HIGH T_c CUPRATE SUPERCONDUCTIVITY AND THE PSEUDOGAP PHASE

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Outline

Fermi Surface Via Quantum Oscillations
-Resonant Ultra Sound (RUS) measurements
-Phase Diagram and Pseudogap Phase
-Competing Phenomenon
  -Charge Density
  -Spin Density
  -Mott Insulator
  -Pseudo Gap
  -Superconductivity
-(Cluster) Dynamical Mean Field Theory

Quantum Oscillations

In a crystal subject to an applied magnetic field, physical properties oscillate

-magnetic moments (De Haasvan Alphen effect)

-resistivity (ShubnikovDe Haas effect)

-specific heat

-sound attenuation

Quantum Oscillations

These oscillations are due to (electron) Landau Levels

$\Rightarrow$ Quantized cyclotron orbits

$\Psi(x, y, z) = e^{ik_y y + ik_z z}\phi_n(x - x0)$

$x_0 = \frac{\hbar k_y}{m\omega_c}$

$\omega_c = qB/m^* \equiv$ electron cyclotron freq.

$\phi_n \equiv$ quantum oscillator

$D = Z(2S+1)\frac{\Phi}{\Phi_0} \equiv$Number in Landau Level

Quantum Oscillations

Effective Mass

$m^* = \hbar/2\pi \frac{\delta A_k}{\delta E}$

$A_k \equiv$ momentum (k) space area of cyclotron orbit $\Rightarrow$ k space area is quantized

$dA_k = 2\pi q B/\hbar$

Extremal orbits "pop" out

$\Delta(1/B) = 2\pi q/\hbar A_{ext}$

Quantum Oscillations

FREQ $\propto$ extremal cross sectional area of fs perp to field
amptlitude(temp) tells effective mass
amplitude(field angle) tells c axis warping
decrease warping as overdope -¿ critical
nanoscale phase separation -¿no more quantum oscillations
no phase separation on cyclotron radius
scattering may be what kills on overdoped region
photo
Neck/Belly geometry (quasi-2d fermi surface)?
Yamaji angle $\equiv$ max angle at which you still get closed constant energy surface

$\Rightarrow$ unique signal for different FS shapes

FOR BC TETRAGONAL CRYSTAL
Γ line $k_f = k_{00} + k_{01}cos(k_z)$

$$R_w = J_0\left[\left(2\pi\Delta F_n/Bcos(\theta)\right)J_{2n}(k_f ctan(\theta))\right]$$

X line $k_f = k_{00} + k_{21}sin(2\phi)cos(k_z)$

RUS

Resonant Ultra Sound measurements

$\sigma_i = C_{i,j}\epsilon_j$

stress = (elastic tensor) strain, i,j = 1,6

sound velocity $\propto \sqrt{C_{i,j}}$

$C_{i,j} = \frac{\delta^2 F}{\delta\epsilon_i \delta\epsilon_j}$

Thermodynamics

$$\Delta F(\epsilon) = F^{sc} - F^{N} = -N(T - T_c(\epsilon))^2$$

$$\Delta C_{i,j} = -2N\frac{\delta T_c}{\delta \epsilon_i}\frac{\delta T_c}{\delta \epsilon_j}$$

$$-\left[2N\frac{\delta^2 T_c}{\delta \epsilon_i \delta \epsilon_j} + 2\frac{\delta N}{\delta \epsilon_i}\frac{\delta T_c}{\delta \epsilon_j} + 2\frac{\delta N}{\delta \epsilon_j}\frac{\delta T_c}{\delta \epsilon_i}\right](T_c - T)$$

$$-\frac{\delta^2 N}{\delta \epsilon^2}(T_c - T)^2$$

(C)DMFT

-Quasipartiles ⇒ Low energy excitations

-gapped in SC and PG states -Atomic Transitions ⇒ High energy excitations

-On-site Coulomb repulsion vs electron hopping -Hunds rules -Mott physics

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