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Fluctuation conductivity behavior in thin films of YBaCuO indicates s-wave pairing*

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Experimental results give controversial answers to the problem of the pairing state especially for YBaCuO material. Is this an s-wave pairing, or a d-wave pairing? Here we present some experimental results from fluctuation conductivity measurements on YBaCuO thin films and what they may indicate about the pairing state.

1. INTRODUCTION

All typical materials have orthorombic structures (for example, YBCuO). This structure predicts the mixed pairing state *as+bd*, proceeding from group consideration [1,2]. The real relation between *a* and *b* is 20% and 80%.

In the last time we have discussed about s,d-wave superconductivity [3]. The problem is that some experiments show d-pairing and others s-pairing.

It is interesting how pairing is displayed in the fluctuation conductivity of high T_c superconductors.

2.THEORETICAL BACKGROUND

The expression for the full fluctuation conductivity is as follows

$$\sigma = \sigma_{AL}^{3D} + \sigma_{DOS}^{3D} + \sigma_{MT}^{3D},$$

where σ_{AL}^{3D} is Aslamasov-Larkin contribution, σ_{DOS}^{3D} is a contribution from density of states, and σ_{MT}^{3D} is Maki-Thompson contribution. These processes are described by the Feyman diagrams showed in Fig.1 (1 is Aslamasov-Larkin diagram, 2 is a diagram giving corrections to the normal density state, 3 is Maki-Thompson diagram).

Detailed calculation of the fluctuation conductivity of layered superconductors are given in Ref. [4]. It is worth to point out that the first two terms are actual for d-pairing. Maki-Thompson effect for d-pairing is very small. In the paper of Yip [5] it was shown that the parameter $1/\tau$ for d-pairing is very small (where τ is a pair bracking lifetime).

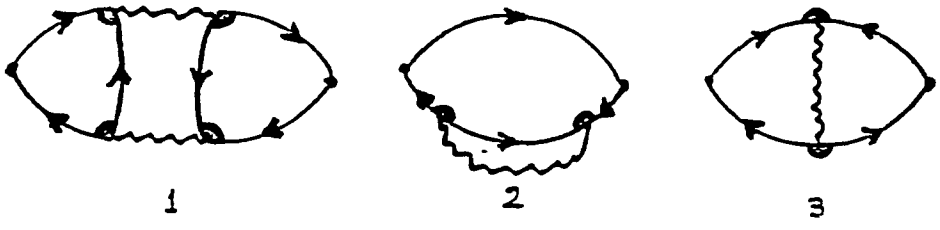

Fig.1 Feyman diagrams for fluctuation conductivity

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So if the Maki-Thompson effect is obsevered in experiments, one can say that s-pairing is actual in this region. Generally very close to T_c an Aslamasov-Larkin contribution is dominant whereas a Maki-Thompson contribution becomes important for temperatures further above T_c (for $\Delta T = T - T_c > 1K$) as has been shown [6].

3.EXPERIMENTAL RESULTS

Fluctuation conductivity, in zero applied magnetic field, is analyzed for different high quality c oriented epitaxial YBaCuO thin films grown on various substrates [7,8] (e.g. $LaAlO_3$, $KTaO_3$). From temperature dependence of fluctuation conductivity behavior critical exponents are extracted and the fluctuation dimensionality is decuded. Two main regions are distinctive after a cross-over. Indeed the influence of a Maki-Thompson term is present further from the transition temperature whereas the Aslamasov-Larkin term dominates closer to T_c. This behavior, for the two films, is depicted in Figs 2 and 3. In both these films the Maki-Thompson mechanism is observed. Such an effect indicates that an s-wave pairing state is present in this high T_c superconducting material.

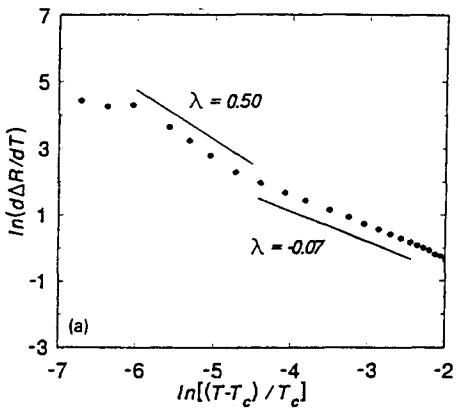

Fig.2 Log-log of $d\Delta/dT$ vs ϵ from which the two different regions emerge characterized with different critical exponents λ. The $\lambda = 0.5$ corresponds to an AL region whereas $\lambda = 0$ corresponds to a Maki-Thompson region. Epitaxial thin film, 1000 Å in thickness, grown on $LaALO_3$ (by using the BaF_2 method [7]) with excellent crystallinity similar to single crystals (RBS yields are 2-3%). $T_c = 90.25K$ inferred from the maximum dR/dT.

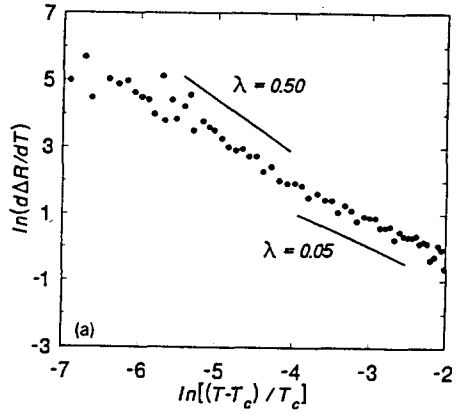

Fig.3 Same as Fig.1 but for an YBaCuO grown on $KTaO_3$. Thickness about 2000 Å, $T_c = 90.15K$

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