

# EMISSION OF THE HYDROXYL BANDS AND OF THE (0,1) 18645 Å ATMOSPHERIC BAND OF OXYGEN IN THE NIGHTGLOW

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**Abstract**—Measurements made at Zvenigorod show that the intensity of the (0,1) atmospheric band of oxygen depends upon the rotational temperatures of the  $O_2$  and OH bands. The relation is similar to that between the intensity and the rotational temperature of the OH bands as observed at Yakutsk.

Systematic observations of the night sky emissions in the visible and near infrared spectral regions which have been carried out in Zvenigorod have enabled us to elucidate a number of characteristics of these emissions. As shown previously comparison of the intensities  $I$  and rotational temperatures  $T$  of the (9,3) OH band does not reveal any definite

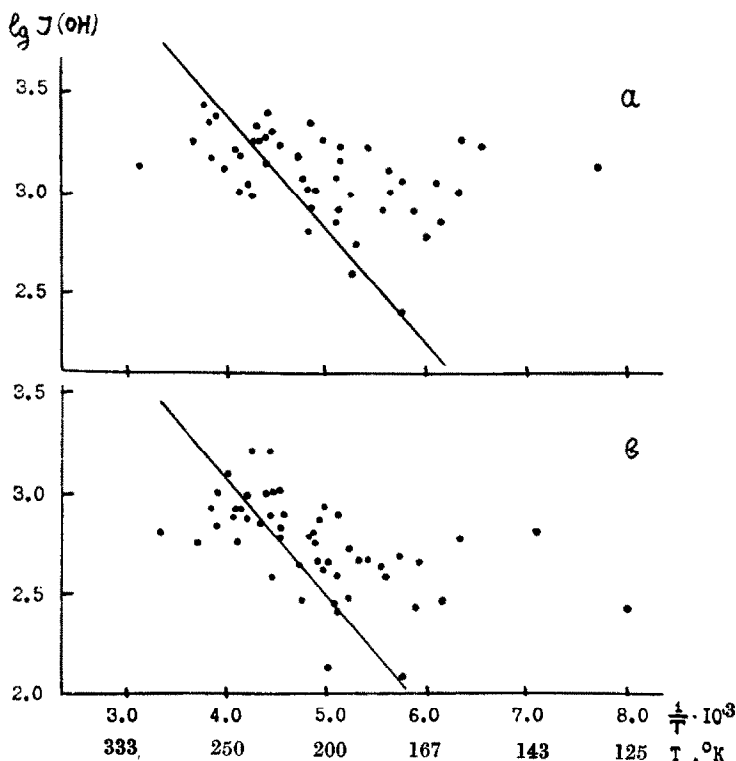


FIG. 1. THE RELATION BETWEEN THE INTENSITIES AND THE ROTATIONAL TEMPERATURE OF OH BANDS.  
a (7,3)OH, b (6,2)OH.

relationship.<sup>(1,2)</sup> During and after the IGY extensive material on the (4,1), (5,2), (6,2) and (7,3) OH bands was obtained. The spectra of the (6,2) and (7,3) OH bands have now been analysed. The new data are given in Fig. 1, a and b. The points correspond to the

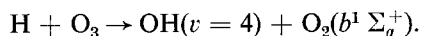
band intensities measured in Rayleighs; and the solid line\* represents the theoretical dependence calculated for the two-component reaction with the activation energy  $E$  taken to be 2.7 kcal mol<sup>-1</sup> (the value which was obtained by Yarin in Yakutsk<sup>(1,3)</sup> for rotational temperatures above 250°K). Fig. 1 confirms the dependence of the intensity of OH bands upon the rotational temperature obtained at Zvenigorod.<sup>(1,2)</sup>

The behaviour of the emission of the (0,1) 28645 Å atmospheric band of the molecular oxygen system  $b^1\Sigma_g^+ - \chi^3\Sigma_g^-$  was studied simultaneously with that of the emission of hydroxyl. The determination of the rotational temperature of the (0,1)O<sub>2</sub> band was made by comparing the observed and theoretical synthetic contours computed for different temperatures. For the computation of the energies of the rotational levels and the wave lengths of the branches of the (0,1)O<sub>2</sub> band the constants given by Babcock and Herzberg<sup>(4)</sup> were used. The intensity factors were computed with the aid of the Schlapp equations.<sup>(5)</sup> The mean measured rotational temperature for the (0,1)O<sub>2</sub> band is approximately equal to 190 ± 20° K. This is in good agreement with the temperatures found by Meinel<sup>(6,7)</sup> and by Wallace and Chamberlain<sup>(8)</sup> but is greater than the temperature found by M. Dufay and J. Dufay<sup>(9)</sup>. The mean intensity of the (0,1)O<sub>2</sub> emission is about 500 R which is less than the values given by Dufay<sup>(10)</sup> (1500 R), Barbier<sup>(11)</sup> (2000 R) and Chamberlain<sup>(12)</sup>.

Surprising results were obtained from a comparison between intensities and rotational temperatures of the molecular oxygen emission and the corresponding intensities and rotational temperatures of hydroxyl emissions. Fig. 2 a, b and c represents the dependence of the oxygen emission intensity upon the rotational temperatures of the (0,1)O<sub>2</sub>, the (7,3) OH and the (6,2)OH emissions respectively. The solid line, as before, represents the calculated dependence corresponding to a two-component reaction with an activation energy of 2.7 kcal mol<sup>-1</sup>. It is of interest to note that the intensities of the (0,1)O<sub>2</sub> band and the rotational temperatures for O<sub>2</sub> as well as for OH, measured at Zvenigorod agree rather well with the relation obtained at Yakutsk.<sup>(1,3)</sup> It is significant that a simultaneous increase of the intensity and rotational temperature of the (0,1)O<sub>2</sub> band was observed by Meinel<sup>(6)</sup>.

Comparison of the rotational temperatures of O<sub>2</sub> and OH shows that there is a correlation between them (Fig. 3a). It should be noted that the experimental error in  $T(\text{O}_2)$  is much greater than that in  $T(\text{OH})$ . Comparison of the intensities of O<sub>2</sub> and OH also reveals a definite tendency for the two to increase simultaneously (Fig. 3b).

All these data suggest that the (0,1)O<sub>2</sub> emission may arise from the same process as the hydroxyl emission. Laboratory experiments<sup>(13,14)</sup> demonstrate that these emissions may be excited through



This process was proposed earlier by Krasovskii<sup>(15)</sup> for the O<sub>2</sub> excitation.

Rocket measurements<sup>(16)</sup> show that the emission of the (0,0)O<sub>2</sub> band arises in a narrow layer at about 90 km and is absent lower than 80 km; and show also that the emission of the (0,1)O<sub>2</sub> band has a maximum at about 80 km and it is inappreciable below 70 km.<sup>(17)</sup> These data and the data given in Fig. 2 and 3 do not agree with the hypothesis that the bulk of the emission of the (0,1)O<sub>2</sub> band is due to resonance scattering of the (0,0)O<sub>2</sub> band in the lower layers of the atmosphere considered by Bates<sup>(18)</sup> and Chamberlain<sup>(19)</sup>. The lack of a close correlation between the intensities and rotational temperatures of O<sub>2</sub> and OH may be due to the fact that the hydroxyl emission arises from a number of processes depending differently upon the ambient temperature and taking place at different levels. This picture is in accord with the rocket measurements.<sup>(16,17)</sup>

\* This line is adjusted to pass through a group of points corresponding to a temperature of about 250°K.

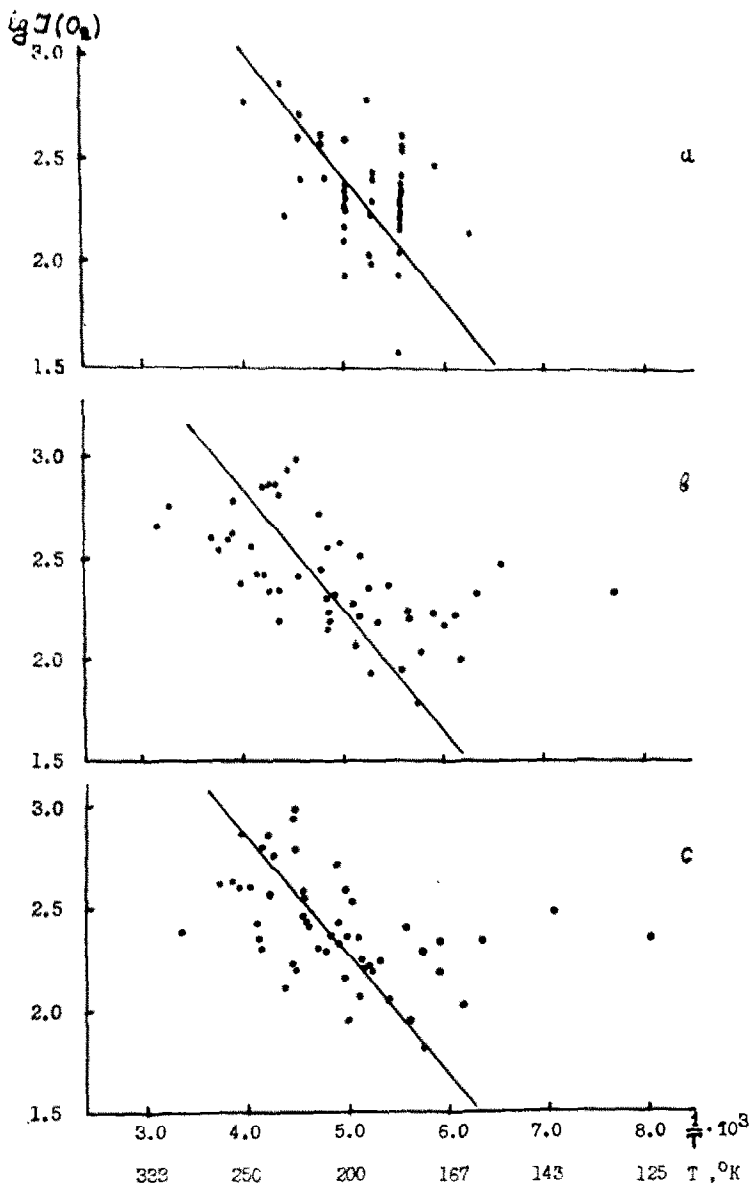


FIG. 2. THE DEPENDENCE OF INTENSITY OF THE (0,1) $O_2$  band upon the rotational temperatures of the (0,1) $O_2$  (a), (7,3)OH (b) and (6,2)OH (c) bands.

Seasonal variations of the intensities and rotational temperatures of the  $O_2$  and OH emissions are given in Fig. 4. As is seen  $T(OH)$  has its maximum in winter and its minimum in summer. These data correspond to the rocket measurements of temperature at heights in the region of the mesopause at about 80 km.<sup>(20-22)</sup> Similar seasonal variations of  $T(OH)$  and  $I(OH)$  are obtained by Fishkova and Markova<sup>(23)</sup> and Wallace<sup>(24)</sup>.

Comparison of the observed intensities of the (0,1) $O_2$  band and [OI]  $\lambda 577 \text{ \AA}$  does not indicate that they are definitely related. This result differs from that of Berthier<sup>(25)</sup> and Dufay<sup>(26)</sup>, who found a correlation between these intensities. Comparison of the observed

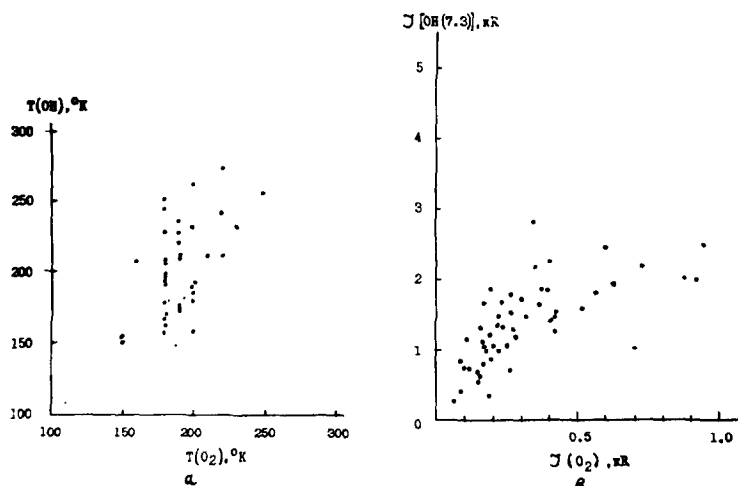


FIG. 3. THE INTER-COMPARISON BETWEEN THE ROTATIONAL TEMPERATURES (a) AND BAND INTENSITIES (b) OF THE (0,1)O<sub>2</sub> AND (7,3)OH.

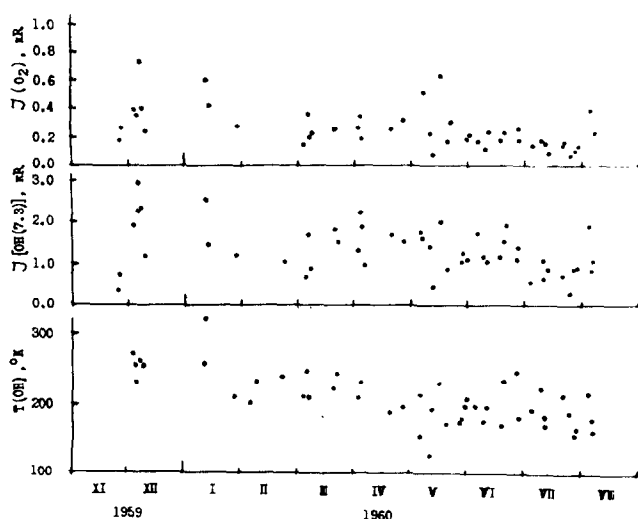


FIG. 4. SEASONAL VARIATIONS OF THE INTENSITIES OF O<sub>2</sub> AND OH EMISSIONS AND OH ROTATIONAL TEMPERATURE

intensities of the (0,1)O<sub>2</sub> emission and of Na  $\lambda$ 5893 Å and [OI]  $\lambda$ 6300, 6364 Å also does not reveal a relationship between them. No significant dependence of the intensities and rotational temperatures of the OH and O<sub>2</sub> emissions upon the magnetic activity was found.

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