Thermal conductivity in glassy materials derived from self-consistent current response theory

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Abstract

The description of heat transport in glass remains a fundamental problem that has sustained interest for decades of research. A hallmark feature is the plateau observed in the temperature dependence of the thermal conductivity, which is linked to a qualitative change in the nature of vibrational modes - from propagating to diffusive.

Starting from first principles, we apply the recently developed self-consistent current response theory (1) to describe vibrational excitations in athermal amorphous materials, extending it to include the heat current. In addition, we employ the Euclidean Random Matrix (ERM) model, whose vibrational modes bridge from propagating sound to random matrix modes, the latter following Wigner's semicircle law. In contrast to anharmonic theories required for crystalline systems, the harmonic ERM framework enables a systematic investigation of disorder effects. Finally, our microscopic theory reproduces the results of the ERM model semi-quantitatively. (1) F. Vogel, P. Baumgärtel, M. Fuchs, Phys. Rev. X 15, 011030 (2025)

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