

The physical origin of intrinsic low thermal conductivity in crystal



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Prof. Jiaqing HE

Southern University of Science and Technology

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Abstract

The pursuit of materials with ultra-low, glass-like thermal conductivity (κ_l) is driven by critical applications in thermoelectrics and thermal barrier coatings. While strategies like alloying and defect engineering can suppress κ_l by disrupting structural order, a fundamental puzzle remains: the emergence of this phenomenon in highly symmetric single crystals, where long-range order is preserved. This report explores the underlying physical mechanisms that lead to ultra-low, glass-like thermal conductivity in high-symmetry single crystals, using materials like AgCrSe_2 , AgI , and BaTiS_3 as key examples. We identify that phonon flat bands are the fingerprints of strong four-phonon Fermi resonance scattering, which operates beyond the framework of the classical Boltzmann transport equation. Furthermore, we provide a comprehensive analysis of the interplay between non-degenerate electronic states, spontaneous symmetry breaking, and abnormal glass-like thermal conductivity behavior, all within the framework of orbital-lattice coupling theory.

Biography

Prof. Jiaqing HE is a Chair Professor in the Department of Physics at Southern University of Science and Technology and the Director of the Research Department. He is also a Fellow of the American Physical Society. He obtained his Bachelor's degree in Physics from Wuhan University in 1998 and his Ph.D. in Physics from a joint program between Wuhan University and the Jülich Research Centre in Germany in 2004. From 2004 to 2012, he worked at Brookhaven National Laboratory and Northwestern University in the United States. His primary research focuses on transmission electron microscopy, thermoelectric materials, and the correlation between structure and properties. He has published over 400 high-impact SCI journal papers, including eight in Science and three in Nature, with nearly 46,000 citations and an H-index of 100. He has applied for 52 domestic and international patents, of which 32 have been granted.