# Cuprate two-gap superconductivity on a vibronically renormalized spectrum formed by doping

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**Abstract**

The active part of the cuprate spectrum is modelled by a "defect" band evolving by doping above the itinerant band. A two-band scheme exploiting pair-transfer and vibronic interactions of these components allows to describe qualitatively cuprate superconductivity characteristics including the pseudogap.

*Key words:* cuprates; two-band model; gaps; doping

The two-component scenario [1] incorporating the striped phase separation [2] of the doped $CuO_2$ planes seems to be the most effective in explaining the cuprate superconductivity physics. Various experimental and theoretical findings reveal that under hole doping a "defect" - midgap band is evolving near $E_F$ above the itinerant valence band. These components can be presumably traced back to the hole-rich and hole-poor regions at stripening. At the same time various experiments suggest the description of cuprates as two-gap superconductors [3,4]. It is natural to describe such a two-component scenario by a two-band pairing scheme [5] incorporating interband interactions. There are different approaches of this kind [6-8]. It is essential that one must use an electronic background prepared and developing by doping.

An interpolative model incorporating the valence band (b) with the weight of states $(1-c)$ extending in energy from -D to zero with a "defect" - midgap band (a) evolving between d and d - $\alpha c$ with the weight c has been supposed in [8]. Here c is the doped hole concentration to be scaled to a real case. Interband superconductivity created by transfer of intraband pairs in this model has given results [8] comparable with the cuprate properties.

The underdoped state (the chemical potential $\mu$ out of the bands overlap) pseudogap appears in this model as the minimal excitation energy of the b - band quasiparticle $\Delta_p = \sqrt{(d-\alpha c)^2 + \Delta_b^2}$. If the under - optimal doping separation line is reached at $c_0 = d/\alpha$, where the bands start to overlap, two "true" superconductivity gaps $\Delta_{a,b}$ work for T < $T_c$. The observed peculiarities in the behaviour of the gaps, as some other properties, can be explained [8].

The bands overlap leads to the change in the nature of the electron liquid, which looses its marginal behaviour. The Fermi surface becomes electron - like with hole pockets and is determined by the states of both bands.

Two band components of the model open also a channel for phonon renormalization through electron - phonon interaction between them as in the vibronic theory of ferroelectricity [9]. It can be shown, that the phonon softening effect is maximal at $c_0$ [10] in accordance with the experiment revealing the maximal probability of the $CuO_2$ - plane structural transition ( LTO → LTT ) at this separation line [11].

Also the gaps, including the pseudogap as mentioned even in [12], will be renormalized by the a - b vibronic hybridization of intensity $VQ_0$. Here $Q_0$ stands for the distortion displacement or for its fluctuation if the structural transition is not realized. The b - band pseu-

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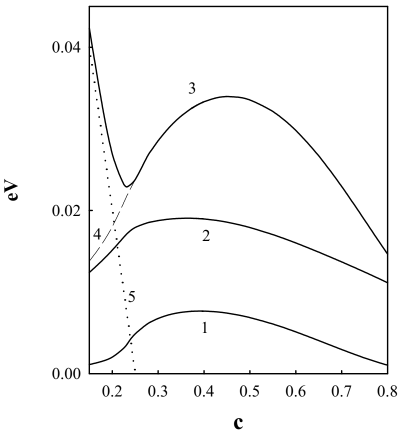


Fig. 1. Dependences on doping of 1- $T_c$; $2-\tilde{\Delta}_a$; $3-\tilde{\Delta}_p$; $4-\tilde{\Delta}_b$ and $5-\mu$.

dogap appears as $\tilde{\Delta}_p = \sqrt{(d-\alpha c)^2+\tilde{\Delta}_b^2}$ for $\mu > 0$ and $\tilde{\Delta}_p = \tilde{\Delta}_b$ for $\mu < 0$ with $\tilde{\Delta}_b = \Delta_b^2 + V^2Q_0^2$. The a - band connected pseudogap is $\tilde{\Delta}_a = \Delta_a^2 + V^2Q_0^2$. The behaviour of the gaps and of $T_c$ vs doping is illustrated in Fig. 1 ($T = 0$) with $|VQ_0| = 0.01$ eV, $Q_0(c)$ taken from [10] and other parameters from [8].

There are now two pseudogaps in the underdoped region. In the normal phase these are of different nature. After passing $c_0$ a common vibronic pseudogap $|VQ_0|$ arises ($T > T_c$), which will be quenched by overdoping, see Fig. 2. Experimentally one sees the normal state pseudogap in the whole doping region [3].

The intensive a - band density peak remains coupled with $\mu$. One associates the peak in the tunneling spectra [13] with $\tilde{\Delta}_a$ and the hump with $\tilde{\Delta}_b$. Because $|\Delta_b| > |\Delta_a|$ the itinerant band contribution can remain masced at larger dopings. The b - band acts as the singlet spin component, while the a - band as a bath of uncompensated spins. The charge and spin - pseudogaps appear as the result of the common source.

A two - band superconductor possesses naturally a critical and an uncritical electronic relaxation channel [14] as observed [15]. Taking account of other aspects discussed in [8] one concludes that two - band pairing schemes on electronic background prepared by doping allowe to describe qualitatively the basic aspects of the cuprate superconductivity.

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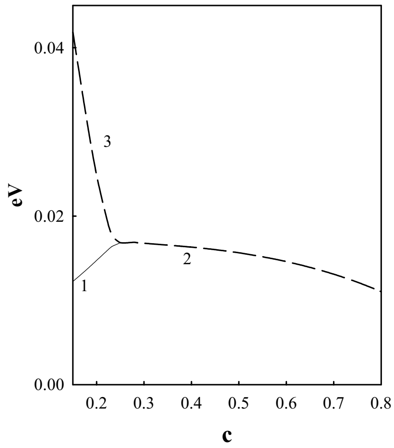


Fig. 2. Normal state pseudogaps vs doping. 1 - 2 - $|VQ_0|$ ; 3 - $\sqrt{(d-\alpha c)^2+V^2Q_0^2}$.

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