

Unveiling the Lost Coulomb Pseudopotential in Sub-Kelvin Superconductors

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Abstract

Sub-Kelvin superconductors are essential for quantum computation and sensitive detectors, but understanding the electron pairing mechanism and correlation effects in these systems remains a challenging frontier. We present a refined theory of quasiparticle pairing in these systems, built on an effective field theory (EFT) approach. To implement this theory, we introduce an innovative AI-powered numerical framework that enables efficient and accurate computation of high-order Feynman diagrams. Our calculations reveal that traditional theories significantly underestimate the strength of the pseudopotential, resolving the long-standing “lost Coulomb pseudopotential” problem and emphasizing its critical role in these systems. We also propose a universal finite-temperature scaling law for predicting new sub-Kelvin superconductors and identify potential candidates among elemental metals. Our findings provide new insights into exploring novel superconducting materials, understanding sub-Kelvin superconductivity mechanisms, and developing advanced superconducting electronics.