SINGLE SCATTERING OF WAVES

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ОДНОКРАТНОЕ РАССЕИВАНИЕ ВОЛН

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Resume

The features of the propagation of electromagnetic waves in randomly inhomogeneous medium have been studied quite thoroughly to date. However, in practice, electromagnetic waves are scattered in inhomogeneities, the scattering of which depends on the direction of the incident wave.

Keywords: *wave scattering, electromagnetic waves, direction of the incident wave, wave characteristics*

Резюме

К настоящему времени особенности распространения электромагнитных волн в случайно-неоднородных условиях изучены достаточно тщательно. Однако на практике электромагнитные волны рассеиваются в неоднородностях, рассеяние которых зависит от направления падающей волны.

Ключевые слова: *рассеяние волн, электромагнитные волны, направление упавшей волны, волновые характеристики*

INTRODUCTION

A random inhomogeneity in a real medium affects the characteristics of waves propagating in it, which manifest themselves in the twinkling of stars and fluctuations of radio emission from sources outside the Earth, in the path of radio waves (fading) and in the scattering of light relays, in laser cone amplification in the troposphere and in the scattering of sound in sea.

The problems of wave propagation in variable parametric media are usually solved by approximate methods. The method of using the approximation depends on the geometry of the problem, how weakly or strongly the environmental parameters, such as the ratio between the wavelength and the dimensions of the inhomogeneity, the path length, the width of the wave cone, etc., fluctuate.

FORMULATION OF THE PROBLEM.

Numerical calculations have shown that with an increase in the distance traveled by a wave in an inhomogeneous medium, the spectrum has a bifurcated shape, the position of its maxima changes insignificantly, and the width increases significantly.

Suppose that the field of monochromatic pulsation $U(\mathbf{r},t) = U(\mathbf{r})\exp(-i\omega t)$ falls into a randomly inhomogeneous medium, the dielectric constant of which is equal to $\varepsilon(\mathbf{r}) = \varepsilon_0 + \varepsilon_1(\mathbf{r})$ where ε_0 – is the average value, and ε_1 – is the fluctuating part of the dielectric constant. Suppose that the following conditions are met: $\varepsilon_0 = 1$, $|\varepsilon_1| << 1$. Neglecting the effects of depolarization, the propagation of waves in a randomly inhomogeneous medium is described by the scalar Helmholtz wave equation

$$\Delta U(\mathbf{r}) + k_0^2\,[1+\varepsilon_1(\mathbf{r})]\,U(\mathbf{r}) = 0\,. \tag{1}$$

Let us use the perturbation method and, when expanding into series, restrict in only the members of the first series, i.e. the scattered field is a linear function of the fluctuation of the dielectric constant $\varepsilon_1(\mathbf{r})$ ($<\varepsilon_1(\mathbf{r})> = 0$). To describe a random inhomogeneous medium, we use the anisotropic Gaussian correlation function:

$$V(\mathbf{r}) = <\varepsilon_1^2> \exp\left[-\frac{1}{2}\left(\frac{x^2}{a^2}+\frac{y^2}{b^2}+\frac{z^2}{c^2}\right)\right],$$

where a, b, c characterize the spatial scales of the correlation of the fluctuations of the dielectric penetration. The corresponding spatial spectrum of the Gaussian correlation function has the following form:

$$W(\mathbf{k}) = (2\pi)^{3/2} <\varepsilon_1^2>\, a\,b\,c \exp\left[-\frac{1}{2}(a^2k_x^2+b^2k_y^2+c^2k_z^2)\right],$$

where k_x, k_y, k_z are the wave vector projections, respectively, on the axles x, y.

CONCLUSIONS

Simulation of scattered radiation in a two-dimensional inhomogeneous medium can be carried out using a simple Gaussian indicator:

$$\chi(\mathbf{s},\mathbf{s}') \propto \exp\left\{-\alpha_\perp^2\left[(s_x-s_x')^2+(s_y-s_y')^2\right]-\alpha_\parallel^2(s_z-s_z')^2\right\}, \tag{2}$$

where $\mathbf{s} = (s_x, s_y, s_z)$, $\mathbf{s}' = (s_x', s_y', s_z')$ - are the unit vectors of the direction of the primary and scattered waves, $\alpha_\perp = \pi l_\perp/\lambda$, $\alpha_\parallel = \pi l_\parallel/\lambda$ – are immeasurable parameters, where $l_\perp$ da $l_\parallel$ – are the transverse and longitudinal correlation radii, respectively, and λ – is the wavelength.

With all kinds of variations in specific media, a significant part of the problems can be solved by several approximate methods, well developed to date. If the relative fluctuations of the medium parameters are weak enough and the scattered field is small compared to the field of the primary wave, then the method of small perturbations can be used. According to the first approximate method of perturbation theory, the analysis of fields is the content of the theory of single scattering. If the media for applying the theory of single scattering are violated (fluctuations in the medium are not weak enough, and the scattered field is not weak), it is necessary to use the theory of multiple scattering of waves.

Multiple scattered waves on weak, but large-scale (relative to the wavelength) inhomogeneities will only slightly deviate from the direction of propagation of the primary wave. Under such media, multiple scattering is effectively described by the short-wavelength asymptotic method of diffraction theory - the method of soft perturbations.

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ДО ПИТАННЯ РОЗРАХУНКУ ГНУЧКИХ СХЕМ ПРОМИСЛОВОГО ВОДОСПОЖИВАННЯ

Поплєвськи Г.[1], Шахновський А. М.[2]

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К ВОПРОСУ РАСЧЕТА ГИБКИХ СХЕМ ПРОМЫШЛЕННОГО ВОДОПОТРЕБЛЕНИЯ

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У статті представлено методологію оптимального проектування гнучких схем водоспоживання. Пропонований підхід базується на теоремі про кутові рішення. Методологія є багатоетапною, причому кожний з кроків процедури розрахунку реалізуються із використанням математичних методів оптимізації. Пропонована методологія проілюстрована промисловим прикладом: розглянутій системі водоспоживання притаманні систематичні та випадкові коливання