Understanding how sound waves travel through disordered materials

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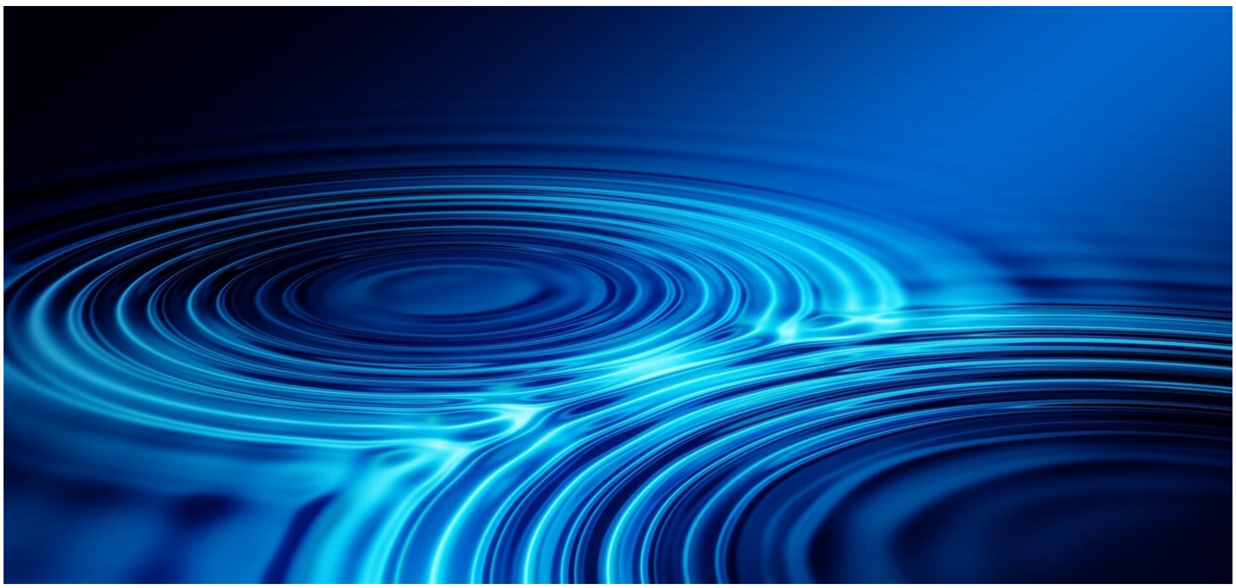

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A team of researchers lead by the University of Tsukuba have created a new theoretical model to understand the spread of vibrations through disordered materials, such as glass. They found that as the degree of disorder increased, sound waves traveled less and less like ballistic particles, and instead began diffusing incoherently. This work may lead to new heat- and shatter-resistant glass for smartphones and tablets.

Understanding the possible vibrational modes in a material is important for controlling its optical, thermal, and mechanical properties. The propagation of vibrations in the form of sound of a single frequency through amorphous materials can occur in a unified way, as if it was a particle. Scientists like to call these quasiparticles 'phonons.' However, this approximation can break down if the material is too disordered, which limits our ability to predict the strength of glass under a wide range of circumstances.

Now, a team of scientists led by the University of Tsukuba have developed a new theoretical framework that explains the observed vibrations in glass with better agreement with experimental data. They demonstrate that thinking about vibrations as individual phonons is only justified in the limit of long wavelengths. On shorter length scales, disorder leads to increased scattering and the sound waves lose coherence. "We call these excitations 'diffusions,' because they represent the incoherent diffusion of vibrations, as opposed to the directed motion of phonons," explains author Professor Tatsuya Mori. In fact, the equations for low frequencies start looking like those for hydrodynamics, which describe the behavior of fluids. The researchers compared the predictions of the model with data obtained from soda lime glass and showed that they proved a better fit compared with previously accepted equations.

"Our research supports the view that this phenomenon is not unique to acoustic phonons, but rather represents a general phenomenon that can occur with other kinds of excitations within disordered materials," co-authors Professor Alessio Zaccone, University of Cambridge and Professor Matteo Baggioli, Instituto de Fisica Teorica UAM-CSIC say. Future work may involve utilizing the effects of disorder in order to improve the durability of glass for smart devices. The work is published in *The Journal of Chemical Physics* as "Physics of phonon-polaritons in amorphous materials" (DOI: 10.1063/5.0033371).

More information: Luigi Casella et al, Physics of phonon-polaritons in amorphous materials, *The Journal of Chemical Physics* (2021). DOI: 10.1063/5.0033371

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