

Anderson Localization of Ultrasonic Waves

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Fifty years after Anderson's classic paper, in which he first proposed that electrons could become localized in the presence of disorder (thus turning a metal into an insulator), there is currently a resurgence of interest in this phenomenon for both quantum particles and classical waves [1]. This interest stems from curiosity in understanding how wave interference alone can cause the breakdown of wave transport in disordered materials, leading to a transition from extended (propagating) to localized ("frozen") waves. While the basic ideas are common to many domains of physics (quantum electronics, optics, acoustics, seismic waves and even matter waves in cold atomic gasses), our focus is in ultrasonics, where recent experiments performed at the University of Manitoba have provided the most convincing demonstration ever that this elusive effect can indeed be observed for classical waves in three dimensions [2].



FIG 1: Side view of one of the brazen aluminum bead samples used in the ultrasound localization experiments.

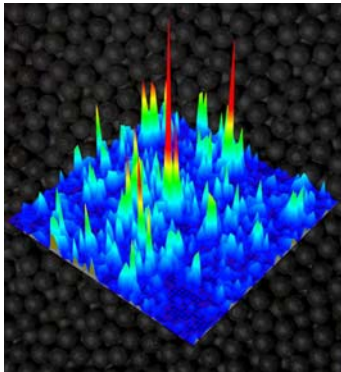


FIG 2: The wave intensity (speckle pattern) varies enormously across the surface of the sample, providing a signature of wave localization that is associated with wave function multifractality.

The goal of this project is to perform new ultrasonic experiments on well controlled samples to discover previously unexplored aspects of wave localization. One area of interest is the nature of this crossover to Anderson localization in three dimensional samples, including the multifractal character of the wave functions near this transition [3]. These experiments will take advantage of our ability to make time- and space-resolved measurements of the ultrasound wave field over a wide range of frequencies, using a combination of piezoelectric and laser ultrasound techniques. The student will gain valuable experience in setting up and performing state-of-the-art experiments, as well as in learning and carrying out the analysis of the data that has been obtained. Collaboration with a theoretical group in Grenoble, France, will facilitate the comparison of experimental results with the latest theories, thereby providing an opportunity to learn about the physics underlying the effects that are expected to be observed in the experiments.

Overall, this research opportunity will enable students, who are interested in developing their experimental and analytical skills, to investigate a fascinating wave phenomenon, thereby advancing their understanding of wave physics - itself so central to much of modern science and engineering.

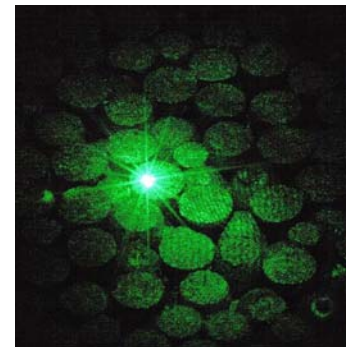


FIG 3: Measuring the ultrasonic wave function on the surface of a sample using a laser interferometer.

- [1] See *Physics Today*, August 2009.
- [2] Hefei Hu, A. Strybulevych, J.H. Page, S.E. Skipetrov and B.A. van Tiggelen, *Nature Physics*, **4**, 945-948, (2008).
- [3] S. Faez, A. Strybulevych, J.H. Page, Ad Lagendijk, and B. A. van Tiggelen, *Phys. Rev. Lett.*, **103**, 155703 (2009)