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Abstract

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PHYSICS

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ON VARIATIONS OF THE INTENSITY OF THE LINE λ6562 Å H I IN THE SPECTRUM OF THE NIGHT-SKY GLOW

(Presented by Academician A. N. Terenin, 19 V 1960)

At the Abastumani Astrophysical Observatory of the Academy of Sciences of the Georgian SSR, in 1958-1959 systematic spectral observations of the night-sky glow were carried out in the region $\Delta\lambda$ 5400—6700 Å. The spectra obtained proved suitable for studying variations in the intensity of the emission line $H\alpha$ 6562 Å of atomic hydrogen, discovered in the spectrum of the night-sky glow in 1957-1958 ([1-3]). A high-aperture diffraction spectrograph SP-48 was used (aperture ratio $1 : 0.8$, dispersion ~ 85 Å/mm, slit width 3.5 Å in the spectrum); the spectra were photographed on panchromatic film of type DN, 350 units according to GOST, sensitized to low intensities by brief pre-exposure before the exposure to a density of 0.3. From January 1958 to September 1959 more than 40 spectra of the night-sky glow were obtained in the indicated spectral region in the direction $z = 67°$ N, taken during clear moonless nights with an exposure lasting the whole night; moreover, the beginning and end of the exposure corresponded to a solar depression angle $> 18°$. In all spectra the section $\Delta\lambda$ 6200—6700 Å was processed, and the relative intensity of the lines $H\alpha$ 6562 Å, $\lambda\lambda$ 6300—6364 Å [OI], and Q, P branches of the OH bands (9–3) and OH (6–1) was determined. The error of measurement, caused mainly by the coarse grain of the film used, was 5-10% for strong lines and 15-20% for weak lines. Simultaneously with the spectrographic observations, during the same nights and in the same direction, the intensity of the main emissions of the night sky $\lambda\lambda$ 5577; 5890; 6300 Å was measured each hour of clear weather in rayleighs (1 rayleigh $= 4\pi B$, where B is the brightness of the night sky in units of 10^6 quanta/cm^2·sec·sterad.) by means of an electrophotometer with light filters, calibrated in absolute units ([4]). In addition, from electrophotometric measurements of the brightness of the Pole Star α U. Minoris during each night, the coefficient of atmospheric transparency P_λ was determined ([4]). Having calculated the mean intensity of the λ6300 Å line in rayleighs for a given night in the direction $z = 67°$ N from the electrophotometric measurements, and

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Fig. 1

Figure 1: Fig. 1

knowing the ratio of the intensity of the $H\alpha$ line to the intensity of the $\lambda 6300$ Å line, determined from the spectral data, it was possible to determine the intensity of the $H\alpha$ line in rayleighs for that night and, in the same way, the absolute intensity of the above-mentioned OH bands (9—3) and OH (6—1).

Figure 1 shows the seasonal course of the intensity of the $H\alpha$ line in the direction $z = 67°$ N (curve 1) and, for comparison, the course of the intensity of the P_2 line 6554 Å (6—1) OH (curve 2). On the ordinate axis the intensity is plotted in rayleighs; each point is the mean for a period including a number of neighboring nights. The intensity of the $H\alpha$ line in the indicated direction varies during the year from $I_{H\alpha} < 5$ rayleighs to $I_{H\alpha} = 25 \pm 5$ rayleighs and reaches a maximum in July of each year. During the period of maximum, individual values of $I_{H\alpha}$ may reach values > 30 rayleighs ([12]). The intensity of the P_2 line (6—1) OH, located in the spectrum next to the $H\alpha$ line and comparable with it in

intensity reaches a maximum in November–December—a seasonal variation typical of atmospheric hydroxyl radiation, as was established earlier from observations of variations in the intensity of OH radiation in the infrared region of the spectrum over a number of years ([5]).

Fig. 1

In Fig. 1, curve 3 shows the seasonal variation of the total intensity of the OH bands in the region $\Delta\lambda$ 9400–10550 Å in kilorayleighs, which was measured systematically on the same nights by the electrophotometric method ([4]); the behavior of the infrared OH bands coincides with the behavior of the intensity of the P_2(6–1) branch. From the same electrophotometric observations it was found that the $\lambda 5577$ Å emission is maximal in October, while the $\lambda 5893$ Å and $\lambda 6300$ Å emissions are maximal in winter and minimal in summer ([4]). Thus, the intensity of the $H\alpha$ line has a seasonal variation different from the seasonal variation of the principal night-sky emissions: it is maximal in summer, in July-August, when the intensity of the other emissions is minimal.

During 9 nights the spectra were photographed simultaneously in two directions, $z = 20°$ S and $z = 70°$ N, for which purpose a right-angle prism was placed in front of the upper half of the slit of the spectrograph. The quantity $I_{70}/I_{20} = r_{H\alpha}$ was determined and compared with the analogous ratio r_{OH} for the bands P_2(6–1) OH, Q(6–1) OH, and Q(9–3) OH. In doing so, atmospheric absorption, the effect of scattering in the lower layers of the atmosphere, and absorption in the right-angle prism were taken into account. The results are given in Table 1.

For $H\alpha$, the mean for 6 nights was $r_{H\alpha} = 1.73 \pm 0.14$, and for OH, the mean for 9 nights was $r_{\mathrm{OH}} = 2.40 \pm 0.40$. The observed value of the $H\alpha$ intensity and of the ratio $r_{H\alpha}$ may be greatly affected by the distribution over the sky of that

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part of the stellar and galactic components of the night-sky glow which emits in $H\alpha$. To take into account possible distortions in this case, the equatorial coordinates of the center of the field of view of the spectrograph were computed for the beginning and end of the exposure. The size of the field of view was 12×13.5 sq. deg. From Becvar' s atlas ([6]), the objects passing through the field of view during the night were determined. It turned out that the maximum intensity of the $H\alpha$ line observed in the direction $z = 67^\circ$ N in July of each year cannot be explained by the influence of the stellar or galactic components, since at that time no objects indicated in the atlas or in the literature ([7])

Table 1

Date	$r_{H\alpha}$	$r_{\text{OH}}\ P_2(6\text{–}1)$	$r_{\text{OH}}\ Q(6\text{–}1)$	$r_{\text{OH}}\ Q(9\text{–}3)$
9-10 VI 1959	1.95	2.32	3.37	2.68
1-2 VII	1.52	1.77	1.83	2.06
2-3 VII	1.59	2.76	3.00	2.60
13-14 VII	1.69	–	1.87	2.44
2-3 VIII	1.92	2.14	2.14	3.09
29-30 VIII	1.48	3.19	2.35	3.15
Mean	1.73	–	–	–
30-31 X 1959	0.70	2.14	–	–
2-3 XII	0.90	2.40	–	–
28-29 III 1960	2.80	2.10	–	2.30
Mean	–	2.35	2.67	2.30

emitting in $H\alpha$, passed through the field of view. The same also applies to the value of the ratio $r_{H\alpha}$, measured during June-July-August 1959: it is unlikely that its value is determined by the nonuniform distribution of the stellar component emitting in $H\alpha$; on these nights such objects did not pass through the field of view of the spectrograph either in the direction $z = 20^\circ$S or in $z = 70^\circ$N. The exceptions are the nights of 30-31 X 1959 and 2-3 XII 1959, when in the direction $z = 20^\circ$S a region of the constellation Taurus passed, and the night of 28-29 III 1960, when in the direction $z = 70^\circ$N the edge of the Milky Way in the region of the constellations Cassiopeia and Cepheus passed. Both of the indicated regions contain objects emitting in $H\alpha$ (7), and, accordingly, $r_{H\alpha}$ has on these nights the anomalous value 0.70-0.90 in the first case and 2.80 in the second.

Recently a hypothesis has been put forward (8, 9) that the emission of the narrow $H\alpha$ line in the spectrum of the night-sky glow can be explained, on the basis of rocket data on the emission of the night sky in the line $Ly - \alpha$, as the result of the so-called resonance scattering (8, 9) of solar emission in the Lyman series by

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interplanetary hydrogen. It appears possible to explain the observed variations in the intensity of the $H\alpha$ line in the spectrum of the night-sky glow on the basis of this hypothesis. Indeed, according to rocket data on the spatial distribution of $Ly{-}\alpha$ emission (10), the isophotes of $H\alpha$ should be symmetric with respect to the antisolar point, at which the intensity is minimal. Then the $H\alpha$ intensity in the direction $z = 67°$N for $\varphi = 41°45'$N should be greater in summer, when the distance of the point toward which the observations are made is 40° farther from the antisolar point than in winter. From these same symmetry considerations, the isophote ratio $r_{H\alpha}$ for the given observing conditions should be 1.31-1.33. But, on the other hand, when the rocket rose above 120 km, $Ly{-}\alpha$ emission was observed also from the Earth' s side in the atmospheric layer at an altitude of 85-120 km, the albedo being 0.42 (10). Such a value of the albedo of the Earth' s atmosphere in $Ly - \alpha$ would imply a large amount of neutral hydrogen in the upper atmosphere at an altitude of 85-120 km (9). If one assumes that $H\alpha$ is also emitted from this same level, then the atmospheric part of the $H\alpha$ intensity measured from the Earth' s surface will amount to $\sim 1/3$ of the total. Since for a luminous atmospheric layer emitting at an altitude of 100 km, $r \sim 2.5$, we obtain that the total measured $r_{H\alpha}$ should be equal to ~ 1.7, which coincides with the observed value.

The observed r_{OH} agrees well with the available data on the possible height of the glow of atmospheric hydroxyl, $\sim$ 70-120 km (11). A slight decrease in the maximum intensity of the $H\alpha$ line in 1959 as compared with 1958 is possibly connected with a certain decline of solar activity by 1959.

Further photometric studies of the temporal and spatial variations of the intensity of the $H\alpha$ 6562 Å line in the spectrum of the night-sky glow should provide valuable information on neutral hydrogen in the Earth' s upper atmosphere and in interplanetary space.

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