# Abstract

## Using Terahertz Pulses to Study Light Scattering

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We describe a new experimental technique for studying the propagation of waves in scattering media, and apply it to the investigation of thin samples of a synthetic random medium. The measurements are based on terahertz time-domain spectroscopy, in which broadband single-cycle pulses of free-space terahertz (THz) radiation are generated and coherently detected using ultrafast photoconductive sampling. This technique offers several unique advantages over other methods used to study multiple scattering phenomena. First, the results are easier to interpret because the samples are extremely well controlled, and the refractive index and residual absorption coefficient are both known accurately. Second, the broad bandwidth of the THz radiation enables the observation of mean free paths ranging over nearly two orders of magnitude within the pulse spectrum. In principle, this permits the characterization of a full range of behavior in a single measurement. Finally, because the technique permits the direct measurement of the spectral phase of the transmitted radiation, a great deal of additional information is available. As a first demonstration of the utility of the THz system, we study the ballistic transport of THz pulses through dense distributions of spherical scatterers. We construct a model scattering medium using commercially available PTFE (teflon) spheres, of 0.794 mm diameter, contained in teflon sample cells. In order to study the ballistic transport as a function of path length, we have fabricated a series of cells, with a range of optical path lengths. These are inserted into the focus of the terahertz beam. The transmitted terahertz pulses can be used to determine the complex propagation constant for the ballistic radiation inside the medium, over a broad bandwidth. We compare these results to the predictions of the quasi-crystalline approximation (QCA). With this theoretical formulation, we compute the propagation constant using the Percus-Yevick pair distribution function to account for positional correlations of the spheres. These experiments probe a regime of very high volume fraction, which has not been thoroughly explored previously, but which could be of relevance in the understanding of electromagnetic propagation in biomedical systems. The correspondence between theory and experiment is reasonable, particularly with regard to the effective group velocity. This is somewhat surprising, since the fractional volume of particles in our experiment exceeds the accepted limits of the validity of the QCA.

¶Presenter