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STUDY OF THE IONOSPHERE LAYERS IN THE INFRARED REGION OF THE SPECTRUM

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STUDY OF IONOSPHERE LAYERS IN THE INFRARED REGION OF THE SPECTRUM*

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SUMMARY

This title refers to ionosphere layers' emission in infrared. The current study is based upon previous measurements of the Earth's and atmosphere radiation into cosmic space in the infrared region of spectrum from the altitude range 25 — 500 km.

The object of the study is to bring forth certain estimates in order to corroborate the possibility, in principle, of fitting the new data into the various other data on the atmosphere.

The authors consider as established the fact of the correlation of ionosphere's infrared emission with flares near the central meridian of the solar disk.

Cutler

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Systematic measurements of Earth's and atmosphere radiation into outer space in the infrared region of the spectrum ($0.8 \div 40\mu$) from heights ranging between 25 and 500 km [6, 7, 8]. These observations were conducted at various times of the year (June, August, October) and in regions separated by distances of several thousand kilometers, the aiming of the apparatus being in different directions relative to countries of the world.

As a result of these measurements it was established that

1) from atmosphere layers above 200 km there is observed an intense infrared radiation. The upper atmosphere emission had in all cases an intensity maximum in the altitude intervals $250 \div 300$ km, $420 \div 450$ km and at ~ 500 km.

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* IZUCHENIYE SLOYEV IONOSFERY V INFRAKRASNOY OBLASTI SPEKTRA
[Note : It is the translator's opinion that the word "IZUCHENIYE" (STUDY) was misprinted for "IZLUCHENIYE" (RADIATION or EMISSION), which corresponds better to the text of the paper]

2) The radiation observed at these heights is mostly concentrated in the $2.5 \div 8\,\mu$ spectral region in the sunlit part of the atmosphere.

3) The upper atmosphere emission has an intensity maximum reaching $(3 \div 7) \cdot 10^{+2}$ watt / m^2 when aiming in the direction of the tangent, when the radiation is integrated over a ray $\sim$ 1000 km long, which corresponds to isotropic radiation of $1\,cm^3$, equal to 10^{-3} erg/sec.

4). The emission intensity depends upon the action of solar radiation on the upper part of the atmosphere and increases in the periods of solar activity maximum. The curves for the dependence of emission intensity from a horizontal direction on the aiming height, obtained during the experiments of 1958, 1962 and 18 June 1963, are plotted in Fig. 1.

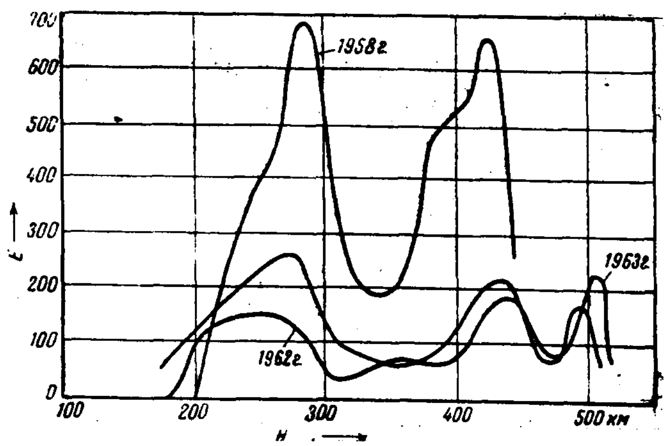

Fig. 1. - Dependence of the intensity of radiation from a horizontal direction on height.

The particular significance of the 1963 experiment should be stressed, for it fully corroborated the results obtained earlier: the emission at heights 280 and 420 km was fixed in it, and, moreover that at 500 km too. In this experiment the operational region of the spectrum was limited by the band $2.5 - 40\,\mu$.

The exhaustive interpretation of the results obtained is beyond the terms of reference of the present work. However, we believe it useful to bring forth certain estimates so as to confirm the possibility in principle of linking our new data with other information on the atmosphere.

At present we do not dispose of reliable data relative to atmosphere composition in the altitude range of interest to us, more particularly relative to complex neutral molecules and radicals of the type OH, NO, NH and so forth, and the more so, by absorption coefficients of these gases in high rarefaction and heavy thickness conditions. It appears to be useful to consider an atmosphere model, not including absorbing gases between emitting layers. The altitude and angular distributions of radiation may be in mutual agreement only in the assumption that the emission is localized in specific layers (5 — 10 km), located at certain heights, close to the upper and lower boundaries of the F_2-layer. We shall assume that the thickness of the emitting layers at heights 280, 420 and 500 km constitutes 5 km, and the effective visual angle of the apparatus (taking into account the abberations and the amplifier's time constant) $\sim 0.5^{\circ}$. It is then possible to compute and plot the course of relative intensity for the curves of radiation's angular distribution, assuming that the intensity is proportional to the length of the emitting layer, taking into account the radiation's dilution.

Plotted in Fig. 2 are such computed and experimental (1963) curves. These curves are constructed in conformity with the motion character of the apparatus's scanning system, with the aid of which the experiment is materialized. At scanning the optical system of the apparatus moved to the horizontal position and then back. This is why the obtained curves are symmetrical relative to the horizontal and correspond to various motion directions of the optical system at scanning. Hence it may be seen that there takes place a satisfactory agreement between the computed and experimental curves for the three observations heights (and also for intermediate heights). A small discrepancy in the curves may be explained by the fact that the apparatus does not register the fine structure of transition regions, and, on the other hand, by the approximation with which the assumptions were made during calculations about the layers' dimensions, their structure, the distribution of density in them by altitude and so forth. The accounting of all these factors may lead to a better agreement between experimental and computed data.

Additional calculations were performed by us for the considered model, having shown that at certain natural assumptions the experimental data allow us to obtain the number of nonequilibrium radiation events, the emission's isotropic flux and so forth. For a layer 5 km thick the length of the emitting gas column along the layer constitutes about 500 km (limited by the Earth's curvature). Therefore, for a measured flux of 10^2 watt/m^2 the volume density will be $\sim 2 \cdot 10^{-10}$ watt/cm^3 (10^{-3} erg/cm^3); this flux constitutes about 0.07% of the solar constant's value. Consequently, to the flux obtained by us corresponds one emission event per second. In the spectrum region, where the radiation is mainly concentrated (2.5 – 8.0 μ), are located the rotating-oscillating absorption bands of molecules entering into the composition of the atmosphere, in particular H_2O, CO_2, NO, CN_4 and others.

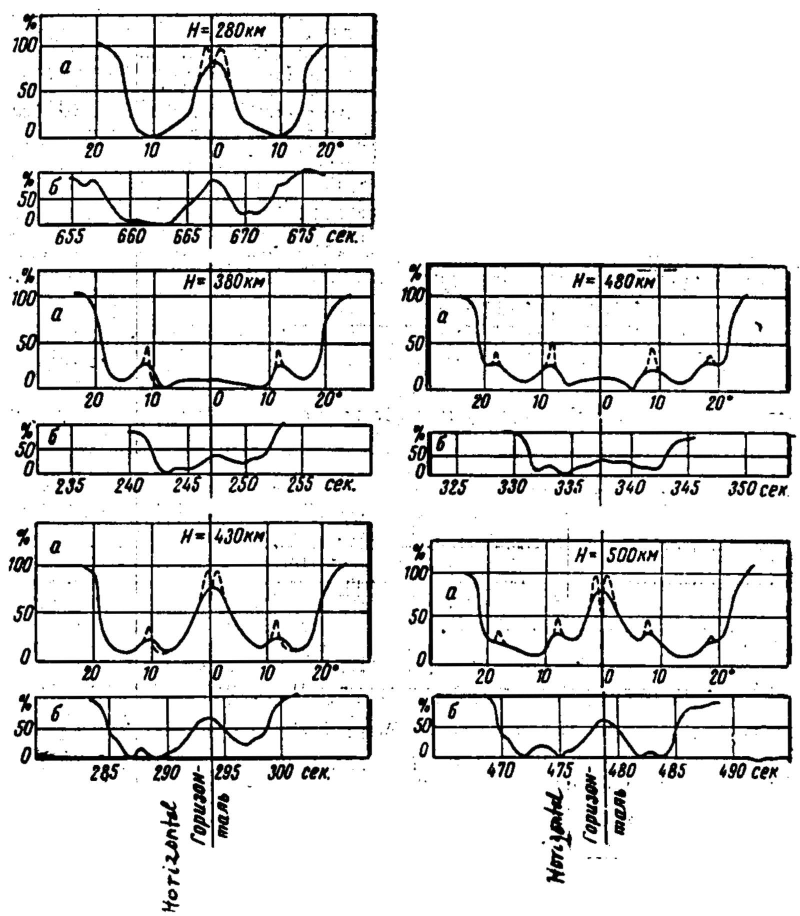

Fig. 2. - Computed (a) and experimental (б) data on the angular distribution of the radiation in the region adjacent to the horizontal aiming direction for various heights.

One of the assumptions about the emission mechanism may consist in that atmospheric gas molecules are excited by the solar flux at specific heights, and the rotational-oscillating transitions in their energy spectrum are responsible for the radiation.

But the data on neutral composition of the atmosphere in the 200 ÷ 500 km are not sufficiently determined. Known is only the ion composition, of which the fraction in the total particle content is quite small (for example, at 300 km it constitutes only 0.1% [9] (see also [1]). However, if we assume that the ion composition reflects to some degree the concentration of neutral particles, we may derive the conclusion of a decisive role played by the NO molecules in the emission (at least at the height of 280 km). The concentration of NO ions at heights $\sim$ 200 km reaches in a series of cases 50 percent of the total number of atmosphere ions, and the molecule NO has an intense absorption band near 5.3 (according to data of [2]). Thus, under these assumptions the concentration of neutral NO molecules, for example in the lower layer, could attain 10^9 cm^{-3}, while the total number of emitting particles over a path length of the order of 500 km is $\sim 10^{17}$. Rough estimates show that, at the same time, for the observed emission intensity the effective temperature, determined by the NO absorption band, reaches the order of 2000° K.

One can not exclude the assumptions of complex excitation mechanism of atmospheric molecules as a result of photochemical reactions, recombination processes etc. However, at present there are no sufficient foundations for bringing forth either mechanism. Estimates of electromagnetic energy of solar radiation in various regions of the spectrum show that its value is insufficient for the observed intensity, so that the required fluxes may apparently be conditioned only by solar corpuscular radiation. Indeed, according to data of [3 — 5], corpuscular fluxes reaching the height of 100 km, constitute several tousand erg/sec cm^2 at least during aurorae, which corresponds to the value of the flux of infrared radiation obtained by us, and possibly even more.

Inasmuch as processes in the Sun exert influence upon the infrared radiation of the atmosphere and, in particular, the solar corpuscular fluxes, reaching the Earth's upper atmosphere, we compiled in Table 1 the characteristics of the state of the Sun and of the Earth's magnetic field (function of solar activity), referred to the days when our experiments were conducted.

TABLE 1

S U N	E A R T H
Experiment of 27 Aug. 1958.	
For two days and during the experiment a flare storm was observed.	The planetary index of the magnetic field was: $K_p = 4 \div 5$.
Experiment of 6 June 1963.	
On 31 May and 1 June there was a small number of flocculi; on 4 June there was a very weak flare; on 6 June — no flares.	From 4 June to 6 June $K_p = 0$.
Experiment of 18 June 1963.	
11 — 12 June — significant number of flocculi; 16 June — 6 flares	18 June $K_p = 3.5$

The graphs of Fig. 1 show that in 1958, which was a year of solar activity maximum, the ionosphere emission was substantially greater than during the 1962 and 1963 experiments (years of the quiet Sun). In the 1963 experiments the emission of ionosphere layers on 18 June was significantly higher than on 6 June, when it was negligible.

Therefore, we may consider as established the fact of correlation between the infrared radiation of the ionosphere and the flares near the central meridian of the solar disk.

**** THE END ****

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