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Localization of sound in a three-dimensional elastic network

John Page[a], Hefei Hu[a], Anatoliy Strybulevych[a], Sergey Skipetrov[b] and Bart Van Tiggelen[c]
[a]Dept. of Physics and Astronomy, Univ. of Manitoba, Winnipeg, MB, Canada R3T 2N2
[b]Université Joseph Fourier, Laboratoire de Physique et Modélisation des Milieux Condensées/CNRS, Maison des Magistères, 38042 Grenoble, France
[c]Université Joseph Fourier, Department of Applied Physics, Hokkaido University, 060-8628 Sapporo, Japan

A long standing question in physical acoustics has been whether or not the Anderson localization of sound can be demonstrated unambiguously in three dimensions. Here we address this question by reporting evidence for the localization of ultrasonic waves in a three-dimensional granular network of weakly sintered aluminum beads. In the upper part of the intermediate frequency regime, where the ultrasonic wavelength is comparable with the sizes of the pores and beads, the intensity time-of-flight profile of the multiply scattered waves exhibits non-exponential decay, which may be construed as a slowing down of the diffusion coefficient with propagation time and is consistent with predictions for localized waves. We use a quasi point source and detector to demonstrate how localization cuts off the transverse spreading of the multiply scattered waves, an effect, which we call 3D transverse localization, that has not been observed previously for any type of wave. These results are interpreted using recent theoretical predictions based on the self-consistent theory of the dynamics of localization, allowing the localization length to be determined. Further evidence is obtained from intensity statistics, which reveal a Thouless conductance g less than unity. These results unambiguously demonstrate the localization of sound in this system.