

Van Hove Scenario for High T_c Superconductors

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Abstract All the high T_c cuprates (HTSC) have a lamellar structure and hence almost two dimensional properties. This 2D character leads to the existence of Van Hove singularities (VHs) or saddle points in their electronic band structure. These VHs have been observed experimentally in all the HTSC and we show that they explain many physical properties of these compounds, both in the normal and superconducting states. This feature induces a topological transition for a hole doping of $p_0 \simeq 0.20$ hole/copper atom. The constant energy curves going from hole-like to electron-like.

The discovery of high temperature superconductivity in cuprates compounds in 1986 [1] has been a great sensation in the physics community and has raised great expectations, which, we hope, will one day be fulfilled. Twenty years after this discovery, the exact mechanism of HTSC is still not yet understood and remains a great challenge for solid-state physicists ... All these compounds are strongly anisotropic and almost two dimensional, due to their CuO_2 planes, where superconductivity mainly occurs. It is well known that in 2 dimensions, electrons in a periodic potential show a logarithmic density of states (DOS), named Van Hove singularity (VHs) (Van Hove (1953) [2]). The Van Hove scenario is based on the assumption that, in high critical temperature superconductors (HTSC), the Fermi Level (FL) lies close to such a singularity (Labbé-Bok 1987) [3]. The constant energy curves are hole-like for a doping less than 0.20 and become electron-like when the doping is increased. This topological transition occurs for a hole doping around 0.20, 0.21 hole/copper atom (Fig. 1). This hypothesis has been confirmed by many experiments, in particular by Angular Resolved Photoemission Spectroscopy in different compounds [4].

We want to stress that the model of 2D itinerant electrons in presence of VHs in the band structure has already explained a great number of experimental facts. Detailed calculations are presented in a review paper [5]:

– critical temperature and gap anisotropy

We have computed the critical temperature T_c and its variation with doping. The optimum T_c is obtained for a hole doping of $p = 0.16$ and not $p = 0.20$ (when $E_{F_0} = E_s$) as predicted in our first simple model. This is because we did not take into account the screening in the beginning. By

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Special Contributions in Honor of K. Alex Müller
on the Occasion of his 80th Birthday

