Exotic gap structures in multiband superconductors

Hooman Nanchian
Thesis supervisor and committee members: K. Samokhin, E. Sternin and B. Shoshany

The symmetry-based approach is a capable method in the theory of superconductivity. To understand how the gap function transforms under the point group operation, one needs to know the transformation properties of the single-electron states. According to the Ueda-Rice prescription, the transformation of the Bloch states, under the operation of a point group element, is described by the pure spin-1/2 rotation matrices, even in the presence of spin-orbit coupling. In the presence of spin-orbit coupling, we show that the Bloch states in a centrosymmetric and non-magnetic crystal are not the eigenstates of the pure spin-1/2 operators. In this case, the transformation of the Bloch states depends on the symmetry of the bands participating in the pairing. This transformation is not necessarily equivalent to the transformation of the pure spin-1/2 Bloch states. In this work, we study a hexagonal multiband superconductor with a D_{6h} point group in the presence of spin-orbit coupling. We discovered that the Bloch states in some specific bands do not transform like pure spin-1/2 states. This behavior of the electron bands leads to an exotic gap nodal structure that we study in two pairing channels. In an interband s-wave pairing, some nodes appear in the gap structure of the superconductor. In an interband i-wave pairing, the gap nodes move by changing the strength of the interband pairing. The pseudospin symmetry-based approach, presented in the textbooks, does not predict these results.