Model of the Meteor Trail Coherent Scattering

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Abstract - **The model of the meteor radio channel based on the heuristic solving diffraction problem of the signal scattering by the ionized meteor trail, which allows to estimate coherent component of the time-varying scattered signal power is proposed.**

Keywords – **meteor trail, coherent scattering, electron density**.

I. Introduction

The ionized meteor trail is characterized by three developmental stages:

1. The initial phase, during which the trail is formed within a few Fresnel zones.
2. Phase, during which the meteor trail is fully formed, and the electron density exceeds a critical value, where the dielectric constant inside the trail is less than or equal to zero.
3. Phase of expansion of the meteor trail due to diffusion, resulting in the electron density decreases and becomes less critical, and the scattering signal is determined by the differential cross section of the plasma electrons with their collective interaction.

To solve this problem in diffraction rigorous formulation is almost impossible, forcing to use heuristic solution methods.

II. Model of the Coherent Scattering

The model of coherent wave scattering by the meteor trail, which takes into account specified in the introduction scattering mechanisms is proposed. Using this model, power of the scattered signal can be described by the expression

$$P_{coh}^{\Sigma}(t)=P_{coh}^{(1)}(t)+\rho(t)P_{coh}^{(2)}(t), \qquad (1)$$

where $P_{coh}^{(1)}$ - coherent component of the signal power scattered by the overdense part of the meteor trail, $P_{coh}^{(2)}$ - coherent component of the signal power scattered by the underdense part of the meteor trail, ρ(t) – weighting function that determines the influence degree of overdense and underdense parts of the meteor trail on the value of the scattered power.

The initial stage of the meteor trail formation considered time interval at which the meteoroid crosses the first and subsequent Fresnel zones. At this stage there are power fluctuations of the scattered signal (Fresnel oscillations) [1].

In the second stage for the meteor trails with the radius (0.01-0.5)λ, and the length exceeds 0.5λ calculated the effective surface scattering using a rigorous solution for an infinite metallic cylinder based on Maxwell's equations [2].

Scattering by overdense part of the trail, in the approximation of the metal cylinder, determined by time-varying critical radius, which is defined as the boundary of the cylinder, within which the dielectric constant is zero.

Upon scattering from the overdense part of the trail simultaneously there are effects of scattering on the metal cylinder and on the fluctuations of the dielectric constant, that increase the scattering intensity is several times [3].

Over time, the value of the bulk electron density decreases and becomes less than the critical value, and dominant becomes the scattering by the underdense part of the meteor trail. The calculation of scattering by this part performed using the scattering function [4] under the assumption that the operating frequency of the signal exceeds the Langmuir frequency.

The influence degree of overdense and underdense parts of the meteor trail on the value of the scattered power can not be strictly defined and involves the use of empirical coefficients to ensure alignment with the observations.

Modeling results of the scattered by the overdense meteor trail signal power, calculated for harmonic signal with a frequency of 37 MHz, are shown on the figure 1, where 1- $P_{coh}^{(1)}$, 2 - $P_{coh}^{(2)}$, 3 - P_{coh}^{Σ}.

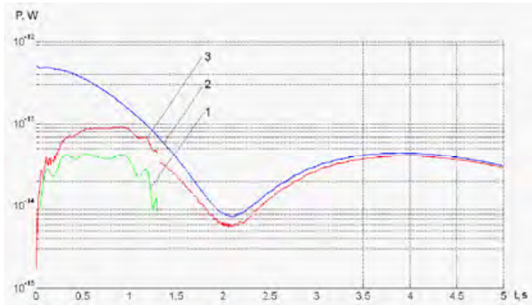

Fig. 1 Modeling result of the time-varying scattered by the meteor trail signal power

III. Conclusion

The model of the meteor radio channel based on a heuristic solution of the diffraction problem of the signal scattering by the ionized meteor trail is developed. Based on the model, proposed the analytical expression that allows to calculate the power of the scattered signal coherent components, to estimate the lifetime of the suitable for information transmission meteor trail and describe the features of the observed diffraction oscillations.

References

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