Terahertz-wave scattering in tissues:
Examining the limits of the effective medium theory applicability

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Terahertz (THz) technology went through the rapid development during the past few decades [1]. Nowadays, they are translated to different branches of biophotonics and medicine [2-4].The THz response of tissues is usually described using various relaxation models of complex dielectric permittivity within the EMT formalism due to its ability to yields reliable estimates for the content and state of tissue water, conceptual simplicity and a number of practical easy-to-use solutions [5]. Meanwhile, a number of recent researches [6-8] works uncovered heterogeneous character of tissues at the THz-wavelength scale, which can lead to the Mie scattering of THz waves and which pushed further research into realms of studying the THz-wave transport in turbid soft tissues.

For this, we developed a tissue-mimicking phantom, that has the form of a gelatin slab, as a highly-absorbing hydrated matrix (a host medium), into which mesoscale SiO2 microparticles (scatterers with lower refractive index and loss) are embedded. Analytical methods of the Mie scattering theory [9] predicted non-isotropic differential extinction cross-section for such scatterers, which doubts the effective medium theory applicability for such tissues. Surprisingly, we found theoretically, using the radiative transfer theory, and confirmed experimentally, using THz pulsed spectroscopy, that the effective optical properties of such tissues still can be predicted by the effective medium theory over wide ranges of diameters ($d \leq 0.47\lambda$) and volume fractions ($f\text{v} \leq 0.2$) of scatterers. This is due to the strong THz-wave loss in a host medium and, therefore, should be general for a variety of soft tissues in the THz range. Thereby, our findings broadened the effective medium theory applicability in THz biophotonics.

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