Analytical Cumulant Solution of the Radiative Transfer Equation for Light Scattering in Turbid Media

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We will discuss an analytical solution of the time-dependent radiative transfer equation in an infinite uniform medium with an arbitrary phase function using cumulant expansion, and compare the theoretical results with the Monte Carlo simulation and experiments.

The expression of the exact spatial cumulants of light distribution function, up to an arbitrary high order, at different angle and time have been derived. We plan to briefly review this derivation. The first cumulant represents the center of the distribution, and the second cumulant represents half-width of spread of the distribution, which can be fast and exactly calculated using the analytical expression. The photon distribution function is expressed by a Gaussian distribution for late times and for backscattering, or by a reshaped distribution for transmission at early times, with exact center and exact half-widths. The computed time-resolved profiles match with that of the Monte Carlo simulation.

The analytical cumulant approach is extended for solution of the polarized (vector) radiative transfer equation. Our computation shows that in the backscattering case circular polarization helicity flips with increase of the size of scatters. These results are compared with our recent experimental results using circular polarization. Approach for including the semi-infinite and slab boundaries is tested, and the results are shown.