CERTAIN PROPERTIES OF THE HYDROXYL EMISSION

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ABSTRACT: According to the materials of observations for many years, the variations in intensity and rotational temperatures of the OH bands were revealed for periods of 27, and 29.5 days.

Systematic observation of hydroxyl emission have been conducted for a number of years at the Zvenigorod station. During these years, data have been obtained on the rotational temperature and the intensity of the OH bands (4.1), (5.2), (6.2), and (7.3). Certain analytical results of these observations have already been published [1-3]. /37

As a result of the long-term observations and the accumulation of many statistical materials, it was necessary to sort out the data from the point of view of error in determining the rotational temperatures. For this purpose, we examined several factors which could affect the accuracy in determining the rotational temperatures. One such cause could be a preliminary illumination in a continuous spectrum during the exposure, caused by the scattering of lunar light from the sky, as well as by the twilight illumination from the Sun during summer observations. In addition to the purely photometrical errors caused by the additional continuous spectrum, it is possible that there is distortion of the intensities for the emission lines by the absorption bands of water vapors. Although there is no real absorption for the principal lines in the OH bands being examined, their effect can be found as a result of blurring of the absorption bands with the emission lines, because of the relatively large width of the instrument circuit (~10 Å) [4]. These effects can be considered, because in the region of the bands (4.1), (5.2), (6.2), and (7.3), the continuous spectrum of the airglow does not produce blackenings on the spectrograms which exceed the background of the film. A significant blackening of the continuous spectrum appears only during exposures for several hours for phases of the Moon which are close to Full Moon. In this case, we should mention that the observations were conducted regularly, both on moonless and on moonlit nights, for a number of years. Since the brightness of the scattered light in the sky in this psectral region was not measured, we calculated the integral quantity of light, in time, which could be incident at the slit of the spectrograph from the given region of the sky, for each exposure. Inasmuch as it was necessary to isolate only the degree of the effect of the preliminary illumination, we used the approximate evaluations of brightness of the sky according to the data in [5] and [6].

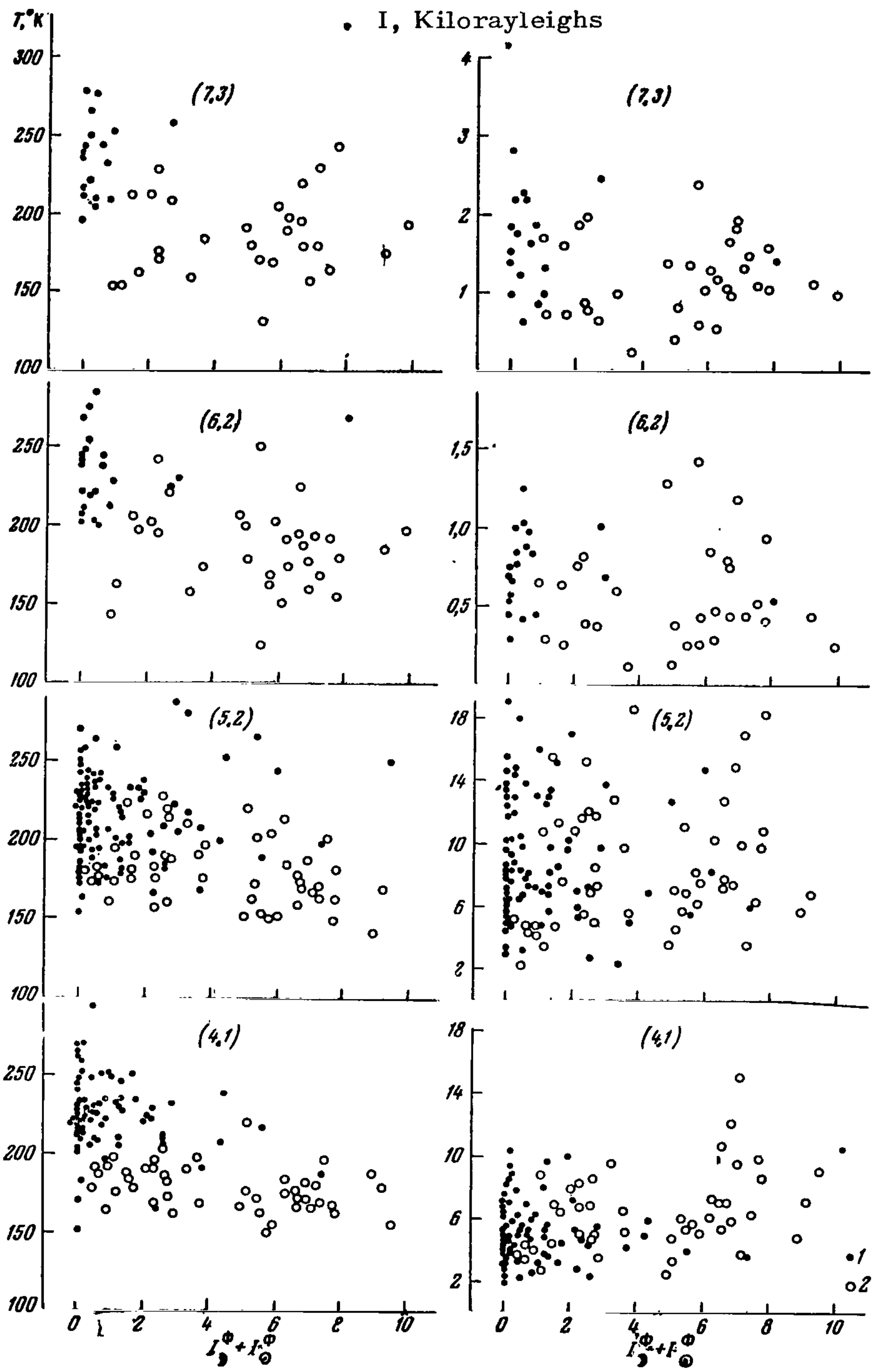

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Fig. 1. Intensities and Rotational Temperatures of the OH Bands (4.1), (5.2), (6.2), and (7.3) Versus the Total Background of Preliminary Illumination by the Scattered Light of the Sky Caused by the Moon (I^b) and the Sun (I^b). (1)Data for the Winter Months (September-April); (2)Data for the Summer Months (May-August).

It was found a long time ago, both by spectroscopic and by rocket measurements, that there is a seasonal change in the temperature at altitudes of about 80 km. Therefore, in order to avoid fictitious correlations, we divided the data into those for the winter (September-April) and the summer (May-August) months. As we can see from Figure 1, on the average the dependence of intensity and rotational temperature on the preliminary illumination is not found separately for the winter and the summer data, although the range of variations in intensity of the preliminary illumination is almost identical.

The quality of the spectrograms is the fully obvious reason, /39
determining the accuracy of the rotational temperatures. Experiment shows that the criterion for evaluating the error in rotational temperature by the distribution of points on a graph [log $I/i(j)$; $F(J)$] is, in a number of cases, a purely formal method. We know of

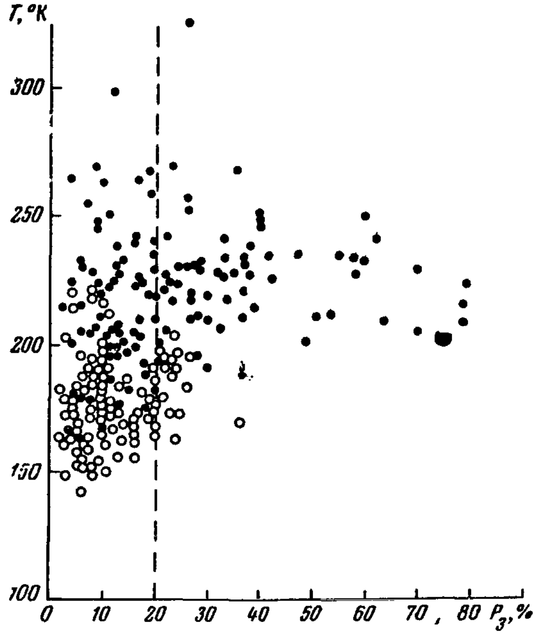

Fig. 2. Comparison Between the Rotational Temperatures of the OH Bands and the Intensity of the Line P_3, as Percentages of the Scale of the Record. The Signs are the Same as in Figure 1.

cases when, with a formal error of $\pm 5°$, the rotational temperature was 350-380°K, which is hardly a real value. Therefore, for a criterion of quality of the spectrogram, we took the intensity of the line P_3 on the recording of the spectrum as a percentage of the scale for the recording. Since the recordings of the spectra were expressed in intensities, and not in the blackenings, we selected the constant range for the change in intensities. Line P_3 is an almost constant fraction of the complete intensity of the OH band in the temperature range being examined, and it is thus a characteristic of the intensity for the entire band.

Figure 2 shows a comparison of the measured rotational temperatures T_{rot} and the values of P_3 on the recording. Note the increase in the dispersion of the values for T_{rot} with an increase in P_3, and the increase in the average value for T_{rot} with a decrease in P_3. Because of the non-linearity of the characteristic curve, there should also be a similar effect for the region of exposures.

On the basis of the results obtained, the criterion for the reliability of the data was selected as the intensity of the lines P_3, equal to 20% on the recording, which corresponds to the blackening on a spectrogram, roughly equal to 30%, against the background of the film.

We can see from Figure 2 that most of the summer values of /40
T_{rot} correspond to a range which is lower than the level of discrimination. This does not mean complete invalidity of these data. However, their real error is correspondingly greater.

Based on the data we had, we attempted to find statistically the existence of periodic variations in the rotational temperature and the hydroxyl emission of the upper atmosphere.

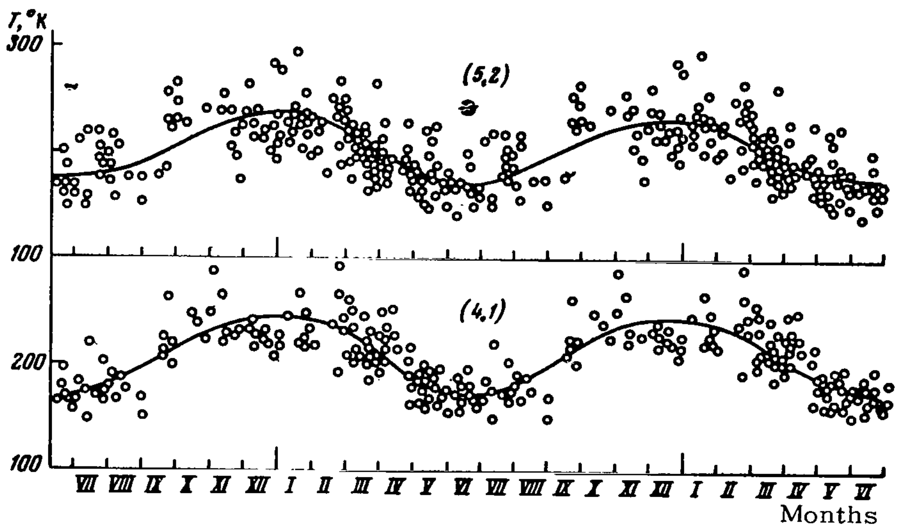

Fig. 3. Average Seasonal Variations in the Rotational Temperature of the OH Bands (4.1) and (5.2). The Solid Line Shows the Average Value of T_{rot}.

It is well known that many airglow emissions studied have a significant patchy structure which changes in time and in space. The OH emission also has unevenness over the sky, both for the intensity and for the rotational temperature. This was found earlier by observations with the aid of spectrographs in various directions over the sky, and then was confirmed more clearly by observations with the aid of a scanning spectrometer [4].

Thus, since there are observed variations in the intensity and the rotational temperature of the OH bands, both during one night and from night to night, in order to find the periods for the variations, we used the method ordinarily applied for these purposes--the overlapping of periods.

The existence of seasonal variations in rotational temperature has been well known for a long time. However, the periods of the observations, in relation to the weather conditions, do not encompass the entire year very frequently. Therefore, in order to obtain the average yearly variation, we used the data of several years of observations.

Figure 3 shows the average changes in rotational temperature for the OH bands (4.1) and (5.2), for one year. According to observations in Abastumani, the variations in T_{rot} for the OH band (9.3) have a similar character [7].

According to the data of observations in Zvenigorod, we looked for other periods of variations in the properties of the hydroxyl emission. For this purpose, all the values of the rotational temperature and the intensity for each of the OH bands were compared in relation to the selected periods of 25, 26, 27, 28, 29.5, and 30 days. The period of 27 days corresponds approximately to the synodic period of rotation of the Sun (as well as to the lunar /41
siderial month of 27.3 days), and the period of 29.5 days--the synodic month--determines the Moon's age. Only these two periods could be determined with reliability. The existence of a 27-day variation for the rotational temperature of the OH band (9.3) had already been indicated in [8].

During the observations, the exposure for photographing the spectra lasted the entire night. However, the mean moment of exposure did not always correspond to the local midnight. Therefore, in order to calculate the effective position of the Moon for finding the possible tidal effects, we checked the tabular values for the age of the Moon. This test was determined by the value of the divergence of the mean moment of exposure from local midnight.

In Figures 4 and 5, the curves show the average values for the intensity of T_{rot}. In this case, in order to obtain smoother curves, we averaged the data for an interval of four neighboring nights. The number of averaged values for the intensity and the rotational temperature was practically constant for each interval of four days (15 $\pm$ 3). The variance in individual values for the rotational temperature was $\pm$ 50°.

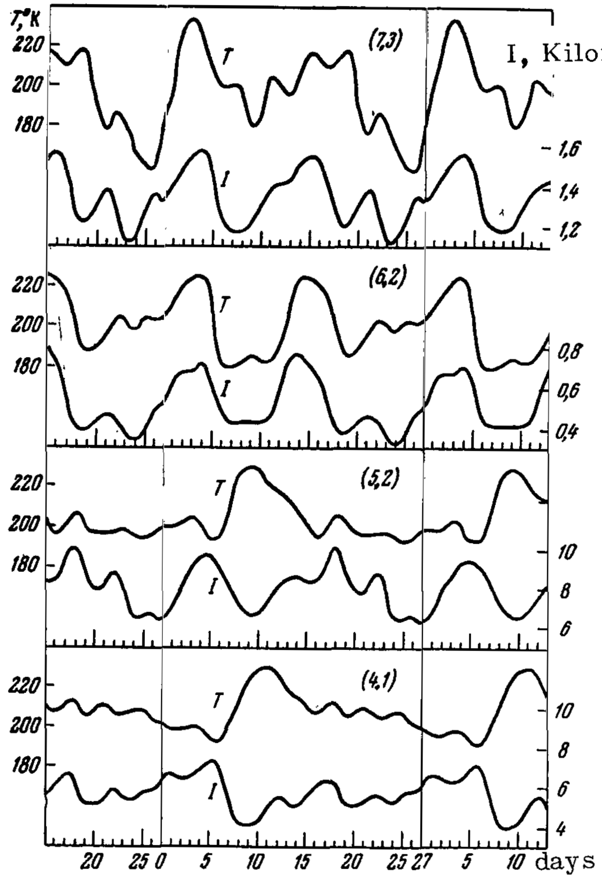

Fig. 4. Average Variations in Intensities and Rotational Temperatures of the OH Bands (4.1), (5.2), (6.2), and (7.3), with a Period of 27 Days.

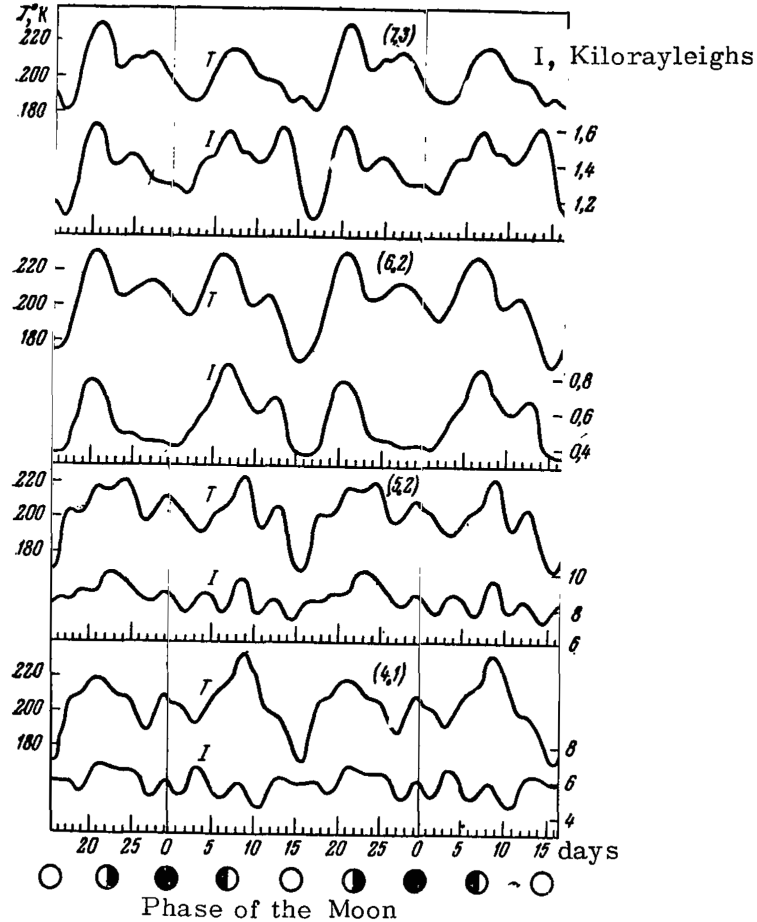

Fig. 5. Average Variations in Intensities and Rotational Temperatures of the OH Bands (4.1), (5.2), (6.2), and (7.3), with a Period of the Age of the Moon (29.5 days).

A verification of the relationships obtained by the selected data was possible only for the OH band (4.1), and completely substantiated the average variations of the intensities and the T_{rot} shown in Figures 4 and 5. /42

After selecting the data for the bands (5.2), (6.2), and (7.3), it was found that there was not enough information for such a verification. We must mention that the total quantity of data for the bands (6.2) and (7.3) was less than for (4.1) and (5.2). Therefore, the results for the bands (6.2) and (7.3) are less reliable.

It is well known that there have been a large number of studies on the lunar variations in intensities of airglow emissions. However, the existence of these variations has still not been definitely established [9-11]. From an examination of the curves of the lunar variations for the OH bands, we can see that, if there are no significant variations in the intensity for some bands, then the lunar variations of the rotational temperature have the characteristic appearance of tidal oscillations. The shape of the curve for the variation in T_{rot}, obviously can be caused only by a simultaneous change in the height and the width of the emitting layer. The exclusion of the 27-and 29.5-day periods for the variations in T_{rot} from the data of the observations somewhat decreases the variance of the points on the graphs of the seasonal variations in T_{rot}.

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