Extended Ginzburg-Landau Formalism for multiband superconductors

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The Ginzburg-Landau (GL) theory distinguishes superconductors of ideally diamagnetic type I and of type II, where the field penetrates in the form of a regular lattice of Abrikosov single-quantum vortices. Which of the types is realized depends on the GL parameter $\kappa = \lambda/\xi$. The switching between types occurs abruptly when $\kappa$ crosses the critical value $\kappa_0 = 1/\sqrt{2}$.

Already in 1970’s it was shown that the reality is more complex than what follows from the GL theory: the picture of the superconductivity types separated by the single point $\kappa_0 = 1/\sqrt{2}$ applies only in the limit $T \to T_c$. Below $T_c$ the intertype regime occupies a finite interval of $\kappa$’s, forming the inter-type domain between types I and II in the $(\kappa, T)$-plain. This domain exhibits a non-conventional field dependence of the magnetization, in particular, the first order phase transition between the Meissner and the mixed states. The physics of the inter-type domain is closely related to the Bogomolnyi self-duality that results in an infinite degeneracy of the superconducting state at the Bogomolnyi point $(\kappa_0, T_c)$. This degeneracy follows from the symmetry of the GL equations at $\kappa_0$ and implies that the mixed state comprises an infinite number of different spatial patterns of the magnetic flux. When lowering the temperature, the degeneracy is lifted and the Bogomolnyi point unfolds in a finite domain in the phase diagram between types I and II.

In conventional single-band superconductors the intertype domain is negligibly small and thus widely ignored. However, recently it has been demonstrated that this domain is enlarged in two-band superconductors and this enlargement can be traced to disparity between the microscopic parameters of the contributing bands. It has been also argued that the effect is a generic phenomenon and independent of the details of the model for band states. Its origin is the non-locality of interactions in the aggregate condensate due to the appearance of multiple bands. Thus, it is of importance to check this expectation and generalize the consideration of the intertype domain in two-band superconductors to the case of multiband superconducting materials with more than two contribution bands.

In this project we investigate the intertype superconductivity in a non-degenerate three-band superconductor with the standard s-wave pairing. Where the main purpose of our investigation is to study how the enlargement of the intertype domain is sensitive to increasing the number of contributing bands.