Proceedings of the International Congress on Advances in Applied Physics and Materials Science, Antalya 2011

The Correlation between the Double Helix Quantum Wave in *d*-Wave Superconductors and Human DNA

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The effective mass of the quasiparticles in a *d*-wave superconducting system has been calculated via magnetization measurements done by SQUID by using the advanced derivative method used in our previous works. Phenomenological analogy between the double helix quantum wave, which does exist within the primitive cell of the *d*-wave superconductor, and the human DNA was previously made. In this work, the numerical proof of the analogy mentioned has been realized by determining the magnitude of the attractive force of *d*-wave structure and comparing with the magnitude of the force that holds the double strand of human DNA that are both of the same order of 10^{-10} N. Moreover, the wavelength of the double helix quantum wave of the superconducting system corresponds to ultraviolet region of the electromagnetic spectrum that exactly coincides with the wavelength which is used for exciting the states in human DNA.

PACS: 74.72.–h, 71.18.+y, 87.14.gk

1. Introduction

The effective mass of the quasiparticles in mercury based *d*-wave high temperature superconducting system has already been calculated by the Ongüas equation derived in our previous works [1, 2]. The Ongüas equation establishes a relationship between the first derivative of supercurrent density of the system and the effective mass of the quasiparticles, m^*. As is known, the supercurrent density is related to the second derivative of the phase difference in layered high temperature superconductors, which are accepted as an array of intrinsic Josephson junctions [1–3]. The phase difference, φ, is a unique parameter in determining the superconducting state which is described by quantum wave function, i.e. order parameter of the system

$$\psi = |\psi| \mathrm{e}^{\mathrm{i}\varphi}, \tag{1}$$

where $|\psi|$ is the amplitude of the quantum wave function.

According to the Ferrel and Prange equation [4], due to the supercurrent flow in the superconductor, the induced magnetic field penetrates to superconductor by the Josephson penetration depth parameter, λ_{J}:

$$\frac{\mathrm{d}^2\varphi}{\mathrm{d}x^2} - \frac{1}{\lambda_{\mathrm{J}}^2}\sin\varphi = 0$$
$$\text{(the Ferrel and Prange equation)}, \tag{2}$$

$$\lambda_{\mathrm{J}} = \sqrt{\frac{c\Phi_0}{8\pi^2 J_{\mathrm{c}} d}}, \tag{3}$$

where c is the speed of light, Φ_0 is the magnetic flux quantum, J_{c} is the critical current density and d is the average distance between superconducting layers in the system.

For low magnetic fields, the Ferrel and Prange equation has an exponential solution as given in Eq. (4)

$$\varphi(x) = \varphi_0 \exp\left(-\frac{x}{\lambda_{\mathrm{J}}}\right), \tag{4}$$

where φ_0 is the phase value at the distance $x = 0$.

According to Schmidt, the first and second derivatives of the phase with respect to distance correspond to the magnetic field, $H(x)$ at any point of the Josephson junction and the supercurrent density, J_{s}, respectively [3]. As is known in condensed matter physics, the effective mass of quasiparticles is determined from the first derivative of the velocity with respect to wave vector [1, 5]. Like this process, the effective mass of the quasiparticles in the Josephson layered superconductors can be determined by the first derivative of the J_{s} with respect to distance x, since the supercurrent density, J_{s} is the function of velocity of the quasiparticles. Hence, we have taken the first derivative of the supercurrent density, $\frac{\mathrm{d}J_{\mathrm{s}}}{\mathrm{d}x}$, which is proportional to the third derivative of the phase, $\frac{\mathrm{d}^3\varphi(x)}{\mathrm{d}x^3}$, to obtain the effective mass equation of the quasiparticles that yields

$$\frac{1}{\varphi_0 m^*} = \frac{c\Phi_0}{8\pi^2 d}\left(-\frac{1}{\lambda_{\mathrm{J}}}\right)^3 \exp\left(-\frac{x}{\lambda_{\mathrm{J}}}\right)$$
$$\text{(the Ongüas Equation)}. \tag{5}$$

The effective mass of the quasiparticles, m^*, calculated by the Ongüas equation, is interpreted as the *net effective mass of the quasiparticles* for the mercury cuprate superconductor which exhibits the spatial resonance due to the occurrence of three-dimensional Bose–Einstein condensation [6, 7].

2. The attractive gravitational force in *d*-wave superconductors

The effective mass of quasiparticles of optimally oxygen doped mercury cuprates have been calculated by determining critical current density, J_c values via magnetization (M) versus magnetic field (H) curves, obtained from superconducting quantum interference device (SQUID). The related M–H curves have been reported in our previous works [1, 2]. All calculations were made at lower critical magnetic field value at which the system is solely diamagnetic so that there is no need to expect any vortex state contribution to the system. According to Eq. (3), the Josephson penetration depth values have been calculated for the temperature interval of 4.2–100 K. In the calculation process, Φ_0 and d are taken as 2.0678×10^{-15} T m^2 and 7.887×10^{-10} m [8], respectively.

The temperature dependence of the net effective mass of the quasiparticles calculated by Eq. (5), for the optimally oxygen doped mercury based copper oxide layered superconducting system, $HgBa_2Ca_2Cu_3O_{8+x}$ is given in Fig. 1a.

On the other hand, it has already been determined that the electroweak symmetry is broken in mercury cuprate superconductors [9]. In addition to electroweak symmetry breaking phenomenon, there is another remarkable relativistic effect in the mercury cuprate system which characterizes itself as the shift of the plasma frequency of the system from microwave to infrared at the vicinity of 55.5 K [1, 6]. Both the occurrence of the electroweak symmetry breaking and the frequency shifting phenomenon in the mercury cuprate system led us to discuss the net effective mass in terms of relativistic manner [1]. The net force for the system mentioned is calculated by the well known equation

$$F = m^* \frac{\mathrm{d}\upsilon}{\mathrm{d}t} + \frac{\mathrm{d}m^*}{\mathrm{d}t}\upsilon\,, \tag{6}$$

where F is force and υ is velocity.

Since, the only variable is temperature in the superconducting state, the related derivatives with respect to time in Eq. (6) can be considered as the derivatives with respect to temperature. The momentum of the quasiparticles in the superconducting system is to be neglected, since the $p = m^* \frac{\mathrm{d}\upsilon}{\mathrm{d}t}$ momentum term of the general relativity vanishes due to the fact that there is practically no acceleration term [10]. The net force is calculated by

$$F = \frac{\mathrm{d}m^*}{\mathrm{d}T}\upsilon\,. \tag{7}$$

The variation of the effective mass with temperature (Fig. 1b) has been calculated by origin Lab 8.0 Graphic program. The maximum value of the derivative has been achieved at the plasma frequency shift point of 55.5 K. The net effective mass of the quasiparticles at 55.5 K indicates the attractive quantum gravitational force due to the concept of the electromagnetic wave shifting to infrared region under gravitational field in a relativistic system [11, 12]. The net force at 55.5 K has been calculated by Eq. (7).

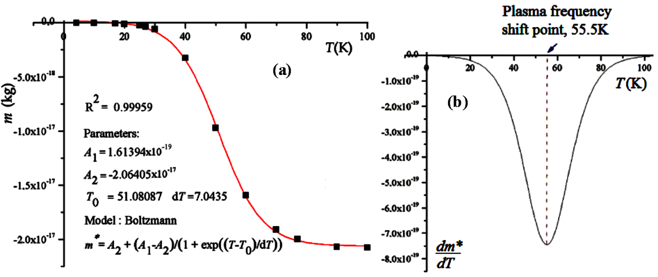

Fig. 1. (a) The temperature dependence of m^* for the optimally oxygen doped $HgBa_2Ca_2Cu_3O_{8+x}$ superconductor. (b) The temperature dependence of the first derivative of m^* with respect to temperature for the optimally oxygen doped $HgBa_2Ca_2Cu_3O_{8+x}$ superconductor [1, 2].

According to Fig. 1b, the maximum value of the first derivative of the net effective mass is $\frac{\mathrm{d}m^*}{\mathrm{d}T} \equiv \frac{\mathrm{d}m^*}{\mathrm{d}t} = -7.5\times10^{-19}$ kg/s. The corresponding net attractive force at 55.5 K has been determined as

$$F = \frac{\mathrm{d}m^*}{\mathrm{d}t}\upsilon = -7.5\times10^{-19}\cdot 3\times10^{8} = -2.25\times10^{-10}\ \mathrm{N}\,. \tag{8}$$

Since the system mentioned is a relativistic frame of reference, we have the right of using the speed of light in calculations.

3. The resemblances between DHQW as a topological soliton in *d*-wave superconductors and human DNA

In this work, we have found an exciting fact that the maximum attractive force at 55.5 K (-2.25×10^{-10} N) has the same order of magnitude of the attractive hydrogen bonding forces for the two deoxyribonucleic acid (DNA) nucleotide base systems. It has been reported that the hydrogen bonding forces for the two DNA nucleotid (adenine–thymine and cytosine–guanine) systems are both in the order of 10^{-10} N [13]. This consequence is neither a surprise nor coincidental, since the mercury cuprate system has inherited the three-dimensional double helix quantum wave (DHQW), namely the Segâh solitons, upon its *d*-wave order parameter symmetry in the *ab*-plane of the superconducting system and the occurrence of spatial resonance both determined in our previous work [9]. The DHQW, which occurs due to the phase difference of 45° between the *d*-wave order parameter in each superconducting copper oxide layers, is schematically illustrated in Fig. 2.

Moreover, some researchers have shown that DNA can conduct electricity and become a proximity-induced superconductor when its metal contacts become supercon-

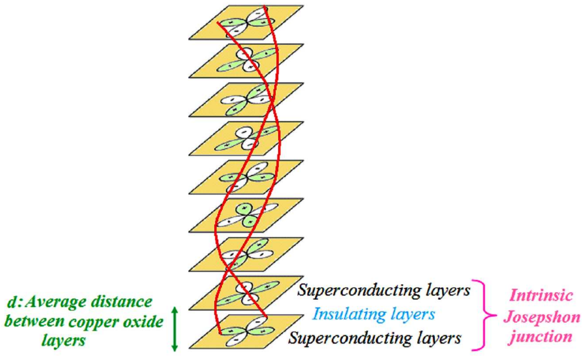

Fig. 2. The schematic illustration of the DHQW (red line) as topological solitons in the mercury cuprate superconductors [9]. The wave function of d-wave symmetry is represented as a four-leaf clover. There is a 45° phase difference between each superconducting copper oxide layer. The average distance between copper oxide layers, $d = 7.887 \times 10^{-10}$ m determined by XRD measurements.

ductor at very low temperature [14]. The DNA molecule is also excited by UV light [15]. On the other hand, the frequency of the DHQW has been roughly estimated as 3.2×10^{16} Hz that corresponds to ultraviolet (UV) region of the electromagnetic spectrum (Fig. 2).

4. Conclusion

In this work, it has been determined that the DHQW resembles to human DNA in some aspects such as topology and attractive force. The attractive gravitational force in the inorganic d-wave superconductors plays the same role as the electrical forces in DNA molecule in organic human body.

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