Nodal Effects on Thermal Hall Conductance in Chiral Superconductors

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Under broken time reversal symmetry, not only the standard Hall current but also thermal Hall current, a heat current propagating vertical to the temperature gradient, occurs. Since the discovery of thermal Hall effect (THE) of neutral particles (e.g. phonon [1], magnon [2] etc.), this phenomenon has been drawing interest both experimentally and theoretically.

For chiral superconductors (SCs), for which spontaneous supercurrents do not reflect the topology of the superconducting phase, the THE provides an intriguing probe of topological properties, especially in 2D. Both bulk and edge state theory lead to a quantization of κ_{xy}/T, revealing the Chern number of the Bogoliubov spectrum [3 4]. Higher-order corrections contain further information of gap function. While the correction is proportional to $e^{-E_0/k_B T}$ (E_0 : the lowest excitation energy) in the gapful case, it displays power laws for nodal gaps, where exponents reflect the nodal structure. We can expect to extract some important features by focusing on these higher-order corrections not only in 2D but also 3D, in which the quantization usually does not hold.

In the present work, we investigate the THE of the 3D chiral p- and d-wave SCs with nodes by introducing a toy model, a nearest-neighber hopping model with SC-inducing attractive interaction, to extract the role of nodes. First, we restrict our argument to tetragonal lattice for simplicity, and then extend to other cases. We show both analytically and numerically that the higher-order corrections to κ_{xy}/T due to line nodes (LNs) and point nodes (PNs) with linear quasiparticle energy spectrum are $O(T)$ and $O(T^2)$, respectively. Furthermore, for point nodes, the coefficients are related to the band structure, i.e., the normal state energy spectrum, in the vicinity of a PN, but not to the topological property. This allows us to give restrictions to the position of PN, which is useful in determining the pairing states.

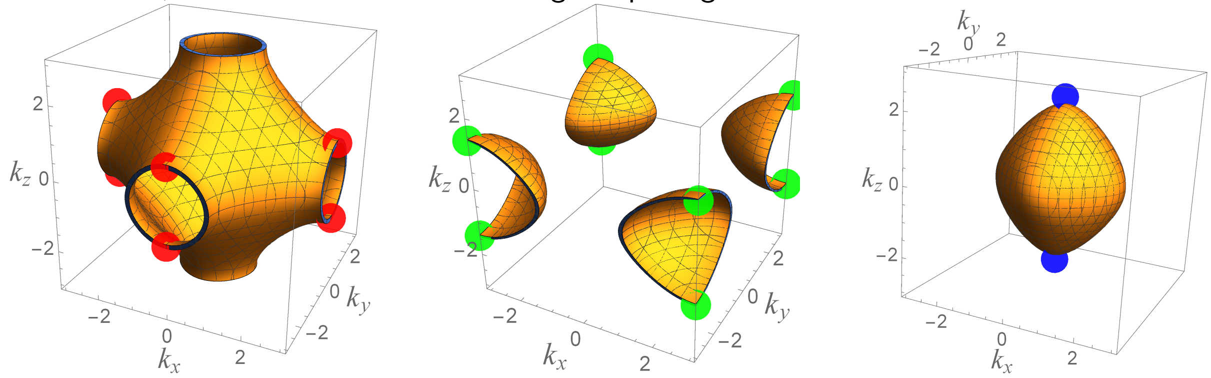

Fig. 1 – Three Fermi surfaces whose coefficient of $O(T^2)$ correction to κ_{xy}/T is zero, positive, and negative in p-wave pairing. respectively. The colored dots indicate the position of the PNs.

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