Vibrational phenomena in glasses at low temperatures captured by field theory of disordered harmonic oscillators

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We investigate the vibrational properties of topologically disordered materials by analytically studying coupled harmonic ocillators in the thermodynamic limit at T = 0. Exploiting field theory, we build up a self-consistent field theory by analysing the Hessian utilizing Euclidean Random matrix theory. In accordance with earlier findings [1], we take non-planar diagrams into account to correctly address multiple local scattering events. By doing so, we end up with a first principles theory that can predict the main anomalies of athermal disordered materials, i.e the Boson peak, sound softening and a transition from Rayleigh damping to a weaker dependence of the sound attenuation around the Ioffe-Regel limit. Additionally, we argue that Rayleigh-damping implies a localisation of the eigenvectors of the random matrices. This is explained by the hybridisation of the phonons with quasi-localised modes (QLMs), which we explicitly detect as an excess in the density of states in the hydrodynamic limit. Thus, we rationalise the vibrational properties of disordered materials on a microscopic scale.

References:

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