Superconducting bubbles percolation in the pseudogap phase for (Hg,Re) – 1223 ceramics

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Abstrct

One of the open challenges to be solved in high *Tc* superconductors physics is the problem of the pseudogap phase [1], which is found in the temperature *T** above *Tc*. The pseudogap phase is characterized by the drop of resistivity with the temperature slightly below the linearity. In this work we believe that this unusual fall is due the formation of small supercondsting fluctuations, referred as "bubbles", that convulate at the pseudogap temperature and form a narrow path for a superconducting current, made from the clusterization of the bubbles. This does not get to the properly superconducting phase because the cluster is still incipient, but the current of this optimized path competes with the normal current.

Keywords (Palavras chaves): percolation, superconductors, fluctuations.

1. Introduction

Since the discover of the high *Tc* cuprate superconductor family in 1986 until nowadays one of the questions that has arisen is the role of the pseudo gap in the superconducting phase diagram [2]. We wonder if the pseudo gap is the beginning of superconducting transition or the other would be a transition phase that precedes the superconducting transition. The pseudogap region is characterized as a region of strong fluctuations and has an initial temperature, *T*,* above the critical temperature *Tc*.

2. The percolative model

In *T>T**, the system is in a diffuse regime and obeys the Drude's law

$$\sigma_n = \frac{ne^2\tau}{m} \qquad (1)$$

With τ being the *time of collision* of the electron with defects and it is proporcional to the inverse of the temperature *(*τ~T*).* Above the pseudogap temperature the superconducting fluctuations start to percolate, creating a stream of condutivity given by [3].

$$\sigma_f = \frac{e^2}{16\hbar d}\frac{T}{(T-T_c)} \qquad (2)$$

With the normal and superconduting phases coexisting together, the condutance is given by the sum of both condutances.

$$G = G_n + G_f = \frac{\sigma_n A}{l_n} + \frac{\sigma_f A}{l*} \qquad (3)$$

If *T* is too close to *T** the stream of fluctuations is very unstable and the number of bubble overlaps is too small, thus forming an incipient clusterization. This regime is referred as the strong disorder. The disorder of the system can be determinated by a parameter a and it is associated with the resistence by [4]

$$R = e^{ap} \qquad (4)$$

Where p is the concetretion of fluctuation bubbles that overlap with each other. The strong disorder is characterized by the parameter a being greater than the sample size L, $a > L$. In the strong disorder the resistence is proporcional to

$$R \sim \frac{(T-T_c)}{Const_1 \times {(T-T_c)}/{T} + Const_2 T} \qquad (5)$$

Where $const_1$ and $const_2$ are, respectivally, relatives to normal and fluctuation conductivities. Since normal conductivity is much bigger than the fluctuation one,

$const_1 \gg const_2$, which leads to a resistence very close to a linearity with the temperature, meaning that the strong disorder regime and the normal state differ very little from each other. The more the temperature falls towards the critical treshold, the more organized and constant the fluctuation appearance and overlap get, leading to a regime of weak disorder. In opposition to the strong disorder, the weak disorder we have $a < L$. In the weak disorder the resistence also depends on the correlation length, that is, the length that indicates the beginning of the percolation process and it's given by $\xi \propto (p - p_c)^{-\nu}$. In this regime, the correlation length is well approximated for the parameter a, or $\xi \approx a$. After further calculations, we come up with a relation for the resistence in the weak disorder.

$$R \propto F(T) \times \frac{(T - T_c)}{[\ln(T^*) - \ln(T)]^{0,293}} \qquad (6)$$

With,

$$F(T) \propto \frac{1}{Const_1 \frac{(T - T_c)}{T}[\ln T^* - \ln T]^{0,293} + Const_2 T}$$

and $d_{opt} = 1,22$ and $\nu = 4/3$.

The plot below shows the correlation between theorical and experimental results.

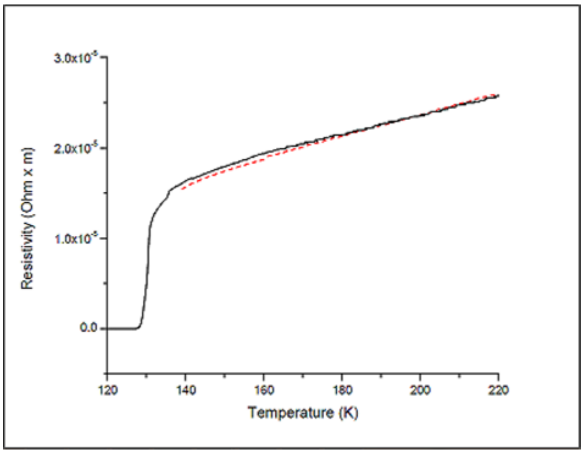

Fig. 1: The comparison between the results of the resistivity mesurements of the Hg,Re – 1223 superconductor (black continous line) with the plot from equations (5) and (6) (red dashed line).

3. Conclusion

The plot above shows a good correlation between the theorical expectations and mesured data. This could indicate that the superconducting state forms before the temperature reaches its critical value.

4. Acknowledgments

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5. References

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