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Modified Coulomb's Law for Cooper Pairs in Conventional Superconductors

Abstract

Cooper pairs are bound entities with attractive interaction provided by the virtual exchange of a phonon between two electrons. Phonon energy is $\hbar\omega_D$ where ω_D is the Debye frequency of a given super-conductor. The corresponding Debye temperature θ_D is related to $\hbar\omega_D$ via the relation $k\theta_D=\hbar\omega_D$. Since the electrons in a Cooper pair are separated by a finite distance (r) called the size of the Cooper pair, there is finite Coulomb repulsion energy (Ec) between the electrons in a Cooper pair. For the Cooper pair to be bound and stable, $\hbar\omega_D>E_C$. It is well known that the electron - electron interaction is screened out exponentially at a distance larger than the Thomas - Fermi radius, rs. Keeping this in mind, a modified Coulomb law for the electron – electron Coulomb interaction in the Cooper pair is proposed. The calculated values for the modified Coulomb energy (Em) are compared with the phonon energy $\hbar\omega_D$ and it is found that $\hbar\omega_D>E_C$. for most of the BCS type (conventional) superconductors for which calculations are done in this manuscript.

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