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On a crossover between two mechanisms of sound propagation in liquids

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Hydrodynamic theory forms the basis for our understanding of the macroscopic propagation of sound in liquids, while viscoelasticity points out solid-like elastic features at large frequencies. However, there is no understanding how the viscoelasticity manifests in the mechanism of propagation of mesoscopic and short-wavelength acoustic excitations in liquids.

We report solutions of the generalized Langevin equation for density-density time correlation functions of a liquid system in terms of dynamic eigenmodes within viscoelastic and thermo-viscoelastic dynamic models. A comparison with molecular dynamics somputer simulations for supercritical Ar is performed. It is shown by analysis of extended dynamic eigenmodes in liquids how the crossover from hydrodynamic mechanism of sound propagation to elastic one takes place. Our analysis of wavenumber-dependent eigenvector components of the sound modes makes evidence that the viscoelasticity of sound excitations is originated by gradual replacement of contribution from hydrodynamic density fluctuations by non-hydrodynamic stress fluctuations. A consequence of the sound viscoelasticity for emergence of structural relaxation is shown.

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