Modeling of Electromagnetic Wave Propagation in
Stratified Discrete Media Including the Inhomogeneous Flow of Scatterers

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Introduction

In paper is created a three-dimensional model of electromagnetic wave scattering on the stratified random discrete media, including the inhomogeneous flow of scatterers. There are investigated the dependencies of scattering and absorbing signals energies from the parameters, describing of inhomogeneous structure of random discrete media and the flow of scatterers. The results of analysis of frequency spectrum of signal scattered from the flow are presented.

Method

There is suggested that the source of electromagnetic wave with isotropic diagram of over-radiating is disposed on the surface of stratified media including of inhomogeneous flow. For solve the task we used the stochastic method of computation of electromagnetic wave multiple interaction with discrete random inhomogeneities in the stratified media [1-4]. Here is assumed that the wavelength of the wave is less than the sizes of the layers and flow, moreover scattering occurs incoherently by an image on statistically independent discrete inhomogeneity. The oscillator of electromagnetic signal is presented as a source of photons with corresponding diagram of radiation. The initial coordinates of photons get out in the point of oscillator disposition. The type of wave interaction with discrete inhomogeneity is determined according to set cross sections of absorption and scattering. In case of fulfillment of a wave scattering condition the direction of photon propagation changes according to set indicatrix of discrete inhomogeneity over-radiation. Solving the problem of wave propagation in the stratified random discrete media, including the flow is reduced to definition of photon distribution function [1-3]. In the result of computation we received the frequency spectrum of scattering signal and the energies of absorption and scattering signal in space coordinates.

Results of numerical modeling

Here is considered the source of electromagnetic signal with isotropic indicatrix of radiation, which disposed on the surface of stratified media in the point with coordinates $x = 0, y = 50, z = 50$. All data in this paper are measured in the relative units. The media is characterized of the presence of the layers and the flow of scatterers in the form of a parallelepiped. Geometry of the task is presented in the Figure 1. In the Figure 2 are shows the profile of concentration $N$ and the profile of velocity $V$ of flow scatterers. The input data of the coefficient of wave absorption and middle free wave propagation distance in the media are presented in the Figure 3 and Figure 4 accordingly. In Figures 5 and 6 are shows the profiles of velocity and concentration of flow scatterers, which used in our numerical experiments. The frequency spectrum of incident wave is presented in Figure 7. This spectrum has the form of gaussoid. The result of computation of frequency
spectrum of scattering signal in dependence of scattering angle is presented in Figure 8. The analysis of this results shows that the form of spectrum is conserved, though here is occurred the essential expansion of spectrum width. This fact may be explicated by the results of wave scattering on the moving scatterers [4]. In the Figure 9 shows the results of calculation the distribution of energy absorbing in stratified media, including the semitransparent object. Here we can see the missing of energy wave inside of the object because the coefficient of wave absorption in this area is very small (Figure 3). In the Figure 10 is presented the result of computation of energy scattering signal in the media. Here we can see that the photons are registered in the area of object shadow that appropriates the phenomena of diffraction. This result is explained by the chaotic direction of moving photons in the media after acts of scattering on the discrete inhomogeneities.

Conclusions

There is has been developed the stochastic model of multiply interaction of electromagnetic wave with the stratified random discrete media, including the flow of scatterers. The numerical computations of frequency and angular spectrum of multiply scattering and absorbing signal are implemented. The three-dimensional visualization of receiving results has been realized. The results of numerical experiments are demonstrated the reflection of electromagnetic wave from the semitransparent object and the penetration of photons inside of area of object shadow. In a future we plan to optimize the algorithm with the aim of decreasing the time of computation.

References:


Figure 1: Geometry of the task. Figure 2: The profiles of concentration and velocity of the flow.
Figure 3: The coefficient of wave absorption in the media.

Figure 4: The middle free wave propagation distance in the media.

Figure 5: The profiles of scatterers velocity.

Figure 6: The profiles of scatterers concentration.
Figure 7: The frequency spectrum of incident wave.

Figure 8: The frequency spectrum of scattering signal.

Figure 9: The distribution of energy signal absorbed in media.

Figure 10: The distribution of energy signal scattered in media.