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CLASSICAL NEWTONIAN MODEL FOR DESTRUCTION OF SUPERCONDUCTORS BY MAGNETIC FIELD

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ABSTRACT

Newton second law is used to describe the destruction of super conductivity for type 1 & type 2.The electron is assumed to be affected by external electric and magnetic field as well as the internal magnetic field. The conductivity and resistance depends on the internal as well as external magnetic field. For type 1 the super conducting state is destroyed when the external magnetic field exceeds the maximum internal field. For type 2 the superconductivity is destroyed partially in the region where the local maximum field is the lowest, and enters completely when the external field exceeds the maximum local internal field.

Keywords: *super conductor, type1 & 2, external magnetic field, internal magnetic field, resistivity, conductivity, destroy.*

I. INTRODUCTION

Superconductors (SCS) are materials that have zero resistance and infinite conductivity below a certain critical temperature. The (SC) is a perfect diamagnetic material .It prevents external magnetic from entering the sc. But when the external magnetic field exceeds a certain critical value, it enter the (SC), and it become an ordinary conductor [1, 2].Superconductivity (SC) was discovered in 1911 in the Leiden laboratory at Holland, where the resistivity of Hg vanished about 4K and well below it. Bardeen and Cooper proposed a theoretical model so as to describe a conduction mechanism for (SC) in 1957. This model explains many phenomena of (SC) materials, especially those having critical temperatures below 130K.Till 1986; critical temperatures at which resistance disappears were always less than 23K. In 1986, Bednorz and Muller published a paper, showing new materials having conductivity of about 135K. They a warded Noble prize at 1987. These new class of materials are known as high temperature superconductors (HTSCS). These new classes of super conductors, i.e. HTSCS have some peculiar features that cannot be described by Bardeen and Cooper model. These include pressure, isotope and pseudo energy gap effects [3, 4]. Many attempts were made to explain such new effects [5, 6] .Some of them are based on classical laws, while others are based on quantum laws [7, 8].Superconductors are widely used in many applications. In medicine, power full superconducting magnets (SCM) are used in magnetic resonance imaging (MRI) devices for diagnosis, superconductors are also used to generate powerful electric energy from powerful magnetic field, high speed trains also utilized (SC) to generate powerful magnetic field. Such applications need new trend and models to describe (HTSCS).

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Classical Model to Describe Magnetic Destruction of Super Conductivity by the External Magnetic Field

The equation of motion of the electron moving inside matter under the action of external electric and magnetic field intensities E and density B is given by

$$m\frac{dv}{dt} = eE + B_i ev - Bev \quad (1)$$

Where B_i is the internal field since the electrons move with constant velocity, hence

$$\frac{dv}{dt} = 0$$

And

$$(B - B_i)ev = eE \quad (2)$$

Therefore the velocity is given by

$$v = \frac{eE}{(B-B_i)e} \quad (3)$$

Thus the current density takes the form

$$J = nev = \frac{ne^2}{(B-B_i)e}E = \sigma E \quad (4)$$

Where n stand for the charge density.
The conductivity σ is thus given by

$$\sigma = \frac{ne}{B-B_i} \quad (5)$$

$$\rho = \frac{(B-B_i)}{ne} \quad (6)$$

Where the internal field can be written in terms of the field per atom as

$$B_i = n_a B_a \quad (7)$$

B_a here represents the magnetic field induced by one atom, while n_a represent the number of diamagnetic atoms that induces magnetic field that opposes the external field B.
The conductivity becomes zero in type I, due to the fact that the induced internal field density B_i increases and when the external flux density increases such that always B_i equals $B, i.e$

$$B_i = B \quad (8)$$

According to equations (5) and (6)

$$\sigma = \infty \quad (9)$$

$$\rho = 0$$

Thus the material becomes superconducting till all atoms N_a in a unit volume become magnetized. But when the external field B exceeds the maximum value

$$B_{im} = B_a N_a \quad (10)$$

i.e. when

$$B > B_{im} \quad (11)$$

In this case no more atoms can be magnetized to oppose and cancel$B$. In this case

$$\sigma = \frac{ne}{B - B_{im}} = finite$$

$$\rho = \frac{B-B_{im}}{ne} \neq 0 \quad (12)$$

And the whole superconductor becomes conducting

For type II superconductor, one can assume that there are regions where the densities of atoms are law and equalsN_{aL}. In such regions the increase of B increase B_i till

$$B_{iL} = N_{aL} B_a \quad (13)$$

When B is less than B_{iL}

$$B = B_i \quad (14)$$

And an equation (5) and (6) reads

$$\sigma = \infty$$

$$\rho = 0 \quad (15)$$

But when

$$b > B_{iL}$$

$$\sigma = \frac{ne}{B - B_{iL}} \neq \infty$$

$$\rho = \frac{B - B_{iL}}{ne} \neq 0 \quad (16)$$

And these regions become ordinary conductors, while other regions are still superconductors. The same hold for other regions with higher concentration than N_{aL}. They become ordinary conductors, when B exceeds their local maximum internal field. This process continues till the external field enters regions where the densities of atoms are high and equalsN_{ah}. In this region the increase of B increases B_i till

$$B = B_{ih} \quad (17)$$

In these cases when

$$B = B_i \leq B_{ih} \quad (18)$$

$$\sigma = \infty$$

$$\rho = 0 \quad (19)$$

According to equations (5) and (6). But when

$$B > B_{ih} \quad (20)$$

In this case

$$\sigma = \frac{ne}{B - B_{ih}} \neq \infty$$

$$\rho = \frac{B - B_{ih}}{ne} \neq 0 \quad (21)$$

Thus when the external field B exceeds B_{iL} the SC becomes partially ordinary conductor in regions where the diamagnetic atoms have law density. Upon increasing B, such that

$$B > B_{iL} \quad (22)$$

More regions become ordinary conductors, till all SC material become ordinary conductor when

$$B > B_{ih} \quad (23)$$

Thus for type II, one have two critical magnetic fields B_{iL} *and* B_{ih}
Another explanation may also explain the behavior of type II SC. This approach is based on assuming that the matter density is homogeneous but the magnetic field of atoms are randomly oriented such that the net magnetic field in some regions is the lowest and in gradually increases and attains its maximum value in another region.According to this model the increase of external field in the lowest B_i value increases B_i according to the Langevin equation

$$w_L = \Delta w = \frac{Be}{2m} \quad (24)$$

$i = -\frac{eZ_0 w_L}{2\pi} = -\frac{e^2 Z_0 B}{4\pi m}$ (25)

Where Z_0 is the number of electrons in the outer most sheet. By considering electrons moving in a circular orbit one gets the internal magnetic field in the form (here one assumes only outer most electrons can produce induced magnetic field)

$B_a = \frac{\mu i}{2r} = \frac{\mu e^2 Z_0}{8\pi m r} B$ (26)

The internal field B_i is given by

$\underline{B_i} = \Sigma \underline{B_a}$ (27)

This internal field increases upon increasing the external one, till the electron kinetic energy exceeds electron binding energy $E_b, i.e.$

$\frac{1}{2} m v^2 > E_b$ (28)

i.e.

$$w > \frac{1}{r}\sqrt{\frac{2E_b}{m}}$$

The electron becomes free. In this case the electron will no longer revolve around the nucleus. Thus it cannot produce internal magnetic field. Thus the maximum produced atomic field is

$$b_{am} = \frac{\mu i_m}{2r}$$

Where the maximum current produced is

$$i_{,} = -\frac{eZ_0 w_m}{2\pi}$$

Where

$$w_r = \frac{1}{r}\sqrt{\frac{2E_b}{m}}$$

Thus the internal field attains maximum value

$$B_{im} = \Sigma B_{am}$$

When B exceeds this maximum value in the region of lowest B_i, i.e.

$$B > B_{imL}$$

The resistivity will no longer vanishes according to equation (6), where

$$\rho = \frac{B - B_{imL}}{ne} > 0$$

The same hold for the region having maximum internal field value due to large orientation of magnetic field of atoms in the opposite direction of the external one. In such region the external magnetic field B is balanced by the internal oneB_{ih}, till electrons energy exceeds binding energy.

II. DISCUSSION

Classical Newton second law is used in equation (1) to describe the electron motion in the presence of external electric and magnetic fields beside the internal magnetic field. The relation between current density with both velocity and conductivity is used to find the conductivity and resistivity in terms of the external and internal magnetic flux density as shown by equations (4) and (5).Since (SC) is a perfect diamagnet the increase of external magnetic increases the internal one such that the net magnetic field vanishes inside the sc (equation 8).In this case the resistance vanishes as equation (9) indicates. However when all atoms produces diamagnetic field, then further increase of external field will no longer increase the internal one and the magnetic field enters the (SC), which becomes ordinary conductor with finite resistance (equations 11 & 12).For type 2 sc the internal magnetic field is no longer uniform, either due to non uniform density or random distribution of atomic dipole moments. The external magnetic field enters partially first the area where the internal magnetic field is minimum. It then enters the (SC) completely when the internal field is maximum as shown by equations (13) & (17).

III. CONCLUSION

The classical Newtonian model that assumes the existence of internal beside the external one can successfully describe the destruction of sc for both type 1 & 2.sc.It assumes that the internal magnetic field has critical maximum value for type 1 and minimum and maximum values for type 2.When the external field exceeds these maximum values the sc is destroyed.

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