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2D Electron System with Quasiparticle Auxiliary Field Correlation of Open quantum System

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Abstract

The objective of this work is to develop the mathematicalmodelfor the auxiliary field and interlink the pair correlation in the external potential of the open quantum system of the 2D electron system. For this, we used 2D Hubbard Model with the action open quantum system Lindbladequation and then apply the saddle point condition to obtainthe auxiliary field of the 2D system. The obtained pair correlation of quasiparticles was found symmetric in nature with cooper pairs electron paring angle. The pair correlation of 0K was found 0.1times, 1 time, 2 times, 3 times, 4 times,and5 times greater when compared with 0.2K, 0.3K, 0.4K, 0.5K, and 0.6K, respectively at -1radain and +1radain copper pairs electron pairing angle which is maximum. In addition, with increasing the temperature, the pair correlation decrease and become minimum without loss of symmetry.

Keywords: Auxiliary field, Pair correlation, Open quantum System, Hubbard Model, Lindblad Equation, symmetry

Introduction

Thermodynamic phase transitions separate normal metal and superconductor, as well as normal liquid and superfluid. The nature of singularities in specific heat and other thermodynamic variables at the transition temperature can be used to characterize each of these phase transitions.The study of physical systems that are not in mechanical and thermal equilibrium with their surroundings,according to the phrase non-equilibrium physics.In some situations, systems attain equilibrium on their own, such as when a molten metallic alloy cools and solidifies. Flowing fluids are driven by temperature or pressure gradients, solid materials deforming or breaking under external forces, and quantum systems—perhaps atomic spins—driven by oscillating electromagnetic fields are all examples [1].

Many-body systems display non-equilibrium physics, in which the constituent particles interact intensely and behave quantum mechanically.The study of non-equilibrium processes has been extended to the quantum domain thanks to recent technological developments in mesoscopic and atomic systems. The present endeavor to construct quantum computers is based on dynamics in non-equilibrium systems. The study of quantum critical processes like the metal-insulator transition demonstrates the importance of dissipation and decoherence. Both linear and nonlinear responses to applied external probe fields are frequently used to study the dynamics of critical processes. Because the effective electron-phonon coupling vanishes at low temperatures, external dissipation is frequently irrelevant to the equilibrium-critical behavior. Since the 1960s, non-equilibrium superconductivity has been a fascinating subject of modern solid-state physics. External disturbances such as laser irradiation, microwave irradiation, phonon injection, and quasiparticle injection via tunnel junctions, time-dependent externally applied currents, and thermal gradients can all lead to a non-equilibrium state.The population of the electron-like and hole-like branches of the quasiparticle spectrum are the same, indicating that the nonequilibrium state is defined by a (non-equilibrium) distribution function that is particle-hole symmetric. Condensed matter physics is built on the idea of quasiparticles, which Landau first proposed as the low-energy excitations of an interacting many-particle system. Applications of this idea range from quantum fluids to conduction electrons in metals to nuclear matter. In order to capture the nonequilibrium characteristics of Fermi systems, Landau additionally devised a kinetic equation for the distribution function of interacting quasiparticles. A photon with an energy well above 2 can split a Cooper pair into two high-energy quasiparticles. These then decay by emitting phonons that can split more pairs into even more low-energy quasiparticles, creating a vast number of quasiparticles [2].

The Hubbard Kanamori (HK) model has emerged as one of the prototypes for transition metal oxide physics in the study of strongly correlated, many-electron systems [3]. The Hunds coupling terms in the multi-band model, which have a significant influence on high-temperature superconductivity, metal-insulator transitions, and other physical features, are multi-band in nature. The single-band Hubbard model1 has been the subject of an unprecedented amount of theoretical study and accompanying algorithmic development since the surprise finding of high-temperature superconductivity in the cuprates. Although most transition metal oxides, pnictides, fullerides, and chalcogenides display a strong correlation, most of these materials also have several bands that cross their Fermi levels, making them inherently multiband in nature [4-5].

A quantum-mechanical system that interacts with an external quantum system, often known as the environment or a bath, is known as an open quantum system. In general, these interactions drastically alter the dynamics of the system and cause quantum dissipation, in which the system's information is lost to the surroundings. Almost all recent research in quantum mechanics and its applications is based on the theory of open quantum systems. In actuality, every system is open, which means it is connected to the outside world. Quantum optics, quantum measurement theory, quantum statistical mechanics, quantum information science, quantum thermodynamics, quantum cosmology, quantum biology, and semi-classical approximations all benefit from techniques developed in the setting of open quantum systems [6].

Due to an imbalance in the populations of the quasi-electron and quasihole excitation branches, only one of the quasiparticle excitation modes that mesoscopic superconductivity deals with—the charge mode—is immediately accessible for conductance measurements. Other charge-neutral modes conveying heat or even spin, valley, or other currents evenly distribute throughout the branches, making it far more difficult to manage them. By looking beyond the typical DC transport measurements and utilizing spontaneous current fluctuations, this apparent gap in the experimental studies of mesoscopic non-equilibrium superconductivity can be filled. Here, we carry out such an experiment to examine the heat transfer in an open hybrid device built around an InAs nanowire that has been proximitized for superconductivity [7].In a sense, research on quasiparticle excitations in superconductors dates back to the beginning of the phenomenon; they make up the 'normal fluid' portion of the phenomenological two-fluid model, with the condensate of Cooper pairs serving as the superfluid component. The development of BCS theory, which states that the quasiparticles are coherent superpositions of electrons and holes, sheds light on the nature of these excitations [8].

A potential Majorana fermion candidate is the Josephson junction of strong spin-orbit material in a magnetic field. InAs nanowire Josephson junctions have shown supercurrent augmentation by a magnetic field, which has been attributed to a topological transition. In this study, we detect related phenomena and describe their nontopological cause by taking into account the capture of quasiparticles by vortices that pierce the superconductor in the presence of a limited magnetic field. The switching current's observed hysteresis while sweeping up and down the magnetic field lends credence to this assignment. Our experiment highlights the significance of quasiparticles in magnetically induced superconducting devices, which can offer crucial insights into the development of superconducting qubits [9].

According to the Bardeen-Cooper-Schrieffer (BCS) theory, excitations in superconductors (Bogoliubov quasiparticles) are represented as an energy-dependent superposition of an electron with amplitude and a hole with amplitude, where the energy « is measured relative to the Fermi energy[10]. To our knowledge, no direct measurement of the charge of the quasiparticles in superconductors has ever been made. Here, we measure the tunneling quasiparticles in a 1D superconductor-insulator-superconductor Josephson junction using our expertise and sensitive methods for measuring the fractional excitations in the fractional quantum Hall effect via quantum shot noise, and discover that their charge is significantly lower than that of an electron.

Our main goal in this work is to determine the expectation or quantity of charge particles, collectively known as quasiparticles, at various temperatures between 0.2K and 0.7K and compare it with 0K because the current represents the flow of rate of charged particles. We are working on the current flows caused by this expectation value together with our other progressive activities. A significant difficulty for both experimental and theoretical physicists is to investigate the current flowing across the junction of two superconductors. Since the electronic circuit is linked to the superconducting after it has formed, any effects that the thermal energy may have on the circuit could cause harm. This work enables us to determine the quantitative increase or decrease in quasiparticles when they are coupled to a microscopic electronic device, demonstrating the significance of the creation of quasiparticles with temperature in a superconductor. Numerous authors have already discussed some of the applications for quasiparticles, including Denisov et al. in 2022 and Sato et al. in 2022. The current is produced through tunneling over the junction and the creation of quasiparticles inside the superconductors. We developed the empirical formula for expectation value in external potential with an auxiliary field and based it on the Hubbard model in order to examine the expectation value using the theoretical model.

LITERATURE REVIEW

Hubbard model

The Hubbard model is based on electron correlations, and it will eventually help us comprehend how the Pauli Exclusion Principle leads to magnetism. The Hamiltonian, on the other hand, is now made up of two terms in the Hubbard model. The kinetic energy of the system is described by the first term, which is parameterized by the hopping integral. The electron repulsion is represented by the second term, the on-site interaction of strength. The two-dimensional Hubbard model Hamiltonian has the form,

$$H = -t\sum_{\langle i,j\rangle}\sum_{\sigma}\left(c^{\dagger}_{i,\sigma}c_{j,\sigma} + h.c\right) + U\sum_{i} n_{i,\uparrow}n_{i,\downarrow} \qquad (1)$$

Hermitian conjugation is denoted by h.c. The sign $c^{\dagger}_{i,\sigma}$ denotes second quantization operators that create an electron with spin σ at lattice site i. t_{ij} denotes the hopping integral between sites i and j.

On each site of the lattice, the Hubbard model creates a contact interaction between particles of opposite spin. The Hubbard model's physics is defined by a conflict between the strength of the hopping integral, which describes the kinetic energy of the system, and the strength of the interaction term.The Hubbard model is a technique of looking at how correlated electrons behave in materials. The model was initially proposed to explain the ferromagnetism of transition metals such as iron and nickel. It's a variation on the 'tight-binding' paradigm, in which electrons can bounce across lattice locations without 'feeling' each other. Electron hopping can only take place between nearest-neighbor sites in its most basic form, and all hopping processes have the same kinetic energy, t. Hubbard's model is considered the quintessential model of many-body physics because it pioneered the field of strongly coupled systems.

The Hubbard model is important in metal conductor-insulator transitions and narrow band magnetism [11]. Hubbard-Mott insulators, for example, are a family of materials that, according to standard band theories, should conduct electricity but are insulators when tested (particularly at low temperatures). This is due to electron-electron interactions in narrow bands, which are not taken into account in traditional band theory. In narrow bands, the Coulomb repulsions of semi-localized electrons are strong enough to break the band into two sub-bands, resulting in the Mott band gap.The scattering atoms are lost intoan environment if the system is subjected to the inelastic collision andresulting dissipative dynamics. The time evolution of the density matrix ρ is described by the Lindblad equation which is given by [12],

$$\frac{d\rho}{dt} = -i[H,\rho] + D(\rho) \qquad (2)$$

Where H is Hamiltonian of system, ρ is density and $D(\rho)$ is Lindblad dissipator with $\mathcal{L}$ is Liovillian superoperator and define as , $D(\rho) = \frac{\gamma}{2}\sum_i(L_i^\dagger \rho L_i + \rho L_i^\dagger L_i - 2L_i\rho L_i^\dagger)$. The L_i operators are commonly known as jump operators [13].Action is define for open quantum system in term of Lindblad equation as

$$S = \int_{\infty}^{\infty} dt \sum_{i\alpha} \alpha \bar{c}_{i\alpha} i\partial_t c_{i\alpha} - \int_{\infty}^{\infty} dt i\mathcal{L} \qquad (3)$$

On solving using the value of $\mathcal{L}$ from [13] and solving by using Hubbard-Stratonovich transformation using the auxiliary fields Δ_α ($\alpha = +,-,\pm$) with U = $U_R + \frac{i\gamma}{2}$ and $U^* = U_R - \frac{i\gamma}{2}$ we get [14],

$$S = \int dt \left\{ \sum_k [\bar{\psi}_{k+}^t \begin{pmatrix} i\partial_t - \varepsilon_k & -\Delta_+ \\ -\bar{\Delta}_+ + i\Delta_\pm & -i\partial_t + \varepsilon_k \end{pmatrix} \psi_{k+} - \bar{\psi}_{k-}^t \begin{pmatrix} i\partial_t - \varepsilon_k & -\Delta_- - i\Delta_\pm \\ -\bar{\Delta}_- & -i\partial_t + \varepsilon_k \end{pmatrix} \psi_{k-} \right] + \frac{\bar{\Delta}_+\Delta_+}{iU} \frac{\bar{\Delta}_-\Delta_-}{iU^*} \frac{\bar{\Delta}_\pm\Delta_\pm}{\gamma} \Big\} \qquad (4)$$

Where $\bar{\psi}_{k\alpha} = (\bar{c}_{k\uparrow\alpha}, c_{-k\downarrow\alpha})^t$, $\psi_{k\alpha} = (c_{k\uparrow\alpha}, \bar{c}_{-k\downarrow\alpha})^t$ ($\alpha = +,-$) on applying saddle-point condition$\langle\partial S/\partial \Delta_\alpha\rangle = \langle\partial S/\partial \bar{\Delta}_\alpha\rangle = 0$ ($\alpha = |, ,\pm$) , we obtain

$\Delta_+ = -\frac{U}{N_0}\sum_k\langle c_{-k\downarrow+}c_{k\uparrow+}\rangle$, $\bar{\Delta}_+ = -\frac{U}{N_0}\sum_k\langle c_{k\uparrow+}^\dagger c_{-k\downarrow+}^\dagger\rangle$, $\Delta_- = -\frac{U}{N_0}\sum_k\langle c_{-k\downarrow-}c_{k\uparrow-}\rangle$, $\bar{\Delta}_+ = -\frac{U}{N_0}\sum_k\langle c_{k\uparrow-}^\dagger c_{-k\downarrow-}^\dagger\rangle$.

Hubbard-Stratonovich transformation, an accurate mathematical transformation developed by Russian physicist R. L. Stratonovich and made popular by British physicist J. Hubbard, is one of the functional integral formalism's most potent methods. Various revisions are made to the Hubbard-Stratonovich transformation of many-body theory. A combined Hubbard-Stratonovich transformation is suggested as a solution to these issues after learning from its shortcomings in dealing with conflicting channels of collective phenomena. This results in a wide range of fluctuating bosonic quantum fields that describe how various phases in the system under examination compete with one another [15-16].

The number of lattice sites is N_0,also known as fermi level more detail in [17] and the expected value for fixed Δ_α and $\bar{\Delta}_\alpha$ is ⟨…..⟩.Then, using $\langle c_{-k\downarrow\alpha}, c_{k\uparrow\alpha}\rangle$ = tr($c_{-k\downarrow}c_{k\uparrow}$) ($\alpha = +,-$) and tr($A^\dagger\rho) = [tr(A\rho)]^*$ the auxiliary fields is obtained as [18], superfluid order parameter of the system and given by

$$\Delta = -\frac{U}{N_0}\sum_k tr(c_{-k\downarrow}c_{k\uparrow}\rho) = -\frac{U}{N_0}\sum_k\langle c_{-k\downarrow}c_{k\uparrow}\rangle \qquad (5)$$

Where

$$U = U_{q\omega} = u_q + 8\frac{\alpha^2}{\epsilon^2}u_q^2\chi_j \tag{6}$$

the first term of the interaction potential is due to the Coulomb e-e repulsion. For the 2D electron gas formed in a uniform system with a bulk dielectric constant ϵ the e-e repulsion is governed by the pure Coulomb potential $u_q = \frac{2\pi e^2}{\epsilon q}$. The second term of the interaction potential is exactly due to the pair spin-orbital interaction (PSOI) with dynamic susceptibilities χ_j, ϵ is dielectric constantand q is static factor $\left(\frac{q}{k_F} = 0 \text{ to } 2 \text{ or more}\right)$. Since $U_{q\omega}$ is spin-independent and correspond response to case of up- and down-spin densities, $n_{q\omega}^{+} = n_{q\omega}^{-}$. The dynamic charge susceptibility of equation (6) is Fourier transformation of $+\chi_n(x,t)$ can be expressed [19] as

$$\chi_n(q,\omega) = \frac{2\frac{N_F}{\left(\frac{q}{k_F}\right)}\left(v_- - sign(Re\, v_-)\sqrt{v_-^2-1} - v_+ + sign(Re\, v_+)\sqrt{v_+^2-1}\right)}{1-2V_{q\omega}\frac{N_F}{\left(\frac{q}{k_F}\right)}\left(v_- - sign(Re\, v_-)\sqrt{v_-^2-1} - v_+ + sign(Re\, v_+)\sqrt{v_+^2-1}\right)} \tag{7}$$

Here $v_{\pm} = \frac{\omega+i0}{qv_F} \pm \frac{q}{2k_F}$, $N_\sigma = \frac{m}{2\pi\hbar^2}$ is the 2D density of states of spin σ per unit area, $\boldsymbol{q}\perp \equiv (qy, -qx)$, ω *is* plasmon frequency and normalized plasmon frequency $\omega_0 = v_F k_F$. For the case χ_0 we have from equation (7) and (6) with e=1, on sloving we get,

$$U_{q\omega} = \frac{2\pi}{\epsilon q}1 + \frac{16\alpha^2\pi k_F N_F}{\epsilon q^2}\left[\left(v_{-sign(Re\, v_-)\sqrt{v_-^2-1} - v_+ + sign(Re\, v_+)\sqrt{v_+^2-1}}\right]\right\} \tag{8}$$

Again using (8) in (5) on solving we get the auxiliary field as

$$\Delta = -\frac{2\pi}{\epsilon q N_0}\left\{1 + \frac{16\alpha^2\pi k_F N_F}{\epsilon q^2}\left[\left(v_- - sign(Re\, v_-)\sqrt{v_-^2-1} - v_+ + sign(Re\, v_+)\sqrt{v_+^2-1}\right)\right]\right\}\sum_k\langle c_{-k\downarrow}c_{k\uparrow}\rangle \tag{9}$$

The contribution of the interaction term can be seen from the physical term it describes: we started from the occupied Cooper pair state $(k', -k')$ and empty $(k, -k)$ and we ended in occupied $(k, -k)$, but empty $(k', -k')$. The occupied Cooper pair gives a factor of v, the empty u, with the corresponding momentum index is expressed in [20] as,

$$\Delta = \frac{1}{2\Omega}\sum_{k'} V_{kk'}\sin(2\theta_{k'}) = \frac{1}{\Omega}\sum_{k'} V_{kk'}u_{k'}v_{k'}^{*} \tag{10}$$

Now, taking u_k and v_k real, the normalization conditionautomatically satisfied $u_k = \sin(\theta_k)$ and $v_k = \cos(\theta_k)$ [21] and replacing with $\sum_{k'} V_{kk'}$ with $U_{q\omega}$ in equation (10) and on solving we get

$$\Delta = \frac{2\pi\sin(2\theta_k)}{\epsilon q N_0}\left\{1 + \frac{16\alpha^2\pi k_F N_F}{\epsilon q^2}\left[\left(v_- - sign(Re\, v_-)\sqrt{v_-^2-1} - v_+ + sign(Re\, v_+)\sqrt{v_+^2-1}\right)\right]\right\} \tag{11}$$

The Average number of creation and formation of particles is same so $\langle c^{\dagger}_{k\uparrow +} c^{\dagger}_{-k\downarrow +}\rangle = \langle c_{-k\downarrow} c_{k\uparrow}\rangle$. Therefore, atzero temperature $T = 0$ with the help of [21] we get,

$$\langle c_{-k\downarrow} c_{k\uparrow}\rangle = \frac{\pi \sin(2\theta_q)\left\{1+\frac{16\alpha^2\pi k_F N_\sigma}{9q^2}\left[\left(v_- - sign(Re\, v_-)\sqrt{v_-^2-1} - v_+ + sign(Re\, v_+)\sqrt{v_+^2-1}\right)\right]\right\}}{8qN_0E_{ks}} \tag{12}$$

$$\langle c^{\dagger}_{k\uparrow +} c^{\dagger}_{-k\downarrow +}\rangle = \frac{\pi \sin(2\theta_q)\left\{1+\frac{16\alpha^2\pi k_F N_\sigma}{9q^2}\left(v_- - sign(Re\, v_-)\sqrt{v_-^2-1} - v_+ + sign(Re\, v_+)\sqrt{v_+^2-1}\right)\right\}^*}{8qN_0E_{ks}} \tag{13}$$

The electron expectation values at finite temperature is given by,

$$\langle c_{-k\downarrow} c_{k\uparrow}\rangle_T = \frac{\pi \sin(2\theta_q)\left\{1+\frac{16\alpha^2\pi k_F N_\sigma}{9q^2}\left(v_- - sign(Re\, v_-)\sqrt{v_-^2-1} - v_+ + sign(Re\, v_+)\sqrt{v_+^2-1}\right)\right\}}{8qN_0E_{ks}} \tanh\left(\frac{E_{ks}}{2k_BT}\right) \tag{14}$$

$$\langle c^{\dagger}_{k\uparrow} c^{\dagger}_{-k\downarrow}\rangle_T = \frac{\pi \sin(2\theta_q)\left\{1+\frac{16\alpha^2\pi k_F N_\sigma}{9q^2}\left(v_- - sign(Re\, v_-)\sqrt{v_-^2-1} - v_+ + sign(Re\, v_+)\sqrt{v_+^2-1}\right)\right\}^*}{8qN_0E_{ks}} \tanh\left(\frac{E_{ks}}{2k_BT}\right) \tag{15}$$

These expectation values follow the same symmetry as the energy gap. Thus, $\langle c_{-k\downarrow} c_{k\uparrow}\rangle$ at values far from k_F is a good representation of the gap symmetry and even the exact functional form.The theory in [22], which is based on the assumption of a fixed average quasiparticle distribution and which perturbs the device operation, successfully describes many experiments involving residual quasiparticles in qubits [23]. The expectation value obtained by the authors in this work is out using Hubbared model which make our theory different from [22]. The net effect of the quasiparticles is equivalent to that of a frequency-dependent resistance included in the circuit. According to photon energy and temperature, there are two types of quasiparticle regimes: hot and cold [24] provides further information on this.

Result and Discussion

Dissipationless tunneling of Cooper pairs through a Josephson junction is essential for creating ideal superconducting devices. For instance, the regulated transport occurs in a Cooper pair pump [25]. Cooper pairs can theoretically be distributed across two or more junctions. allow for the correlation of frequency and current, and hence enable such a device's metrological uses [26]. For the purpose of quantum information, the nonlinear relationship between the junction's supercurrent and phase difference making the junction a perfect nonlinear component for a qubit. But aside from the couples tunneling, single-particle. Tunneling is also possible for quasiparticle excitations. In the due to "counting mistakes," which restrict the precision of current-frequency relationships. In qubits, quasiparticles interact with the phase degree of freedom, providing an unwanted channel for the qubit energy relaxation [27].

Pair-correlation function can be expressed by can be obtained as [28], the pair correlation function related annihilation and creator operator with opposite momentum as cooper pair formation and quasiparticles environment as

$$\rho = \langle c_{k\uparrow}^{\dagger} c_{-k\downarrow}^{\dagger} \rangle \langle c_{-k\downarrow} c_{k\uparrow} \rangle \tag{19}$$

At T=0K,

$$\rho = \frac{\pi^2 \sin^2(2\theta_q)}{\epsilon^2 q^2 N_0^2 E_{ks}^2} \left\{1 + \frac{16\alpha^2 \pi k_B N_c}{\epsilon q^2} \left[\left(v_- - sign(Re\, v_-)\sqrt{v_-^2 - 1} - v_+ + sign(Re\, v_+)\sqrt{v_+^2 - 1}\right)\right]\right\} \left\{1 + \frac{16\alpha^2 \pi k_B N_c}{\epsilon q^2} \left(v_- - sign(Re\, v_-)\sqrt{v_-^2 - 1} - v_+ + sign(Re\, v_+)\sqrt{v_+^2 - 1}\right)\right\}^* \tag{20}$$

Case 1: For $v_- = v_+$ we have from equation (20),

$$\rho_{(v_- = v_+)} = \frac{\pi^2 \sin^2(2\theta_q)}{\epsilon^2 q^2 N_0^2 E_{ks}^2} \tag{21}$$

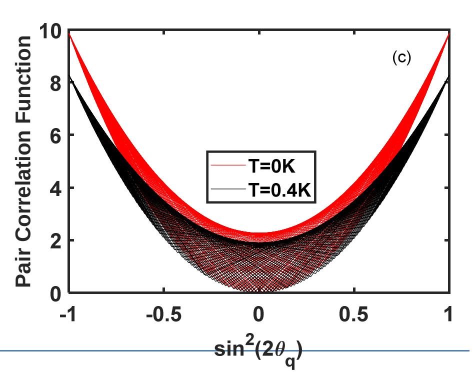
At $T \neq 0K$,

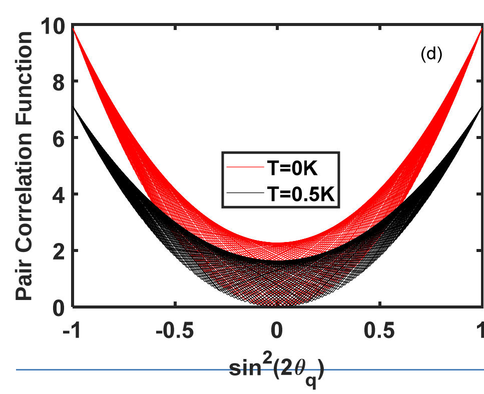
$$\rho_T = \frac{\pi^2 \sin^2(2\theta_q)}{\epsilon^2 q^2 N_0^2 E_{ks}^2} \tanh^2\left(\frac{E_{ks}}{2k_B T}\right) \left\{1 + \frac{16\alpha^2 \pi k_B N_c}{\epsilon q^2} \left(v_- - sign(Re\, v_-)\sqrt{v_-^2 - 1} - v_+ + sign(Re\, v_+)\sqrt{v_+^2 - 1}\right)\right\} \left\{1 + \frac{16\alpha^2 \pi k_B N_c}{\epsilon q^2} \left(v_- - sign(Re\, v_-)\sqrt{v_-^2 - 1} - v_+ + sign(Re\, v_+)\sqrt{v_+^2 - 1}\right)\right\}^* \tag{22}$$

Case 2: For $v_- = v_+$ we have from equation (22),

$$\rho_{T(v_- = v_+)} = \frac{\pi^2 \sin^2(2\theta_q)}{\epsilon^2 q^2 N_0^2 E_{ks}^2} \tanh^2\left(\frac{E_{ks}}{2k_B T}\right) \tag{23}$$

Equation (21) and (23) are the case (1) and case (2) of pair correlation with temperature independent and temperature dependent. The correlation shows in both case for constant number of quasiparticles is directly proportional to angle of cooper pair formation, inverselyproportionalto dielectric constant of material, q is static factor, $E_{ks}$is quasiparticle excitation energy for both cases but in case of (2) pair correlation is additional proportional to hyperbolictrigonometric function tan.





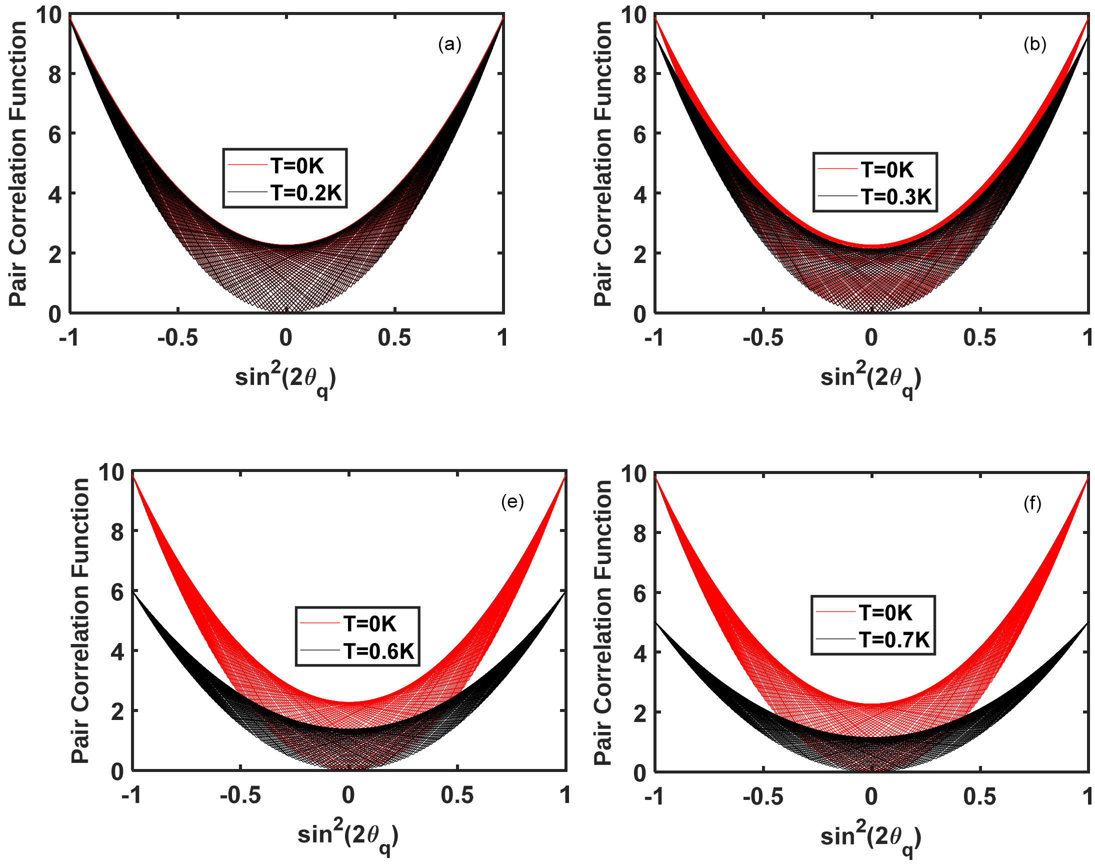


Figure 1: Pair correlation function with cooper paring arrangement angle, (a) at 0.2K, (b) at 0.3K, (c) at 0.4K, (d) at 0.5K, (e) at 0.6K and (f) at 0.7K temperature

Figure 1(a), (b), (c), (d), (e)and (f) shows the pair correlation comparisonof temperature independent (0K) with temperature depend (0.2K, 0.3K, 0.4K, 0.5K0.6K and 0.7K) when external potential $(U_{q\omega})$ is apply to the system. The pair correlation below 0.2K for both temperature dependent and temperature independent found same but with the increasing the temperature the pair correlation of temperature dependent correlation goes decrease in compare to temperatureindependent. The red part of graphin figure 1 represent pair correlation with copper paring angle at temperature independent case (1). While black represent pair correlation with cooper pair angle at temperature dependent case (2). At lower paring angle the pair correlation pairing form temperature dependent and independent case is quite similar. This is because the oscillation of copper pair with external field is very lower effect but with the increasing the angle of formation of cooper pairs the oscillation is high. This oscillation causes the pair correlation of temperature dependent and temperature independent differ. The deep dark and deep red region show the pair is loosely between the cooper pair and oscillation is high because of excitation energy of quasiparticles.

From equation (5) and (11), it is observed auxiliary field of open quantum system with annihilation and creator operator is directly related therefor auxiliary field of quasiparticles also related with pairangle, dielectric constant, numbers of quasi particle static factor and quasiparticles excitation energy. The auxiliary field also have same nature as similar to pair correlation for both case temperature dependent and temperature independent. The Pair correlation of 0.2K, 0.3K, 0.4K, 0.5K, 0.6K and 0.7K when compare with 0K the different was observed. The pair correlation when compare at 0K and 0.2K, the pair correlation at 0.2K was found 0.1times less than that of 0K at -1 and +1 radian. Similarly, 1, 2, 3, 4, and 5 times less when pair correlation of 0.3K, 0.4K, 0.5K, 0.6K and 0.7K temperature is compare with 0K at -1radian and +1 radian, respectively. This is because with increasing the temperature the annihilation and creation of particles goes disturbance and process is faster but at zero temperature the annihilation and creation of the particlesare slower. So, the pair correlation of 0K was found greater than non-zero temperatureand also pair correlation goes decrease with increasing the temperature.

Conclusion

When pair correlation was observed with pair angle of cooper pairs electron, the nature of pair correlation at considers zero and non-zero temperature was found symmetric. In addition, the paircorrelation of goes decrease with increasing the temperature without breaking the symmetry. The observation of pair correlation at zero and non-zero temperature (0.2K to 0.7K), shows the pair correlation at 0.2K is 0.1times less than that of 0K, at 0.3K is 1times less than that of 0K, at 0.4K is 2times less than that of 0K, at 0.5K is 3times less than that of 0K, at 0.6K is 4times less than that of 0K and at 0.7K is 5times less than that of 0K, at -1radain and +1radain cooper pairs electron pairing angle.

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