Stony Brook University
The Graduate School

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Abstract

Low temperature thermal conductivity in a *d*-wave

superconductor with coexisting order parameters

By

Philip Ross Schiff

The low energy excitations of cuprate superconductors are Dirac fermions which arise due to the *d*-wave nature of the superconducting order parameter. At low temperatures, these quasiparticles lead to a striking prediction of a universal thermal conductivity, κ_{00}, which is independent of disorder in the limit ($\Omega \rightarrow 0, T \rightarrow 0$). The universality of the low temperature thermal conductivity is not always observed, however, in the underdoped region of the phase diagram for several materials. In this region, the situation is complicated by evidence of coexisting order parameters, such as charge and spin density waves. These competing orders may be responsible for suppressing the universal limit thermal conductivity via their effect on the quasiparticle spectrum. In this thesis we present the two following results.

First, we suppose the addition of a $\mathbf{Q} = (\pi,0)$ charge density wave to a *d*-wave BCS-like superconductor. At low temperatures, where impurities are the dominant scattering mechanism, we calculate analytically the thermal conductivity, including the effects of vertex corrections within the self-consistent Born approximation.

Using the results of the previous calculation, which indicates that simpler bare-bubble results are adequate to describe the thermal conductance, we proceed to write a mean-field description of a *d*-wave superconductor in the presence of a variety of density waves. By calculating the effect of these competing orders on the quasiparticle spectrum and comparing it to the low-temperature thermal conductivity, we examine the way in which the universal limit thermal conductivity is affected by the incipient density waves. In general, the presence of competing orders induces disorder dependence in κ_{00}, and can suppress it entirely given sufficient amplitude of density wave.

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