Functional characteristics estimation of intensity field of transmitting radiation for realistic models of random media by the Monte Carlo method

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Using the Monte Carlo simulation of the transport of particles (radiation quanta), a detailed analysis of the particle passage through a stochastic medium averaged over the realizations of this medium is given. This is important for applications in particular because, if the ergodicity property is fulfilled, this averaging is equivalent to averaging over the surface of a sufficiently large detector of particles, which is confirmed by the analysis given in this paper. The analysis uses the so-called mosaic models of homogeneous isotropic random fields (media) with known correlation functions that, accordingly to the previous investigations, to a large measure determine the mean probability of passage P. The present investigation is devoted to the verification of the similar property of functional characteristics of the random field of transmitted radiation: correlation functions and the mean angular distributions. For this purpose the comparative estimates were realized for the elementary Poisson mosaic field and for realistic random field, determined by the sum of special elementary Poisson mosaic fields.

The logically simplest approach to the estimation of such functionals as P seems to solve a series of radiative transfer problems for a number of realizations of the stochastic medium and then average the probabilities of passage. However, the computational complexity of this method applied to real-life problems is too high. For such models, the conventional approaches based on closing the chain of probability moments and small perturbation theory gives estimates with a poorly controlled error. For this reason, we use in this paper the so-called double randomization technique in which one or more (depending on the order of the moment) particle trajectories are simulated for each realization of the medium.

To simulate trajectories of particles in mosaic media, special algorithms of the maximum cross section method based on the geometric leveling of the medium attenuation factor by adding an artificial delta-scatterer to the medium are developed. It is shown that this method is the direct consequence of the known rejection property of the Poisson point flux.

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