	—	– –
November 1966	3	– –	5	−.881	8	−.637
December 1966	3	– –	9	−.912	12	−.891
January 1967	6	−.004	5	−.847	11	−.211
April 1967	6	−.520	6	−.955	12	−.886

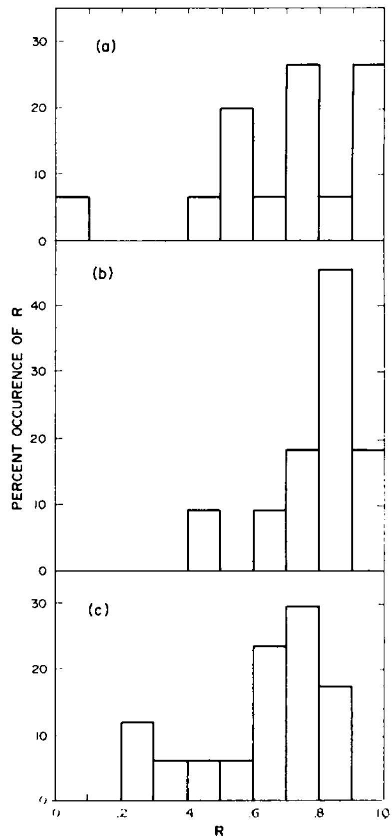

Fig. 6. The percentage occurrence of negative correlation coefficient R between $I_{(5893)i}$ the initial sodium intensity and m the rate of change of sodium intensity in its linear variation. (*a*), (*b*) and (*c*) represent three categories discussed in the text.

In the categories (*a*) and (*b*) of main interest the correlation coefficients range from insignificant in some lunations to highly significant in others. In fact, that all but one in 27 of (*a*) and (*b*) and none in 17 of (*c*) correlation coefficients turned out to be negative, indicate that those variations of sodium emission which are linear, tend to fall under the hypothesis discussed here.

From Fig. 5*a*, *b* it can be seen that $I_{(5893)i}$ corresponding to $m=0$ varied, to some extent from night to night, and quite considerably from lunation to lunation. This daily and seasonal trend in the equilibrium value of I_{5893} could mainly be due to the variations in both, the temperature dependent reaction rate coefficient and the atomic sodium concentration (Baliff & Venkateswaran, 1962). In the present analysis the variations in these two parameters were not considered and the variations in sodium emission were assumed proportional to the variations in O_3. However, the variations in these two parameters, if considered in a lunation, do not affect appreciably the analysis, but an appreciable seasonal charge in them restricted this analysis to individual lunations only.

The assumption is quite reasonable if the hypothesis were tested with a set of $I_{(5893)i}$ and m having at least 5 values in the same night. With this idea the whole data were surveyed and it was found that, from the present data from Mt. Abu, at the maximum, three points were available on each of the nights of December 9–10 and 10–11, 1966. No correlation coef-

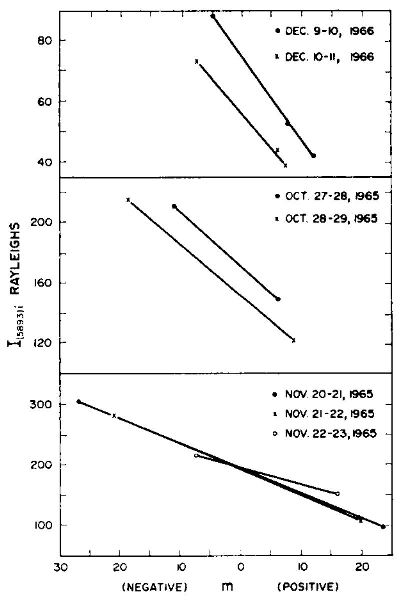

Fig. 7. Three sets of points ($I_{(5893)i}$, m) available from individual nights show that the points fall roughly on a straight line and the two points available on individual nights show an approximate parallel shift on the successive nights.

ficients were determined with the three points, only a plot of these points has been shown in Fig. 7. The points falling more or less on straight lines further support the hypothesis. Another aspect of such nights is that on these nights the intensity does not attain equilibrium; rather it fluctuates showing maxima–minima around some equilibrium value. These nights show a near-parallel shift in their lines. Two nights of October 1964 giving only 2 points each also indicate a near-parallel shift. The November 1965 nights (Fig. 7) do not show much of a shift between them but the lines tend to fall in a near-parallel discipline.

The assumption that the increase, decrease or steadiness in I_{5893} was due to respectively a possible increase, decrease or steadiness in O_3 concentration could be substantiated by Hesstvedt's (1968) recent theoretical studies. Taking into account the eddy diffusion he has derived the day and night time O_3 height profiles. From these profiles it can be seen that near 85 km, within the sodium layer, there existed levels where O_3 concentration during the night increased, decreased and remained the same as compared to the day time concentration. At times the region prevalent would control the temporal variation of O_3 and the integrated intensity would show the variation of the type related to that. Moreover, as discussed by Ballif & Venkateswaran (1963), when O_2^* (excited molecular oxygen) is also responsible for the emission, the differential variation of O and O_3 could produce varied nocturnal variation of Na emission.

The observed fact that I_{5893} may not reach its equilibrium concentration or may fluctuate during a night indicates that O_3 also acted likewise. On the other hand in a static model atmosphere the characteristic time for O_3 to reach its equilibrium concentration could work out very small compared to the length of the night. But the region of sodium emission around 85 km has a complex dynamical structure where alternately the turbulent and the laminar fields of motion are present (Blamont & Barat, 1967). The experience also says that if the motions were included in the photochemical treatment of this atmosphere the picture was very much different from the one in static atmosphere. Therefore, there is every likelihood of changing the equilibrium concentration continuously, abruptly or in a fluctuating manner causing to make the characteristic time apparent and uncertain.

4. Mechanisms

Two excitation mechanisms for Na emission in nightglow, governed respectively by O_3 and O_2^* the vibrationally excited molecular oxygen have been extensively discussed by Potter & Del Duca (1960), and Ballif & Venkateswaran (1962, 1963). In these discussions a static model atmosphere was adopted where the effect, on these mechanisms and consequently on Na emission, of the atmospheric motions was not considered. Following a similar treatment of the problem, with reasonable assumptions on different parameters of the model, the author found it difficult to interpret the variety of observed intensity variations as discussed in the preceeding sections. Though quite a few interesting features, realistic as well as unrealistic, were noted from this study, however, a discussion on all of them is not of much interest here.

The observed diurnal variation of Na intensity exhibiting increase, decrease and periodic and non-periodic fluctuations shows the dynamic behaviour of the atmosphere. Bullock & Hunten (1961) pointed out that on quite a few occasions they observed large overnight increases in sodium abundance over Saskatoon. As mentioned before, the atmosphere near 85 km is found to have a complex dynamical structure (Blaumount & Barat, 1967) where alternately the turbulent and the laminar fields of motion are present. An extended discussion by Hunten & Godson (1967) on the relationship in the upper atmospheric sodium and the stratospheric warming suggests that a strong vertical mixing was responsible for the changes observed in sodium intensity. A concomitancy in 60 km and 30 km levels of atmosphere, through the weather maps of these levels, has been advocated by Finger et al. (1963) and Edwards et al. (1963) and in 70–80 km and 30 km levels by Huruhata (1965) who found a correlation between OH radiation and the height of 10 millibar surface. A theoretical model of Na abundance as proposed by Gadsden (1964) also suggests, though for long term variation, that the consideration of motions in this range of atmosphere was important.

A dynamical model taking into account the motions along with the photochemical considerations and the time variations on a short and long term basis would be appropriate to explain most of the observed features of night time sodium emission. This dynamic model being beyond the scope of this text shall be discussed elsewhere.

5. Conclusions

The analysis of Section 3 reveals that in sodium intensity variations of the linear nature, relatively lower intensity rises and the higher falls towards a mean value. As discussed in Section 4, these changes are thought to be due to the atmospheric motion which tends to change the effective height of Na layer. Then both the increasing and the decreasing trends of Na intensity observed day after day at Mt. Abu, point out that in the tropics the atmosphere close to mesopause suffers reversals in its vertical movements to acquire a mean level.

From some of their twilight observations Bullock & Hunten (1961) also have pointed out the height changes in Na layer. As discussed in Section 2 the oscillatory nature of Na intensity observed in the same night is interesting, though presently nothing much could be commented upon. More observational and theoretical work is needed to understand the behaviour of the atmosphere around mesopause level. The nightglow emission, in different wavelengths, from different constituents of this level is one of the important tools to give a good deal of observational information of this atmosphere.

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ОСОБЕННОСТИ ЭМИССИИ НАТРИЯ В СВЕЧЕНИИ НОЧНОГО НЕБА

На основе данных наблюдений с ноября 1964 г. по апрель 1967 г. на горе Абу (24,6° с. ш., 72,7° в. д.) обсуждаются средние суточные вариации эмиссии Na в свечении ночного неба. Найдено, что интенсивность эмиссии изменяется со временем линейно, хотя в некоторых случаях вариации носили осцилляторный характер. В ряду линейных суточных вариаций найдена антикорреляция между начальными интенсивностями линейных вариаций и скоростями их изменений. Эта взаимосвязь между начальными интенсивностями и скоростями изменений связывается с тенденцией приближения к равновесной величине в интенсивности эмиссии натрия в ночное время.