Multiple Scattering in Turbid Liquids: Theory, Simulation, and Experiment

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In highly turbid samples, the scattering intensity contains single and multiple scattering contributions. New techniques enable the separation of single scattering from multiple scattering. Multiple scattering contributions can also be analyzed, which requires the assessment of such contributions by both theory and simulation.

We report simulations of the scattering processes in Latex solutions with particles of different sizes (diameters of: 50, 100, 250, and 450 nm) and of mixtures in the vicinity of the critical solution point. The polarized and depolarized contributions to the intensity and corresponding time-correlation functions are calculated for singly scattered light and various multiple scattering contributions. Simulation results are compared to analytical calculations and experimental results. Even in highly turbid samples, the majority of multiple scattering contributions reaching the detector involve particles essentially within the scattering volume defined by the scattering geometry. In highly turbid samples, the maximum of the scattered intensity is shifted to the positions within the scattering volume where the light–path is short. The time dependence of the correlation function assumes a universal structure: at short times the decay of the correlation function is independent of the scattering angle, given by the product of the multiplicity of the scattering with the angular average of the time constant for the decay of the correlation function of singly scattered light. At longer times, the decay is determined by the intermediate scattering angles leading to the shortest light path. The intersection between the two regions is determined by the size of the particle, where the short time region becomes smaller with increasing particle size. In the Gaussian approximation, the exponents of the form factor and the time-correlation function of single scattering, form a universal parameter for determining the intensities and correlation functions of the various multi-scattering contributions.