SUPERCONDUCTING PAIRING AND ELECTRONIC ANOMALIES INDUCED BY THE SPIN COLLECTIVE MODE IN HTC SUPERCONDUCTORS

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This work is part of a theoretical project which aims to unravel the mechanism at work in the high temperature cuprate superconductors. In the recent article [1] we have studied the role of spin fluctuations, and namely of the collective spin mode, for the superconducting pairing and numerous electronic anomalies observed in cuprates. This mode strongly coupled to the electrons (which develops in the vicinity of the antiferromagnetic wave vector and has an anomalous downward dispersion) was first predicted theoretically [2] and then observed by neutrons [3], Fig.1.

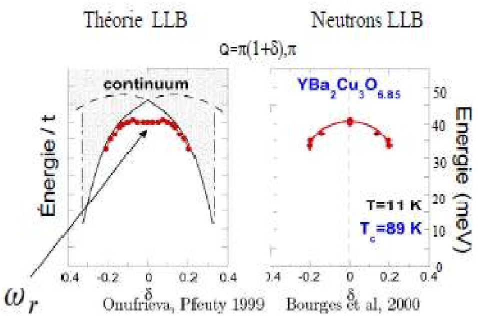

Fig.1 Spectre de fluctuations de spin avec le mode collectif (rouge)

The microscopic theory [1] is based on a dynamic strong coupling approach. The final equations are integral equations for the electronic correlation functions. They allow to describe all electronic properties. In [1] we analysed the superconducting properties together with the properties of the so called "normal" electrons for which important anomalies have been observed by photoemission and tunneling spectroscopy.

We found that the properties of the superconducting state induced by the spin mode are very close to those observed in the cuprates: The superconducting order parameter changes sign in the Brillouin zone while the superconducting gap angular dependence presents an anomalous shape very close to that observed by photoemission, Fig.2 (effect unexplained until now). The value of the maximal gap is high (high Tc). The theoretical electronic spectrum is very close to that observed by photoemission, namely the nodal spectrum (spectrum in the part of the Brillouin zone where the gap vanishes) exhibits a kink. [The problem of the nodal kink is a hot problem in the field since its energy Ωkink represents the lowest energy scale in the electronic properties]. Not only the form of the theoretical spectrum is very close to that in the experiment (Fig.2), but the relation between Ω_{kink} and the spin mode energy ω_r, $\Omega_{kink} = -2\omega_r$, obtained in [1], corresponds very well to the two independent experiment data (photoemission and neutrons), Ω_{kink}=66meV, ω_r=34meV (for YBCO with Tc=61 K), Ω_{kink}=78meV, ω_r=40meV (for YBCO with Tc=90 K). Finally, for the first time the anomalous form of the conductance (proportional to the electronic density of states) observed by tunneling spectroscopy has been explained (Fig.2) and the relations between the energies if its characteristic points and ω_r have been obtained. Again the energy ω_r extracted is in a good agreement with that seen by neutron.

All these results obtained within unified theory constitute an important argument in favour of the spin fluctuation mediated superconductivity in the high Tc cuprates.

References:

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[3] Ph. Bourges et al, Science **288**, 1234 (2000).

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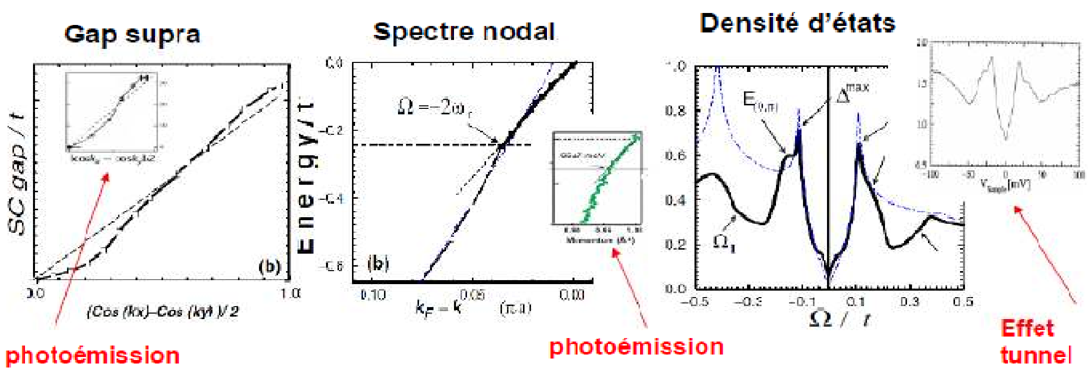

Fig. 2: *Intensity map of the quasi-1D incommensurate at 3 meV and 5 K*