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# QUANTUM EFFECT OF MAGNETIC FIELD IN DESTROYING SUPERCONDUCTIVITY

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## ABSTRACT

The effect of magnetic field in destroying superconducting state the proved theoretically by using quantum resistance model. In this model the resistance is assumed to have positive superconducting part and negative part. When no external magnetic field is applied the super conducting resistance vanishes, while application of the magnetic field leads to none vanishing of resistance and destroying of superconducting state.

***Keywords***: *critical temperature superconductivity, zero resistance, plasma Equation, destroying, Quantum, effect, Magnetic field.*

## I. INTRODUCTION

Superconductivity was first observed by Heike Kamerlingh Onnes in 1911[1]. while inspecting the low-temperature properties of solid mercury. He discovered that the resistance of the metal dropped sharply to zero below a certain temperature. Nowadays, there are a number of other effects were observed, including a total expulsion of magnetic fields known as the Meissner effect, and Quantum effect of Magnetic field.

As temperature decreases, many metals pass from the normal to the superconducting state. The result of a change in some external parameter of magnetic field strength, that superconductivity can be destroyed [2].

The phenomenon of superconductivity, in which the electrical resistance of certain materials completely vanishes at low temperatures, is one of the most interesting and sophisticated in condensed matter physics.

Also The phenomenon of superconductivity has always been very exciting, both for its fundamental scientific interest and because of its many applications.

There are two types of superconductors, I and II, characterized by the behavior in an applied magnetic field [3,4]. Type I superconductors depends on Critical Temperature $T_c$ and Critical Magnetic Field $B_c$. In the presence of an applied magnetic field B, the value of $T_c$ decreases with increasing magnetic field for several type I superconductors. When the magnetic field exceeds the critical field, $B_c$ , the superconducting state is destroyed and the material behaves as a normal conductor with finite resistance. Type II also depends on two critical magnetic fields, designated $B_{c1}$ and $B_{c2}$. When the external magnetic field is less than the lower critical field $B_{c1}$, the material is entirely superconducting and there is no flux penetration, just as with type I superconductors. When the external field exceeds the upper critical field $B_{c2}$ , the flux penetrates completely and the superconducting state is destroyed, just as for type I materials. For fields lying between $B_{c1}$ and $B_{c2}$, however, the material is in a mixed state, referred to as the vortex state [3].

Plasma equations describe ionized fluids subjected to electric and magnetic potentials for particles having thermal energy [5]. These equations are more generalized than Newton's equations for single particle[6]. Because it accounts for particles having thermal energy and moving in bulk matter [7].

Thus plasma equation is suitable for describing behavior of bulk matter
[8]. Thus it can be used to develop quantum equation for particles moving inside a certain medium [9]. Such equation can reduce quantum equation from large degrees of free dimension to 3dimensionson space only. Such equation was first developed by M.Dirar and Rasha. A [10]. This equation is used to explain some Schrödinger

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behavior, unfortunately this approach is complex mathematically. Thus there is a need for a simple model that can explain some Schrödinger phenomena. Section (2) is devoted for quantum equation derived from energy equation found from plasma equation. The solution and equation expression for resistance is exhibited in section (3). Section (4) is concerned with finding critical temperature. Discussion and conclusion are in section (5) and (6) respectively.

Another direct approach can also be found by considering the pressure exerted by the electrons . In this case [9] the Hamiltonian becomes :

$$\hat{H} = \frac{\hat{p}}{2m}^{2} + KT - V \qquad (1)$$

For spin repulsive force :

$$V = -V_0$$

Thus :

$$\hat{H} = \frac{\hat{p}}{2m}^{2} + KT - V_0 \qquad (2)$$

Thus the average energy which is equal to the classical energy is given by:

$$\hat{H} = < \frac{\hat{p}^2}{2m} > +KT - V_0 = E_0 + KT - V_0 \qquad (3)$$

Resistance for harmonic oscillator where,

$$x = x_0 e^{i\omega t}, \qquad v = i\omega t, \qquad T = \frac{1}{2} m|v|^2 = \frac{1}{2} m\omega^2 x^2,$$

$$V = \frac{1}{2} K x^2 = \frac{1}{2} m\omega^2 x^2 = T, \quad H = T + V = 2V, \quad eV_e = V = \frac{H}{2},$$

Where $V_e$ is the potential , thus $V_e = \frac{H}{2e}$

Using the quantum definition of [10]:

$$R = \frac{V_e}{I}$$

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$$R = \frac{<\hat{H}>}{2eI} = \frac{E_0 + KT + V_0}{2eI}$$

$$R = R_+ + R_- \qquad (4)$$

Where one splits R to positive and negative one.

When :

$$E_0 + KT - V_0 < 0 \qquad (5)$$

$$R_- = \frac{E_0 + KT - V_0}{2eI}, \quad R_+ = 0 \qquad (6)$$

From equations (5) and (6) the super conductivity resistance $R_S$ Vanishes i .e :

$$R_+ = R_s = 0 \qquad (7)$$

When :

$$KT < V_0 - E_0$$

$$T < \frac{V_0 - E_0}{K} \qquad (8)$$

Thus the critical temperature is given by :

$$T_c = \frac{V_o - E_o}{K} \qquad (9)$$

Again for $T_c$ to be positive $V_0 > E_0$

Thus for:

$$T < T_c \qquad (10)$$

$$R_{sc} = R_+ = 0 \qquad (11)$$

In the case when external magnetic field of flux density $B$ is applied on the superconductivity, the total magnetic field $B_m$ and potential $V_m$ resulting from both external and internal to magnetic fields are given by:

$$B_m = B - B_i \qquad (12)$$

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$$V_m = V - V_i \tag{13}$$

Where $B_i$ and $V_i$ stands for the internal magnetic density and potential respectively. When the magnetic field attract electrons, the Hamiltonian and the average energy in equations (1), (2) and (3) are given

$$\hat{H} = \frac{\hat{p}}{2m}^2 + KT + V_m - V_0$$

$$< \hat{H} > = E_0 + KT + V_m - V_0 \tag{14}$$

Thus according to equation (4) the quantum resistance is given by:

$$R = \frac{KT + E_0 - V_0 + V_m}{2eI} = R_+ + R_- \tag{15}$$

In view of equation (9) and by denoting $V_m$ to be

$$V_m = KT_m = m_L \left(\frac{e\hbar}{2m}\right) B_m = C_m^{-1} B_m \tag{16}$$

Equation (15) reads

$$R = \frac{K(T + T_m - T_c)}{2eI} \tag{17}$$

When,

$$T_m > T_c \tag{18}$$

Thus the critical $V_m$ and $B$ are given by (18), (12) to be

$$B_c = B_{mc} + B_{ic} = C_m V_{mc} + B_{ic} = C_m K T_c + B_{ic} \tag{19}$$

In this case $R$ is positive always, no matter what the value of $T$ is therefore

$$R = R_+ + R_- = \frac{K(T + T_m - T_c)}{2eI} \tag{20}$$

Thus,

$R_+ \neq 0$ always, when condition (18) is satisfied.

## II. DISCUSSION

The quantum resistance model done by Dirar and Einas splits it to positive superconducting resistance and negative one. In this model the

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Effect of applying external magnetic field is examined. The external magnetic field incorporates itself in the resistance relation (15) via the medium potential term  as shown by equation (12) and (13). The quantum resistance consists of positive superconducting part beside negative part according to equation (15). The critical magnetic flux density is given by equation (19). If  exceeds this critical value the superconducting resistance does no longer vanish and the superconducting state is destroyed. This conforms with experiments.

## III. CONCLUSION

The quantum resistance model based on temp erature dependent Schrödinger equation, beside positive and negative resistance model can explain the destroy of superconducting state by magnetic field.

## REFERENCES


1. *Pranjal Vachaspati, Sabrina Pasterski, Superconductivity (2013).*
2. *V F Gantmakher, V T Dolgopolov, Superconductor-insulator quantum phase transition, Uspekhi Fizicheskikh Nauk, Russian Academy of Sciences, Physics - Uspekhi 53 (1) 1 - 49 (2010).*
3. *Serway, Raymond. A., Jewett, John, W. Physics for Scientists and Engineers, Thomson Brooks/Cole, (2004).*
4. *C. M. Aegerter, H. Keller, S. L. Lee, C.Ager, F. Y. Ogrin and R. Cubitt . Transition from Type-I to Type-II Superconducting Behaviour with Temperature observed by µSR and SANS, School of Physics and Astronomy, University of Birmingham, Birmingham B15 2TT, UK. May 26, (2003).*
5. *J.A. Bitten Court, Fundamental of Plasma Physics, Springer Science & Business Media, New York, 3rd Edition, 2004.*
6. *Francis F. Chen, Plasma Physics, Springer science and Business Media, LLC., 2nd Edition, (2013).*
7. *T. J. M. Boyd , J.J. Sonderson, The Physics of Plasma, Cambridge University Press, (2003).*
8. *Richard Fitz Patrick, Plasma Physics: An Introduction, Tayloraud Francis Group, LLC. (2015).*
9. *James E. Drummond, Plasma Physics, Dover Publications, Inc., Mineola. New York, (2013).*
10. *R.AbdElhaietal,, Using the tight binding approximation in deriving the quantum critical temperature superconductivity equation, Natural Science,v.5,N.8,941-946, (2013).*