Photoemission Line-Shapes and Dispersion Relations in the Superconducting State of BISCO

\(/\text{Bi}_{2}\text{Sr}_{2}\text{CaCu}_{2}\text{O}_{8}/\)

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Motivation:

detection of Bonding and Anti-bonding bands in BISCO /bi-layer splitting/
advanced their understanding and generated questions about “Peak-Dip-Hump” picture

Y.-D. Chuang et al., PRL 87, 117002 (2001)

A.A. Kordyuk et al., PRL 89, 77003 (2002)
PDH as a signature of strong coupling

FIG. 2. ARPES data from normal and superconducting states of underdoped Bi2212 near \((\pi, 0)\). As illustrated in the inset of Fig. 1(b), the Fermi surface crossing point along the \((\pi, \pi)\) line and it is very close to \((\pi, 0)\). The upper two sets of curves were recorded with 55 meV energy resolution while the low set of curves was recorded with 20 meV energy resolution.

FIG. 3. Illustration of photoemission process and spectral shape in systems with weak \((\alpha)\) and strong couplings \((\beta)\) and \((\pi, 0)\). The Fermi surface picture depicts the phase space considerations for the coupling between the quasiparticle and collective excitations near \((\pi, \pi)\). The light shaded area indicates the filled states, and the dark shaded area indicates the flat band region near the Fermi level.

FIG. 3. (a) \(\text{Im} \Sigma\) and \(\text{Re} Z\) at \((\pi, 0)\) from Eqs. (2) and (3) \((\Gamma_r = 200 \text{ meV}, \Gamma_i = 30 \text{ meV}, \Delta = 32 \text{ meV}, \Omega = 1.3\Delta)\). Comparison of the data at \((\pi, 0)\) for (b) wide and (c) narrow energy scans with calculations based on Eqs. (1)-(3), with an added step edge background contribution.

FIG. 2. Same as in Fig. 1 but at strong coupling. The resonance and onset frequencies are presented in the text. The spin resonance frequency \(\Omega_{res} \approx \xi^{-1}\), is equal to the distance between the measured gap \(\Delta\) and the dip frequency \(\omega_0\). The hump frequency differs from \(\Delta\) roughly by \(\xi^{0.7}\).
Overdoped sample /$T_C=58$ K/

Indication of strong coupling

($\pi;0$)
Temperature and Momentum Dependence, $(\pi;0)$

\[ Sqrt(\varepsilon(k)^2 + \Delta p^2) \]

Energy (meV) vs. Momentum (units of $\pi$) for different temperatures: T=10K, T=30K, T=50K, T=60K, T=65K, T=70K, T=75K, T=85K.
Nodal direction

MDC at $E_F$

$\Sigma ((\text{meV})\text{meV})$

Energy (eV)

$0.15 0.15 0.0 0.0$

$k (\pi \text{units})$

Binding Energy (meV)

-300 -100 0 100 200 300

-150 150 0 320 400

0.2 0.3 0.4 0.5

UD85 100 K

OD64 100 K

10 K

$0.2 0.3 0.4 0.5$

-300 -200 -100 0 100 200 300

-150 150 0 320 400

100 K

10 K

Nodal direction

$0.2 0.3 0.4 0.5$

-300 -150 150 300

-150 150 0 320 400

-0.15 -0.10 -0.05 0.00

-0.15 -0.10 -0.05 0.00
Summary of the energy scales

- $E_{\text{kink}} (\pi; \pi)$
- $E_{\text{kink}} (\pi; 0)$
- $E_{\text{res}}$ (INS)
- $\Delta_p (\pi; 0)$
- $\Delta_{LE} (\pi; 0)$

Energy (meV) vs. $T_c$ (K)
Single-layer BISCO, nodal direction

100 K

80 K

50 K

20 K

~50 meV
EDC and MDC, temperature dependence

- Energy (meV)
- Momentum
- Intensity (arb. units)

20 K
100 K
2H-TaSe$_2$ below CDW transition

Note two well-resolved bands /bi-layer splitting/ crossing the Fermi level

Kink in the dispersion is very clear

MDC analysis of the kink