Effective Vortex Mass from Microscopic Theory

Jung Hoon Han[a], June Seo Kim[a], Ping Ao[b]
[a] *Department of Physics, Sungkyunkwan University,Suwon, Korea 440-746*
[b] *Department of Mechanical Engineering, University of Washington, Seattle, WA 98195, USA*

We calculate the effective mass of a single quantized vortex in the BCS superconductor at finite temperature. Based on effective action approach, we arrive at the effective mass of a vortex as integral of the spectral function $J(\omega)$ divided by ω^3 over frequency. The spectral function is given in terms of the quantum-mechanical transition elements of the gradient of the Hamiltonian between two Bogoliubov-deGennes (BdG) eigenstates. Based on self-consistent numerical diagonalization of the BdG equation we find that the effective mass per unit length of vortex at zero temperature is of order $m(k_f\xi_0)^2$ (k_f=Fermi momentum, ξ_0=coherence length), essentially equaling the electron mass displaced within the coherence length from the vortex core. Transitions between the core states are responsible for most of the mass. The mass reaches a maximum value at $T \cong 0.5T_c$ and decreases continuously to zero at T_c.

keywords : vortex, effective mass, BCS theory