Multiple scattering in discrete random media using incoherent interactions

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We consider scattering and absorption of light in discrete random media of densely packed spherical particles. The particle size is assumed to be of the order of the wavelength. First, we extend the numerical Monte Carlo method of radiative transfer and coherent backscattering (RT-CB, [1]) to the case of dense packing of particles [2]. We adopt the ensemble-averaged first-order incoherent extinction, scattering, and absorption characteristics of a volume element of particles as input for the RT-CB. The volume element must be larger than the wavelength but smaller than the mean free path length of incoherent extinction. In the RT part, at each absorption and scattering process, we account for absorption with the help of the single-scattering albedo and peel off the Stokes parameters of radiation emerging from the medium in predefined scattering angles. We then generate a new scattering direction using the joint probability density for the local polar and azimuthal scattering angles. In the CB part, we utilize amplitude scattering matrices along the RT path and the reciprocal path, and utilize the reciprocity of electromagnetic waves to verify the computation. Second, in what we term radiative transfer with reciprocal transactions (R^2T^2, [3]), we derive the volume-element scattering and absorption characteristics using the Superposition *T*-Matrix Method (STMM, e.g., [4]), and compute its incoherent volume-element scattering characteristics. Using an order-of-scattering approach (resembling that in RT-CB), we then compute a numerical Monte Carlo solution for the scattering problem with an exact treatment of the interaction between two volume elements. We compute both the direct and reciprocal contributions along a sequence of volume elements, allowing us to evaluate the coherent-backscattering effects. Finally, we show that the dense-medium RT-CB and R^2T^2 solutions are in agreement with the exact STMM solutions for large finite systems of densely packed spherical particles [2,3]. We study the effect of the finite volume-element size on the computation of the incoherent scattering and absorption characteristics for the elements themselves as well as for the entire discrete random media.

References

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