International Journal of Advanced Research in Engineering Technology & Science

ISSN: 2349-2819

Email: editor@ijarets.org Volume-4,Issue-9 September-2017 www.ijarets.org

TO STUDY CRITICAL FIELD IN HIGH-Tc CUPRATE OXIDE COMPOUNDS:

Vijay Kumar Pancholi

Department of Physics Government College Kota

Rajasthan India

ABSTRACT

The discovery of high- T_C copper oxide based compounds and subsequent experiments have raised two important and almost certainly related issues: (i) What the possible mechanism of pairing responsible superconductivity in these systems? (ii) What is the nature of the normal state? Many of the normal state properties of these newly discovered cuprate superconductors those observed in other metals or expected for a Fermi liquid. The electrical resistivity ρ (T), the thermal conductivity K(T), the optical conductivity σ(ω), the Raman scattering intensity s(ω), tunnelingconductances function of voltage g(V), the nuclear relaxation rate T_1^{-1} (T) and the Hall coefficient R_H(T) are all anomalous and hence one can characterize these conducting compounds as anomalous metals. Excepting the temperature dependence the Hall Coefficient all normal state properties of cuprate superconductors are qualitatively the same. An outstanding feature is the linear temperature dependence of the electrical resistivity, ρ(T) that is now observed in all good quality samples of copper oxide based compounds if measured parallel to Cu-O planes.

Keywords:Critical field

INTRODUCTION

On the other hand, many of the superconducting properties appear surprisingly conventional for these high- T_C systems. A BCS type peak has been reportedly observed in the ^{17}O N M R relaxation rare just below T_C, with exponential decay at low temperatures. Several other experimental observations such as tunnelling and London penetration depth point towards the existence of a finite energy gap over the entire Fermi surface below T_C and the existence of Josephson tunnelling between high – T_C oxides and conventional superconductors establishes that the superconductivity has conventional s-wave symmetry. These experimental results point to a superconducting state that has some peculiar features but is otherwise not too different from what is found in conventional superconductors The carriers of superconductivity in cuprate superconductors are likely to be pairs of holes and hence it seems reasonable that the superconducting properties should be affected by the concentration of such holes, which can be changed by varying the cation, and/ or oxygen content. Measurements on La_{2-x}, Sr_X, CuO_4 show that superconductivity is present in a narrow region of hole concentration 0.30 > x > 0.06. For (x < 0.06), the material is semiconducting and certain magnetic phenomena appears to dominate the properties. At higher concentrations (x > 0.30), even though the conductivity is higher, superconductivity disappears. The Y $Ba_2Cu_3O_{6+y}$ system is much more complex, with holes on both the ribbons and sheets, but one analysis suggests that T in this material is also a function of hole concentration on sheets.

Along with the search for high - T_C superconductors a spate of theoretical model mechanisms have been suggested to explain the phenomenon of high- T_C superconductivity in cuprates. The identification of the possible mechanism responsible for the high-T_C superconductivity in copper and non- copper oxide systems is possibly the most challenging problem.

Green's Function Technique :

In order to study the superconducting phase transition in high - $T_C$cuprate oxide compounds. We follow the method of calculation based upon the Green's Function technique as described by Zubarev. Here we shall review in brief the principal definitions and basic equations of this technique.

We define average of an operator A over- a grand canonical ensemble as

$< A > = Z^{-1}\text{tr}\ [A\ \exp]\ \{-\beta(\hat{H} - \mu\hat{N})\ ]$ with

$$Z = \text{tr}\ [\exp\beta(\hat{H} - \mu\hat{N})] \qquad \ldots (1)$$

Here H is the Hamiltonian and N the total number Operator, $\beta = 1/K_BT$. K_B = Boltzmann constant and T = absolute temperature.

Now let $A(t) = \exp(i\hat{H}t)\ A(o)\ \exp(-i\hat{H}t)$ (in the units of $\hbar = 1$) and B (t*) be two operators. Then retarded (+) and advanced (-) Green's functions say be defined by

$$<< A(t); B(t^*) >> (\pm) = \pm\, i\, \theta\, (\pm(t - t^*)) \times <[A(t), B(t^*)]_n> \qquad \ldots (2)$$

where

$$[A, B] = AB - \eta\ BA \qquad \ldots (3)$$

With $\eta = -1$ for fermions and $\eta = 1$ for bosons and (t) is well known step function or unit function given by

$\theta(t) \quad = 1$ for $t > 0$

$\qquad\quad = 0$ for $t < 0$

Thus, for fixed t the retarded function exists only for times t later than t', and the advanced function exists only for times t earlier than t'.

The Green's function (1.9) can be shown to satisfy the equation of motion

$$i\ \ d/dt << A(t)\ ;\ B(t') >> (\pm) = -\ \delta\ (t-t') < [A(t).B(t')_n>$$

$$+ << [A(t), H], B(t') >> (\pm) \qquad \ldots (4)$$

In the second term on the right hand side of equation (4) the commutator [A(t). H] appears, this term gives rise to Green's functions which generally contain more operators than the Green's function on the left. The equation of motion of these higher order Green's function is

$i\ d/dt << [A(t)H]; B(t') >> (\pm) = -\delta(t-t') < [[A(t), H], B(t')_n] >$

$+ << [[A(t), H], H]; B(t^*) >> (\pm)$ ... (5)

Generally the last term has again a higher order Green's function than the Green's function on the left hand and has a new equation of motion and so on.

Finally, one obtains an infinite chain of equations of the Green's functions. Equations so obtained are exact and the solution of this chain equation is extremely complicated. The important point of the whole theory is to cut this infinite chain ingeniously in order to solve the remaining system what is called the decoupling procedure). By suitable approximations one can always reduce the chain of equations so obtained to finite set of equations which can be solved. In our treatment we shall make use of appropriate decoupling procedure.

It is useful to introduce the Fourier transform of equation (5) with respect to (t-t') as one obtains ordinary algebraic equations in place of differentional equations. We define. for real ω, the Fourier transform as

$$<< A, B >>_w^{(\pm)} = \int_{-\infty}^{+\infty} << A(t), B(0) >>^{\pm} e^{-iwt} dt \quad \text{... (6)}$$

In the case of retarded (+) Green's function, the integral (5) converges also for complex ω plane provided

$I_m\omega < 0$, So $<< A; B >>^{(+)}\omega$

can be defined and is a regular function of w in the lower half of the complex ω-plane. Similarly $<< A; B >>\omega^{(-1)}$ is a regular function in the upper half of the complex W plane. We may now define

$$<< A;\ B >>_w = \begin{cases} << A,\ B >>_w^{+} & \text{if} \quad I_m w < 0 \\ << A,\ B >>_w^{-} & \text{if} \quad I_m w > 0 \end{cases} \quad \text{... (7)}$$

Which will be function regular throught the whole complex ω-plane except on the real axis. From equation (5) it can be shown that $<< A; B >>^{(\pm)}$ satisfies the equation

$$\omega << A,\ B >>_\omega = <[A, B]_n> \mp << [A,\ H];\ B >>_\omega^{(\pm)} \quad \text{... (8)}$$

OBJECTIVES

To studycritical field

RESEARCH METHODOLOGY

The low temperature critical field is given by.

$$H_C = [8\pi[F_N - F_S]]^{\frac{1}{2}} \quad \text{... (9)}$$

On solving equation, we obtain:

$$H_C = (8\pi v)^{\frac{1}{2}} \left[\frac{\Delta^2}{|U|} - \frac{4N(0)}{\beta} \int_0^{\hbar\omega_D} dF_{K''} \log \left\{ \frac{\cosh\left(\frac{\beta E}{2}\right)}{\cosh\left(\frac{\beta E'}{2}\right)} \right\} \right]^{\frac{1}{2}} \quad \text{... (10)}$$

Using equation (8) we can also put low temperature critical field as:

$$H_C = (8\pi v)^{\frac{1}{2}} \left[\frac{\Delta^2}{|U|} - N(0) \left\{ \frac{1}{2} \Delta(2Z - \Delta) + (Z - \Delta)^2 \right.\right.$$

$$\left. \log \frac{2\hbar\omega_D}{(Z - \Delta)} - Z^2 \log\left(\frac{2\hbar\omega_D}{2} \right) \right\} + \frac{1}{3}\pi^2 N(0)(k_B T)^2$$

$$\left. - 4NV(0)k_B T \int_0^{\hbar\omega_D} dF_{K''} \log\left(1 + e^{-\beta E}\right) \right]^{\frac{1}{2}} \quad \text{... (11)}$$

For normal superconductors, the above equation reduces to

$$H_C(T) \approx H_C(0) \left[1 - 1.06 \left(\frac{T}{T_C} \right)^2 \right]_{T \to 0} \quad \text{... (12)}$$

Where $H_C(0)$ is the critical field at T = 0. The lower critical field H_{C_1} is given by

$$H_{C_1} = \frac{H_C}{\sqrt{2K}} \ln K \quad \text{... (13)}$$

and the upper critical field H_{C_2} is given formally given by

$$H_{C_2} = \sqrt{2}\, K\, H_C \quad \text{...(14)}$$

Where K is the Ginzburg - Landaun parameter.

DATA ANALYSIS

CRITICAL FIELD (H_c)

The low Temperature critical field is given by equation (14)

$$H_C = [8\pi([F_N - F_S])]^{1/2} \quad \dots (15)$$

The variation of H_c, with temperature is shown in fig.1 and fig. 2 are given in table 1

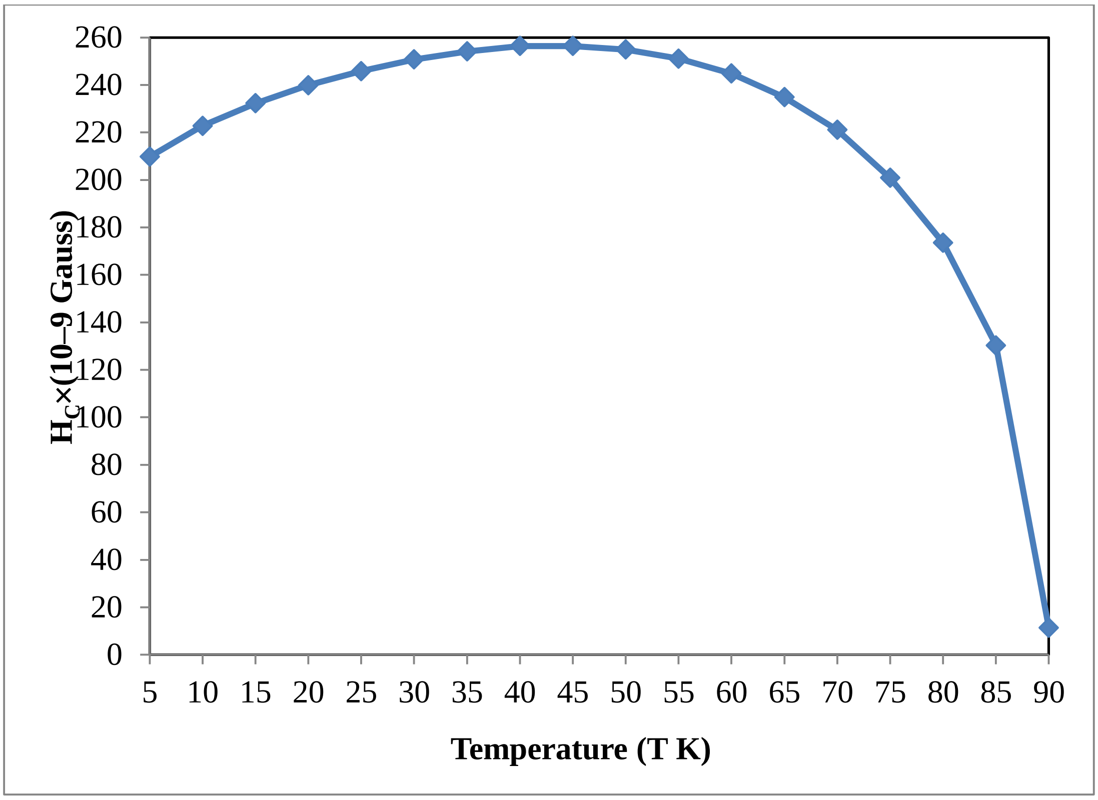

Fig. 1

Variation of Critical Field with Temperature

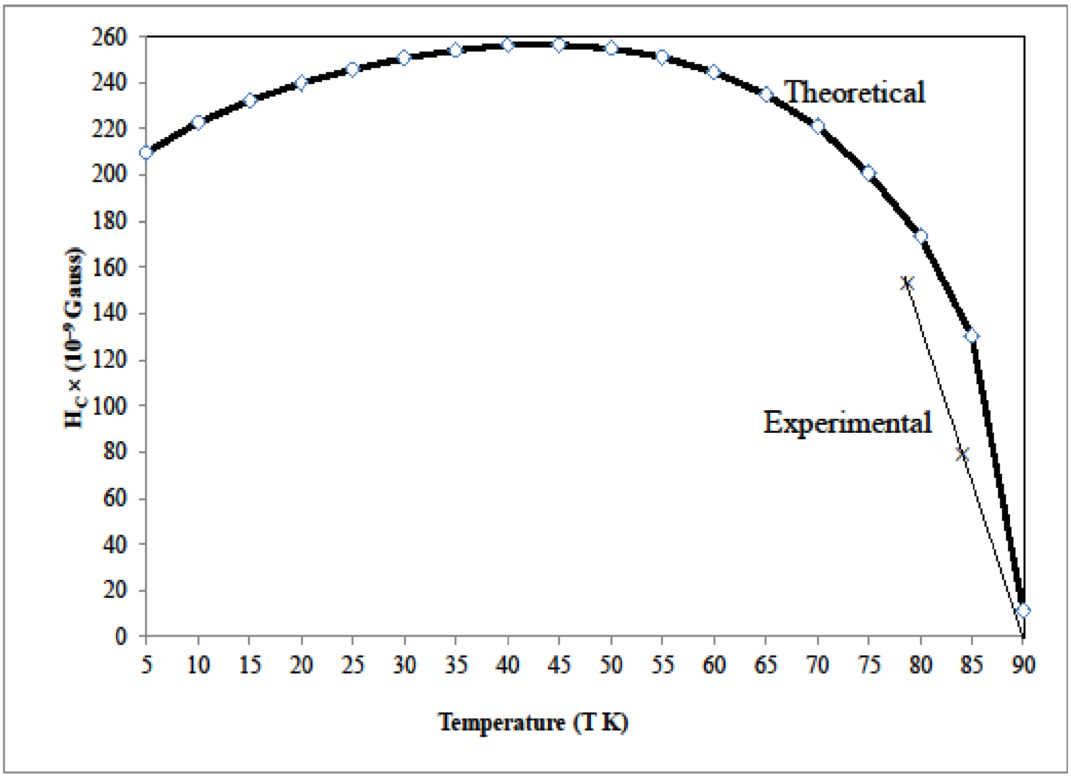

Fig. 2
Variation of Critical Field with Temperature

Table 1

S. No.	Temperature T (K)	$[F_S - F_N]$ 10^{-18} (erg/mole)	$\mid H_C \mid \times 10^{-9}$ (K Gauss)
1.	5	-1750.335	209.7396
2.	10	-1974.879	222.7871
3.	15	-2146.16	232.2474
4.	20	-2289.812	239.8942
5.	25	-2303.884	245.7970
6.	30	-2501.386	250.7323
7.	35	-2568.729	254.0850
8.	40	-2616.11	256.4176
9.	45	-2615.556	256.3905
10.	50	-2586.141	254.9447
11.	55	-2508.79	251.1031
12.	60	-2384.212	244.7892
13.	65	-2194.734	234.8609
14.	70	-1944.605	221.0729
15.	75	-1605.387	200.8675
16.	80	-1197.401	173.4761
17.	85	-675.7065	130.3163
18.	90	-5.092192	11.31285

CONCLUSION

The good overall agreement between our theoretical model and experimental results reinforces the supposition that the charge carriers in the new high – T_C materials have polaronic character. In order to understand the mechanism leading to high – T_C superconductivity it is essential to have a precise knowledge of the nature of charge carriers in the normal state. Detailed high resolution photoemission spectroscopy can in principle answer this question. Available results are not sufficient to draw any conclusion. We will to have wait for more decisive results.

REFERENCES

1. R. J. Cava, B. Batlogg, C. H. Chen, E. A. Rietman, S. M. Zahurak, and D. Werder, Nature 329, 423 (1987).
2. S. Uchida, H. Takagi, K. Kitazawa, and S. Tanaka, Jpn. J. Appl. Phys. 26. L 1 (1987).
3. C. N. R. Rao and P. Ganguly. Curr. Sci. 56, 47 (1987)
4. P. Ganguly, R. A. Mohanram, K. Sreedhar and C. N. R. Rao, J. Phys. 28, L 321 1987).
5. T. Siegrist, S. Sunshine, D. W. Murphy. R. J. Cava, and 5. M. Zahurak, Phys. Rev. B 35, 7137 1987).
6. J. Beille, R. Canabel, C. Chaillout, B. Chevallier, G. Demazeau, F. Deslandes, J. Etourneau, P. Lejay. C. Michef, J. Prevost, B. Raveau, A. Sulpice, J. L. Tholence and R. Tournier, C. R. Acad. Sci. 11 1097 (1987). 304.
7. K. Sekizawa, Y. Takano, H. Takigami, S. Tasaki, and T. Inaba, J. Appl. Phys. (Japan) 26, L 840 (1987).
8. E. A. Early. N. Y. Ayoub. J. Beille. J. Beille, J. T. Markert and M. B. Maple, Physica C 160, 320 (1989).
9. H. Takagi, S. Uchida and Y. Tokura, Phys. Rev. Lett. 62. 1197 (1989).
10. S. Ghamaty. B. W. Lee, J. T. Markert, E. A. Early, T. Bjomholm, C. L. Seaman and M. B. Maple, Physica C 1 (1989).
11. Y. Tokura. T. Arima. H. Takagi, S. Uchida, T. Ishigaki, H. Asamo. R. Beyers. A. 1. Nazzal, P. Lacorre and J. B. Toorance, Nature 12. 21 (1989).
12. R. J. Cava. M. Marezio, J. J. Krajewski, W. F. Peck, Jr. A. Santoro and F. Beech (Preprint 1989).
13. R. J. Cava, B. Batlogg, J. J. Krajewski, R. Farrow, L. W. Rupp, Jr. A. E. White, K. Short, W. F. Peck and K. Kometani, Nature 332, 814 (1988).
14. L. F. Mattheiss and D. R. Hamann, Solid State Commun. 63. 395 (1988).
15. L. F. Mattheiss and D. R. Harmann, Phys. Rev. B 38, 5012 (1988).

16. L. F. Mattheiss and D. R. Hamann, Phys. Rev. Lett. 60. 2681 (1988).

17. L. F. Mattheiss and D. R. Hamann, Phys. Rev. B 39, 4780 (1989).

18. M. J. Rosseinsky, A. P. Ramirez, S. H. Glarum, D. W. Murphy, R. C. Haddon, A. F. Hebard, F. T. M. Palstra, . Phys. A. R. Kortan. S. M. Tahurak and A. V. Makhiza Rev. Lett. 6. 2830 1991).