## 10. DISTRIBUTION OF ELECTRON CONCENTRATION WITH HEIGHT AND ITS INFLUENCE ON THE PROPAGATION OF RADIO WAVES

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ABSTRACT

In this paper there is investigated the propagation of radio waves in a non-homogeneous ionized atmosphere with a dispersion of ionization obtained as a result of recent investigations into the structure of the ionosphere.

On the basis of the wave treatment of the problem, relations were found for the electric field intensity, expressed as Airy functions; and the results were compared with the approximate solution by geometric optics.

According to the latest experimental data, there occurs a change in the ionization gradient in the E-region of the ionosphere. Here we find an approximately steady increase of ionization density with height.

According to previous assumptions, the ionization density has a maximum in the E-layer. Hence, with higher frequency and in crossing the critical value (for the E-layer), the region of signal reflexion from the E-layer has a discontinuity in the higher regions of the ionosphere ($F_1$ or $F_2$). In accordance with the new ideas concerning the dispersion of ionization, the level of signal reflexion changes gradually from the E-region to the higher regions of the ionosphere. In this paper we investigate the electric field of the reflected wave for both of these essentially different pictures of the structure of the ionosphere in the E-region, where we take into account the influence of absorption in the atmosphere. We study the reflexion of the electromagnetic wave in the F-region of the ionosphere. The field of the reflected wave is determined for frequencies close to the critical frequency of the F-region of the ionosphere, for different values of the gradient of the ionization density above maximum.

We investigate the form of the impulse reflected from a non-homogeneous ionized atmosphere with ionization dispersion, which corresponds to the new experimental data.

## 11. ABSORPTION OF RADIO WAVES IN THE IONOSPHERE AND DISTRIBUTION OF ELECTRON CONCENTRATION IN THE $F_2$-LAYER

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ABSTRACT

One of the methods used in the treatment of the results obtained during radio observations of Earth satellites consists of determining the radio-wave absorption coefficients by measurements of the electric-field strength at comparable positions.

Over the territory of the Soviet Union the Earth satellites sometimes passed below the maximum of the $F_2$-layer, sometimes above it, and sometimes near it.

By analysing the measurements of the field strength of the satellite radio signals in the area of direct visibility, and comparing integral coefficients of absorption at different heights of the satellite in relation to the maximum of electron concentration of the $F_2$-layer, it is possible to determine the radio-wave absorption both in the whole thickness of the $F_2$-layer and in its two halves as well as in lower regions.

Preliminary investigations show that the value of the integral absorption in the $F_2$-layer, found experimentally, agrees well with that calculated for the so-called 'bi-parabolic' layer with exponential extension. Using a model in which the variation of a distribution model of electron concentration with height most closely corresponds to the



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experimental data, the number of electrons in a vertical column of 1 $cm^2$ cross-section was determined both for the lower and upper regions of the $F_2$-layer. For the upper region this figure turned out to be twice that for the lower one. At great distances of the satellite from the observation post, beginning with 6000–8000 km, the field strength exceeded the values obtained from the equation for ideal radio transmission. This indicates that electromagnetic energy was propagated, due to formation of ionosphere wave-guides, to great distances which made it possible to receive satellite radio signals at distances reaching 16,000 km.

## 12. SATELLITE ORBITS AND ATMOSPHERIC DENSITIES AT ALTITUDES UP TO 750 KILOMETERS OBTAINED FROM THE VANGUARD ORBIT DETERMINATION PROGRAM

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The satellites 1958 $\beta_2$ (Vanguard I) and 1958 $\gamma$ (Explorer III) represent extremes from the orbit-determination standpoint. The absolute fluctuations in the mean motion were smallest for the former, and largest for the latter, among the satellites for which precision Minitrack radio observations were available. Accordingly, the orbit of the former has been determined with the greater precision. Even in the case of 1958 $\gamma$, however, the root-mean-square value of the residuals is less than twenty minutes of arc. The radial distances between adjacent arcs at the times for transferring from one arc to the next are of the same order as the residuals within the individual arcs. The results obtained with this satellite are of interest since they indicate what can be done in the way of determining the orbits of satellites having very low perigees and very high fineness ratios. Errors of less than four minutes of arc have been obtained for some of the orbital arcs of 1958 $\beta_2$ [1].

A significant measure of air density at a very high altitude was obtained from the orbital data for this satellite. In the case of 1958 $\beta_2$, the drag parameter has the value 3·25 g/$cm^2$, if diffuse reflexion with no accommodation is assumed. The observed rate of change of period was $3{\cdot}1 \times 10^{-4}$ minutes per day during the first three months of its lifetime. If the atmosphere over the entire orbital range is considered to be isothermal, these data imply the relation between perigee density and scale height which is indicated by the uppermost curve of Fig. 2. An assumption about scale height allows one to arrive at an estimate of the density at this altitude. Similar curves for other altitudes also appear in this figure. It is seen that the 750 km level is of particular interest. At this height any assumption as to scale height in the range from 125 to 350 km yields very nearly the same implication concerning the density. This height can thus be regarded as a pycnometric level, i.e. a level at which the density is separated relatively well from the other atmospheric parameters, and hence can be determined by means of the satellite observations on the basis of assumptions which are not very restrictive. This type of analysis has also been conducted for two other cases, corresponding to temperature gradients of 2° per kilometer, and 4° per kilometer, respectively. The resulting curves of density versus scale height are similar to those of Fig. 2. The 750 km level again has useful pycnometric properties. The atmospheric density is found to lie within about 8% of $1{\cdot}2 \times 10^{-16}$ g/$cm^3$ for all scale heights between 125 and 350 km and all temperature gradients from 0° K per kilometer to 4° K per kilometer. Variations of about 25% were observed in the period decrements for 1958 $\beta_2$ during the period covered by this study. Correlations with other geophysical and solar parameters are being sought in further analyses. The effect of contributions of charged particles to the drag would be to decrease the corresponding value of the total mass density [2]. Estimates based upon moderate assumptions about the charged-particle drag indicate that it may contribute perhaps 10% of the total drag effect.