INTENSITY OF TRANSMISSION OF RADIO SIGNALS
REFLECTED FROM IONOSPHERIC INHOMOGENEITIES
DIRECTED ALONG THE EARTH'S MAGNETIC FIELD

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Experimental results are reported for an investigation into the activity of radio signals strongly scattered by anisotropic inhomogeneities of the ionosphere: the distribution of peak amplitudes is given, together with the diurnal variation of the percent contribution of various forms of reflections and their total number and overall duration, the diurnal variation of the average duration of discrete radio reflections, the diurnal variation of the space factor, and the distribution of reflection duration. The experiment was carried out over a latitudinal path located in the middle latitudes; it was ~1400 km long. The center of the active scattering zone (equidistant from transmitter and receiver) was located to the north of the plane of the arc of the great circle between transmitter and receiver at an angle of 22°. Continuous-wave transmissions were made at 74 and 44 MHz. The results obtained were compared with analogous data for meteor propagation and auroral radio reflections.

INTRODUCTION

It was shown by Hines and by Forsyth and Vogan [1, 2] that the influence of the Earth's magnetic field makes possible the selective nature of observations of forward-scattered meteor signals. Specially designed experiments [3-5] later proved that long-range propagation of meter waves was possible owing to scattering by ionospheric inhomogeneities localized at altitudes of the order of 100 km and oriented along the lines of force of the geomagnetic field.

In the autumn of 1969, summer of 1970, and autumn of 1971 several experiments were organized and conducted over a latitudinal path ~1400 km long in the south of the European part of the country (φm. l. ≈ 45°) in order to investigate the characteristics of signals reflected by magnetically-oriented inhomogeneities (MOI). The center of the active scattering zone was equidistant from transmitter and receiver; it lay to the north of the plane of the arc of the great circle (between transmitter and receiver) at an angle of 22° [6]. The magnetic dip and declination at the center of the active zone were 65 and 6°, respectively. Continuous-wave transmissions were made at 74 and 44 MHz. Transmitter power was 2 kW for simultaneous operation on two frequencies and 4 kW for operation on just one frequency. The Yagi transmitting antennas had a radiation-pattern width of 12° for operation on 74 MHz alone. The receiving antennas were Yagis having radiation patterns with a width of 24° in the horizontal plane and double-rhombic antennas with a corresponding pattern of −10°. The receiving systems, using type R-250M base receivers, could operate in two modes: linear and logarithmic.

During the first cycles of experiments ordinary meteor reflections were received along with radio signals propagating with the indicated "zigzag geometry" on a path having the same transmitting and receiving points but located along an arc of a great circle. Here both channels were identical in terms of energy relationships (the same transmitter power, identical antennas). Only the frequencies differed slightly (by 50 kHz), as required for channel separation during reception. This made it possible to compare signals reflected from MOI with ordinary signals scattered by the sporadic (in space) meteors.

It was thus possible to determine the specific features of radio signals reflected from MOI. In particular, we could compare the quantity and duration of such signals at the same level.

In addition to ordinary signals reflected by meteor trails, a special type of signal propagated over this path; such signals are called H_E signals.

The majority of signals received may be classified into three types on the basis of their statistical nature and duration [7]: burst-type, quasicontinuous, and background.

Burst signals may, in turn, be divided into three types by analogy with the classification of meteor reflections given in [8]. The first type includes signals having a steep leading edge, no flat top, and an approximately exponential drop in amplitude with time. Such signals may be of the nonfading or fading type. The second type comprises bursts having a flat top. For most such signals, as a rule, the amplitude fluctuates sharply as their level decreases. Bursts exhibiting a fairly slow increase and decrease in amplitude belong to the third type. Most signals of this type have an envelope with a pronounced peak; this is most probably produced by satisfaction of the condition of specular reflection at this instant. There is a variety of this type of signal that has no well-defined peak, a somewhat lower level, and a far greater duration; we refer to these as nonspecular-reflection signals.

One feature of radio-wave scattering by ionospheric MOI that distinguishes this process from ordinary meteor reflections is the presence of continuous signals over an extended period of time (up to dozens of minutes or even several hours). Although such signals are accompanied by very heavy fading (they do not reach the zero level, however), they are fairly steady-state. The process during which the amplitude of these signals increases and decreases while they appear and disappear takes dozens of seconds and may last several minutes.

The background signal was recorded quite frequently in the 1970 experiments and less frequently in the 1969 and 1971 autumn sessions. The low but continuous signal is usually observed during the night and morning hours. It occasionally reaches quite high levels during the morning, considerably complicating the statistical processing of the remaining types of burst-like signals.

For the discrete form of signal propagation it is necessary to investigate the degree of activity (i.e., such parameters as the frequency of occurrence and duration, the diurnal and seasonal variations, the distributions over levels and durations, the dependence of the activity on the path geometry, etc.).

The methodology of discrete statistics is well developed in the study of meteor propagation, but when it is employed in our case certain difficulties are encountered in estimating the intensity of long bursts, quasicontinuous signals, and even short bursts when a background signal is passing at the same time.

Data from the summer experiments of 1970 and, in part, the autumn expedition of 1971 were used to investigate the intensity of H_E signals. In this series of experiments the receiver systems operated in the logarithmic mode and made it possible to record signals with no substantial distortion up to 50 dB above the level of cosmic noise and receiver noise. Only those signals exceeding 0.3 μV in level were used to evaluate burst-like H_E signals. Burst duration was estimated for the 0.1 μV level. The estimated activity of H_E signals was investigated just at 74 MHz. For the given path the effective wavelength (λ_e = λ sec θ, θ is the scattering angle) was 19 m. The statistical population of discrete signals taken for processing was 37,260 bursts.

1. Intensity of Transmission of Burst-Like Signals

a) Distribution of Peak Amplitudes. To understand the mechanism for propagation of burst-like signals it is very important to determine the relationship between the peak amplitudes of such discrete signals and the frequency of their appearance. The distribution of peak amplitudes has been found for the period covering the second half of June and the first half of July, 1970.

Figure 1 shows a graph characterizing the number of reflections whose intensity exceeds a prescribed value.

Despite the existence of very long bursts and the fact that they are more complicated in their statistical character than ordinary meteor signals, the experimental result obtained for peak-amplitude distribution is typical of meteor propagation.

b) Diurnal Variation in Percent Contribution by Various Types of Reflections to the Total Number. Figure 2 shows the diurnal variation in percent contribution by various types of reflections to the total number for the 0.3 μV level. For this level the largest numerical contribution is represented by type-I