ELSEVIER

Physica B 259–261 (1999) 456–457

PHYSICA B

CDW scenario for pseudogap in normal state of bilayer cuprates

M.V. Eremin*, I.A. Larionov, S.V. Varlamov

Kazan State University, Kazan 420008, Russia

Abstract

Using the model of the singlet-correlated band the temperature dependence of d-wave superconducting (SC) and charge density wave (CDW) gaps have been calculated. Temperature interval of SC and CDW coexistence strongly depends on the relation between superexchange and Coulomb parameters. At low temperature the superconductivity suppresses CDW. © 1999 Published by Elsevier Science B.V. All rights reserved.

Keywords: Singlet-correlated band; Superconductivity; CDW; Pseudogap

The relationship between s-wave superconductivity (BCS) and CDW has been considered in many papers in the framework of Fermi liquid model. In one dimensional Fermi liquid BCS and CDW are, in general, very incompatible [1]. In the two-dimensional case coexistence is possible and CDW critical temperature T_{CDW} is always above T_C [2]. Both SC and CDW transitions in usual metals are caused by phonon mediated interactions. In underdoped layered cuprates superexchange interaction of copper spins plays the principal role, see for example, Refs. [3,8]. This is one of the reasons that motivated us to search for possible solutions of the integral equations for SC and CDW in the singlet-correlated band model [4,9,10]. Another important motivation is that CDW, caused by short range interactions (superexchange + Coulomb), can be responsible for the pseudogap in the normal state of underdoped cuprates [5]. It is the so-called CDW scenario, which is responsible for pseudogap in the normal state [6,11].

In our calculations we start with the Hamiltonian

$$\hat{H} = \sum_{l\sigma} \varepsilon_p \Psi_l^{\sigma,\sigma} \sum_{lm} t_{lm}^{pp} \Psi_l^{pd,\sigma} \Psi_m^{\sigma,pd} + \sum_{l>m} j_{lm} \left[2(\bar{S}_l \bar{S}_m) - \frac{n_l n_m}{2} \right] + \sum_{l>m} g_{lm} \delta_l \delta_m, \quad (1)$$

where $\Psi_m^{pd,\sigma}(\Psi_m^{\sigma,pd})$ are Hubbard like quasiparticle creation (annihilation) operators in the singlet correlated oxygen band [5,10], $n_l = \Psi_l^{\uparrow,\uparrow} + \Psi_l^{\uparrow,\uparrow}$, $\delta_l = n_l + 2\Psi_l^{pd,pd}$ is the number of holes per unit cell of Cu_2O_4 bilayer and j_{lm} and g_{lm} are the superexchange and Coulomb interaction parameters.

In the general case, the superconducting order parameter is given by

$$\Delta_{k_1} = \frac{1}{P_{pd}} \sum_k [2j(\boldsymbol{k}_1 - \boldsymbol{k}) - g(\boldsymbol{k}_1 - \boldsymbol{k}) + P_{pd}^2 B(\boldsymbol{k}_1, \boldsymbol{k}_1 - \boldsymbol{k})] \langle \Psi_k^{\downarrow,pd} \Psi_{-k}^{\uparrow,pd} \rangle, \quad (2)$$

where $j(\boldsymbol{q})$, $g(\boldsymbol{q})$ and $B(\boldsymbol{k}_1, \boldsymbol{q})$ are Fourier transforms of the superexchange, Coulomb and Frohlich interactions, respectively, $j(\boldsymbol{q}) = j(\cos \boldsymbol{q}_x + \cos \boldsymbol{q}_y)$, $g(\boldsymbol{q}) = g(\cos \boldsymbol{q}_x + \cos \boldsymbol{q}_y)$. We are taking into account the buckling modes as in Ref. [7]. The energy dispersion is determined by $t_1 = 80$ meV, $t_2 = 10$ meV, $t_3 = 27$ meV and describes the

* Corresponding author: Fax: 7-8432-38-0994; e-mail: mikhail.eremin@ksu.ru.

0921-4526/99/$ – see front matter
PII: S0921-4526(98)00990-9