Deconvolution-improved angular resolution in the early-time diffusion imaging through random media +

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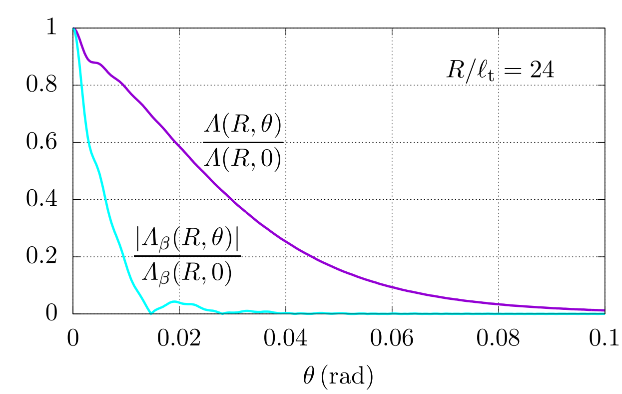
The "early-time diffusion" (ETD) phenomenon has been identified [1] as a specific component of the radiative transfer equation (RTE) solutions for a pulse propagation in a medium consisting of scatterers fairly large compared to the wavelength. The ETD signal is characterized by a sharply rising structure in the time-resolved intensity. That signal, when extracted by high-pass filtering, can be potentially useful in imaging through obscuring media. Although a fine range resolution is achievable, the angular resolution is affected by the spread in the energy flux density, related to the angular width of the forward-scattering peak of the scattering cross-section on a single medium constituent.

This contribution presents improvements in the angular resolution, as measured by the width of the point-spread function (PSF) associated with the ETD signal,

Reduction of that width is achieved by means of (Tikhonov-type) regularized deconvolution. This technique allows us to fully utilize that segment of the PSF spectrum in which the PSF decays with the distance at the lower rated than the coherent signal. The improvement (shown in the Figure) was achieved with a regularization parameter β set above the level of the coherent contribution to the radiance, i.e., assuming that the coherent signal component is below the noise level and may be unobservable. In this way, the obtained FWHM ≈ 0.01 radian represents the PSF dominated by the incoherent ETD contribution.

The original PSF Λ of the ETD signal for the propagation distance R equal 24 mean free paths ℓ_t, compared to the narrower PSF Λ_β obtained by a deconvolution with a regularization parameter β.



[1] E. Bleszynski, M. Bleszynski, and T. Jaroszewicz, "Early-time diffusion in pulse propagation through dilute random media," Optics Letters, vol. 39, p. 5862 (2014).
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