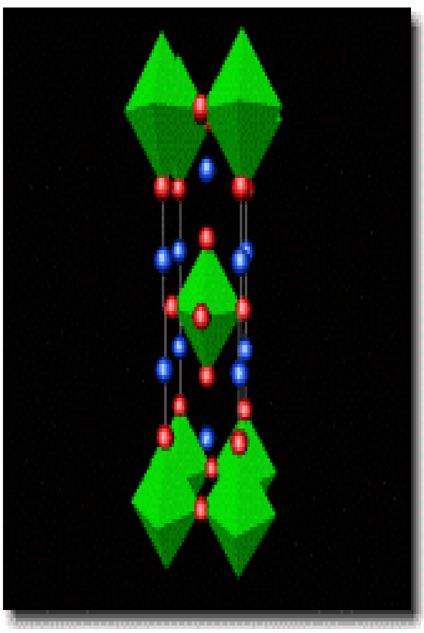
Part I
Cuprate (High Tc) Superconductors

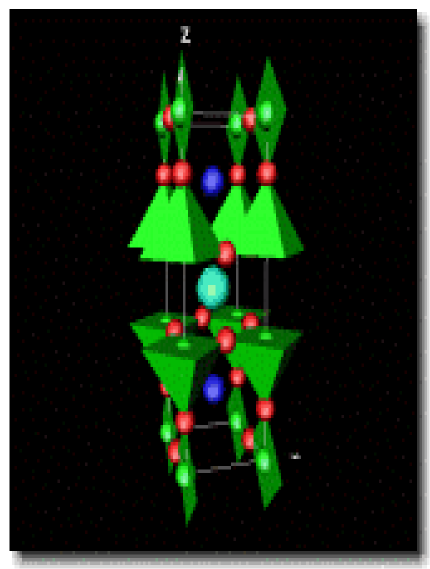
$La_{2-x}Sr_xCuO_4$



Tc = 40^0

Bednorz &Muller ‘86

$YBa_2Cu_3O_7$

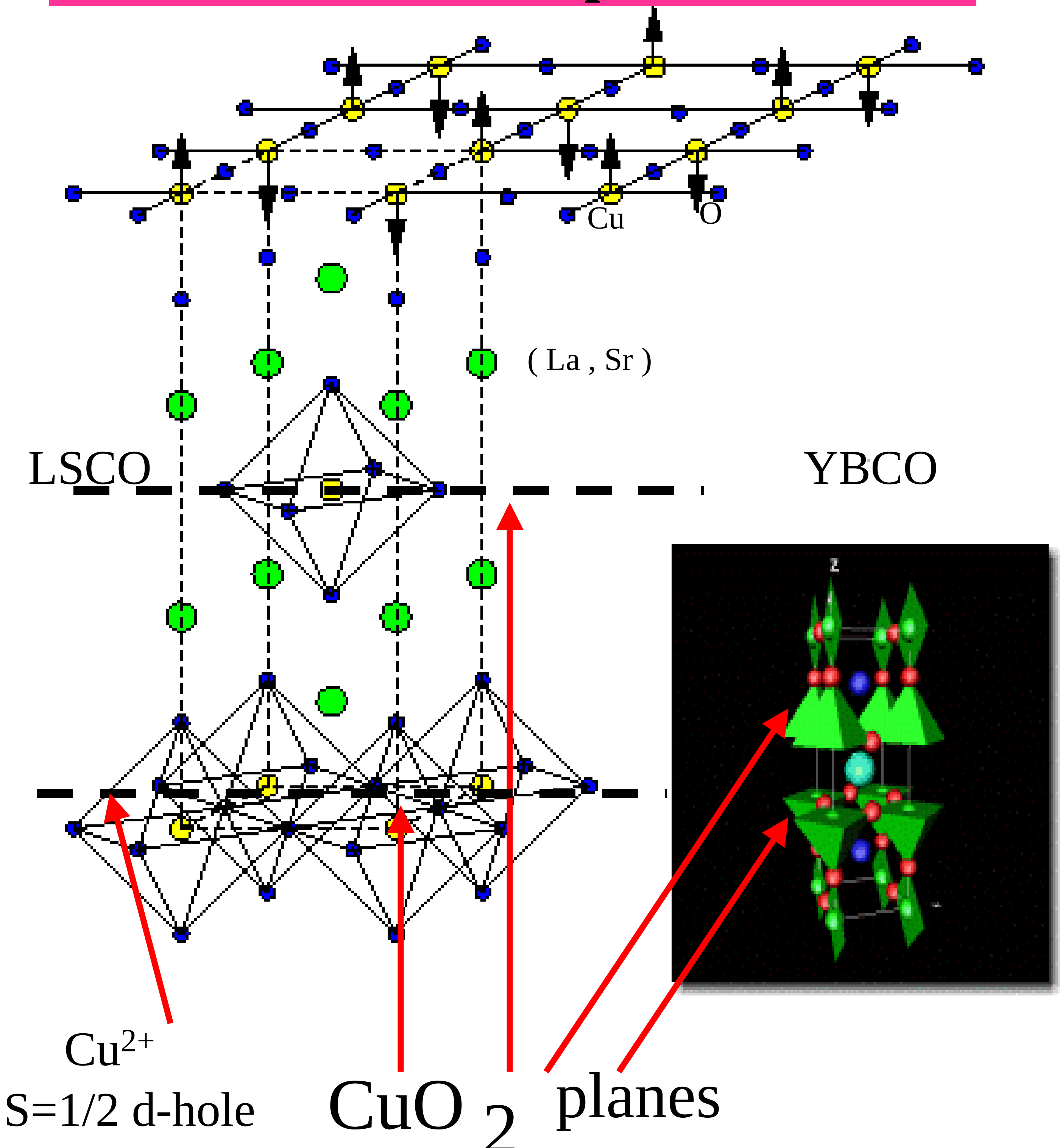


Tc = 90^0

Wu et.al. ‘87

What is the Mechanism? (Non BCS?)

Conduction planes



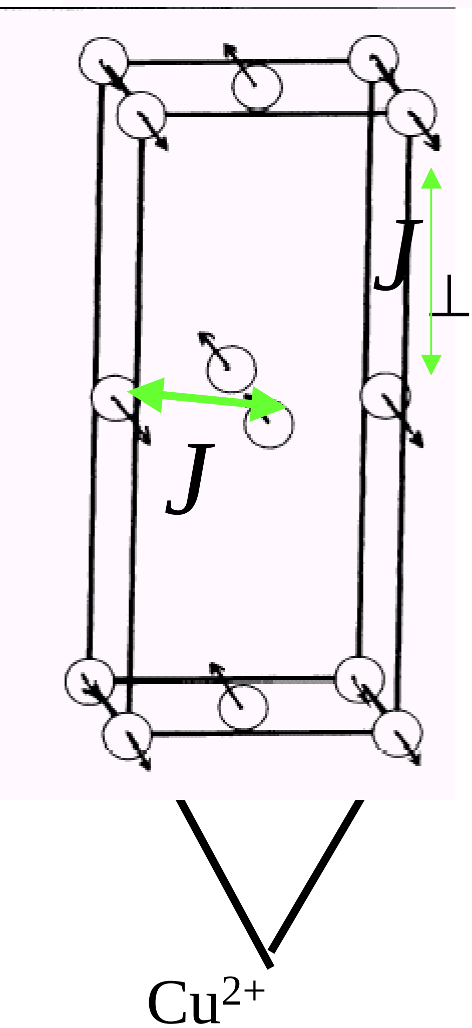
Bangalore, India 1/87

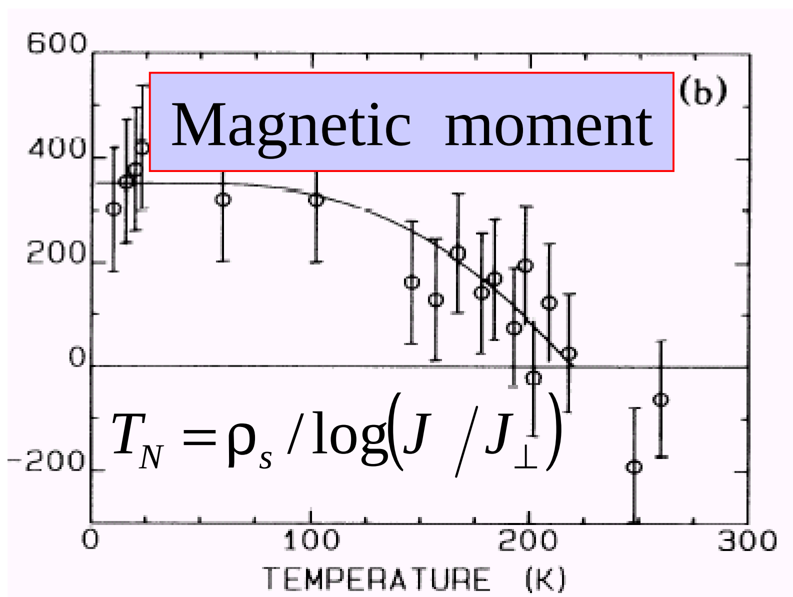
P.W. Anderson: ``One Band Hubbard Model''.
``Resonating Valence Bonds'' Jan '87

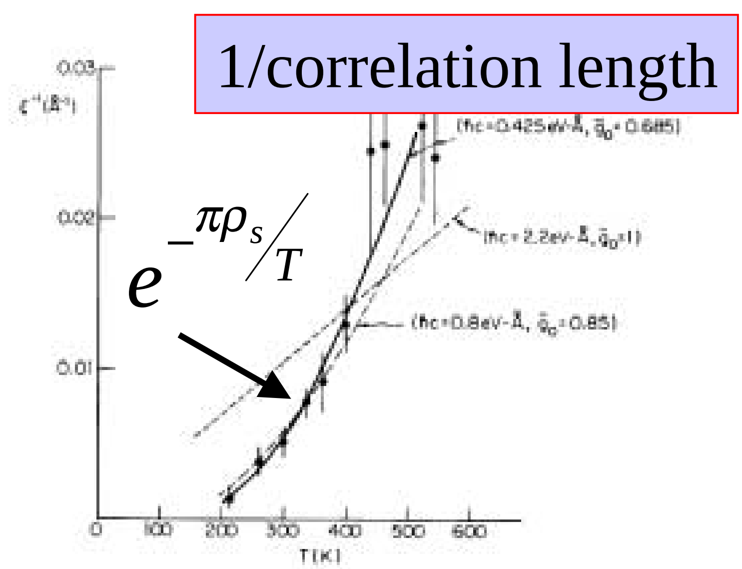
Parents Compounds
Antiferromagnet Mott Insulators

Antiferromagnetism in La_2CuO_{4-y}

D. Vaknin,[a] S. K. Sinha, D. E. Moncton, D. C. Johnston, J. M. Newsam,
C. R. Safinya, and H. E. King, Jr.
esearch Laboratories, Exxon Research and Engineering Company, Annandale, New J
(Received 4 May 1987)

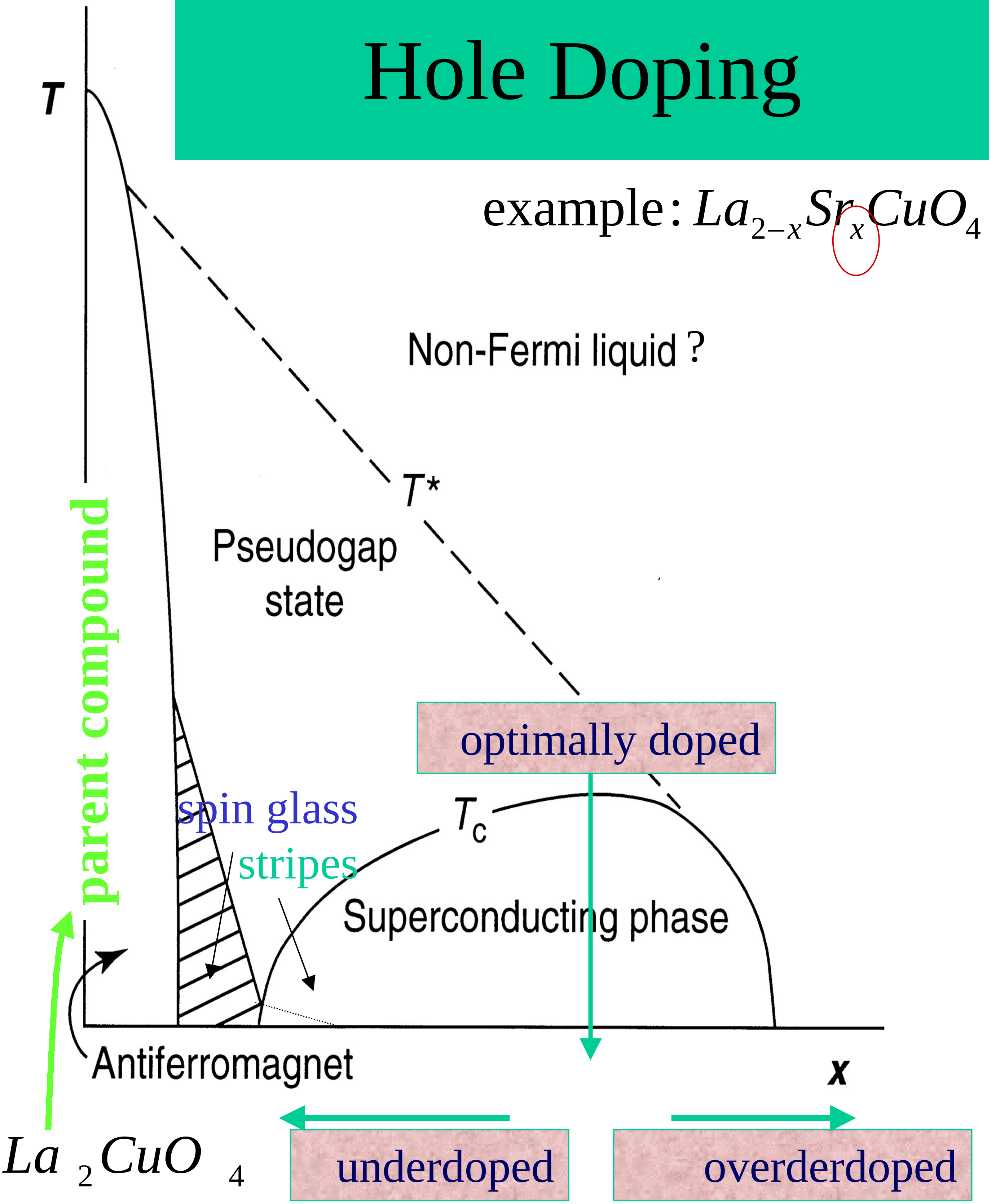






Hole Doping

example: $La_{2-x}Sr_xCuO_4$

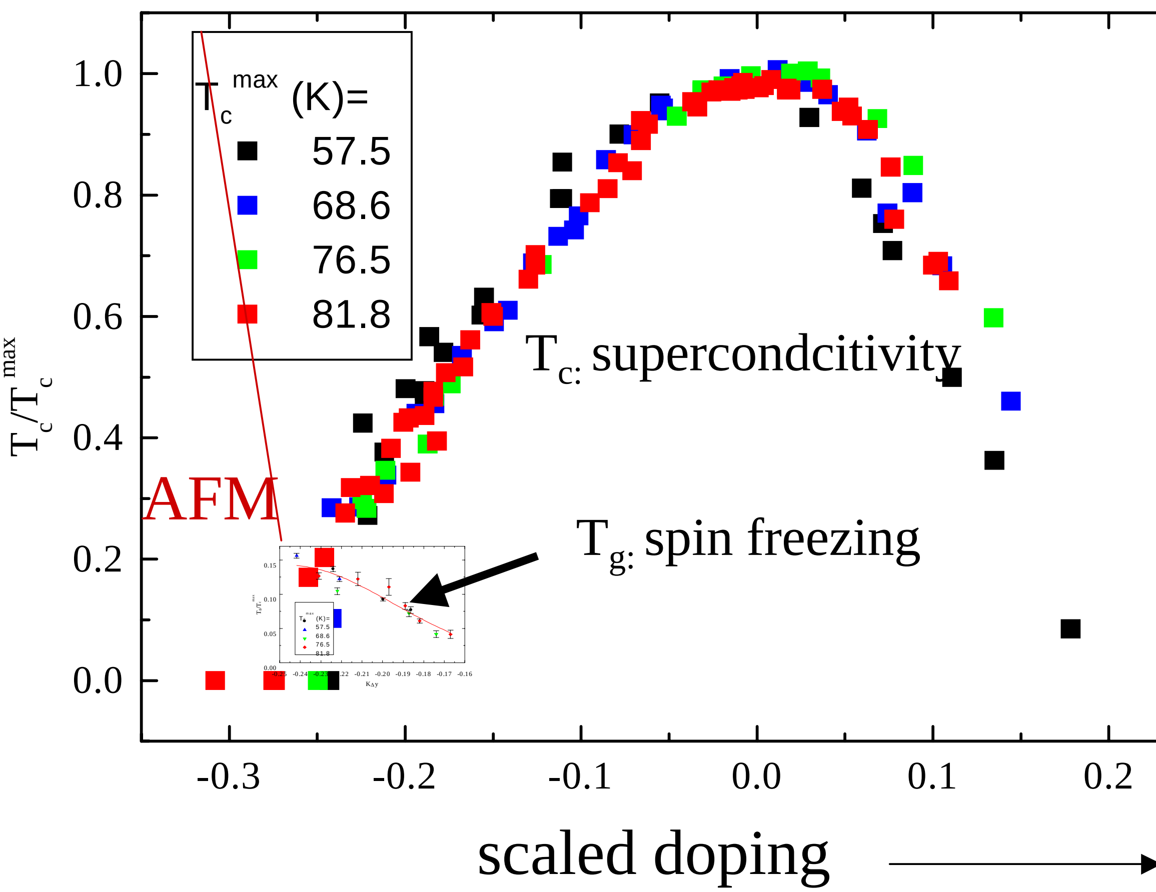


Low energy spin fluctuations

A. Remnant local moments in underdoped superconducting phase.

$(Ca_xLa_{1-x})(Ba_{1.75-x}La_{0.25+x})Cu_3O_y$

Kanigel&Keren, Technion



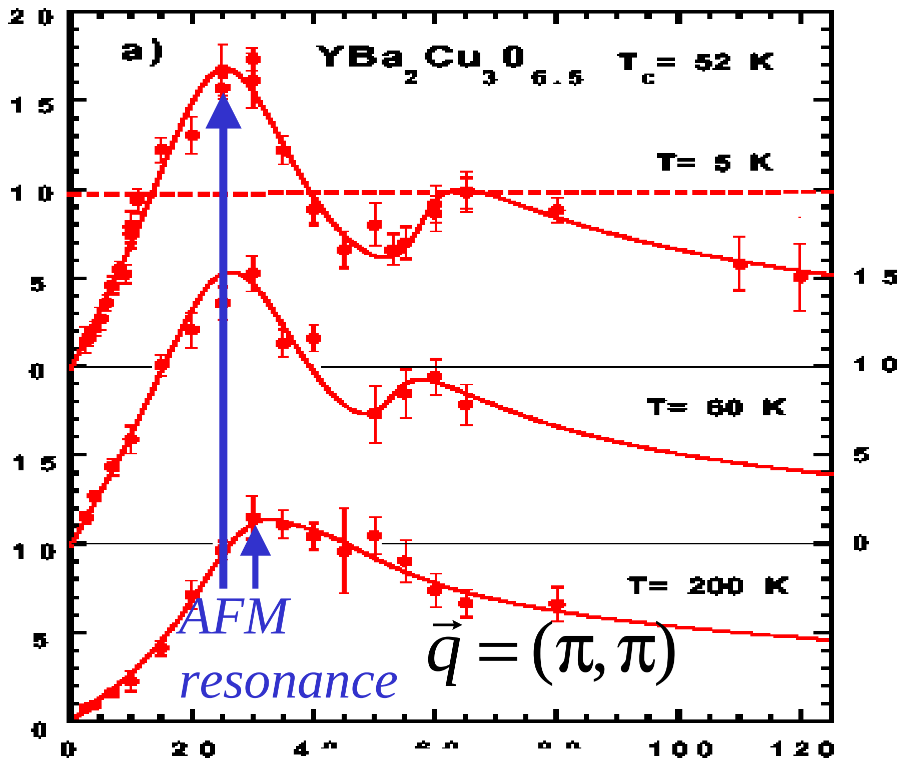
B. Low energy antiferromagnetic spin fluctuations

Low energy spin fluctuations cont'd

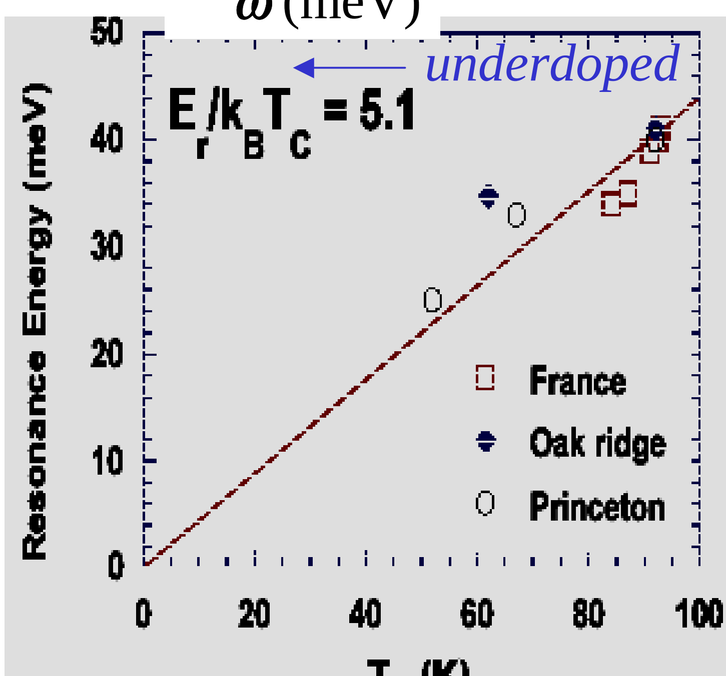
The Antiferromagnetic resonance

neutron scattering

$S(\vec{q},\omega)$



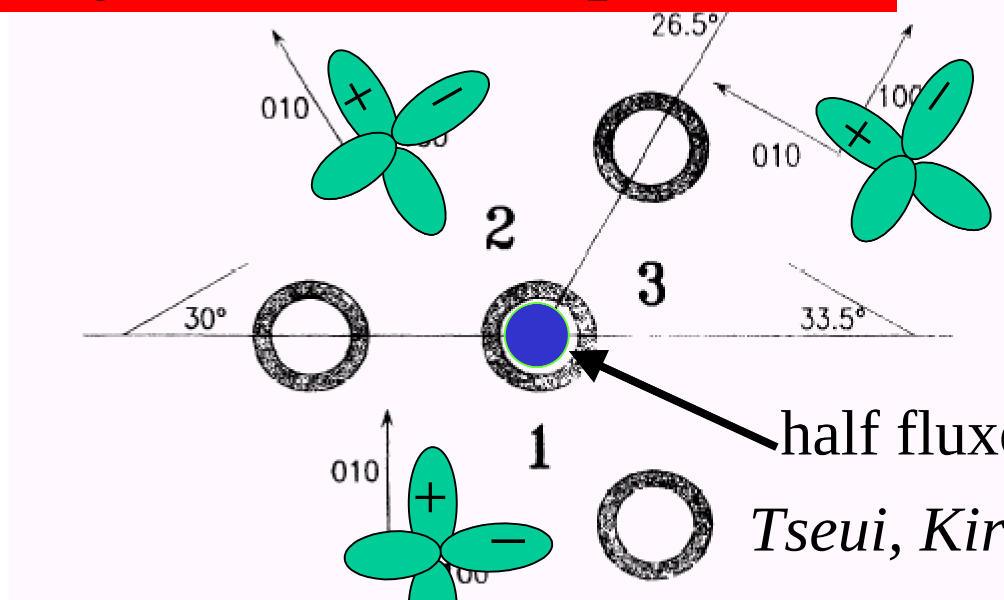
ω (meV)



Very sharp paramagnons? Why $\vec{q}=(\pi,\pi)$?

d-wave Superconductivity

Trictystal SQUID experiment



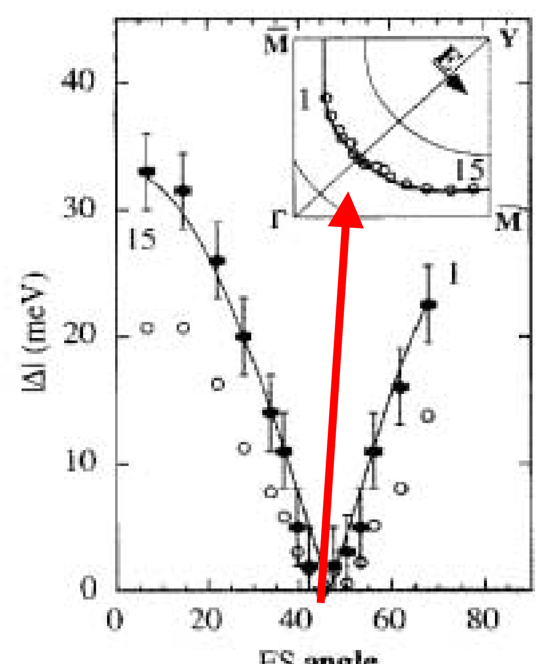
Tseui, Kirtley (94)

FIG. 1. Schematic diagram for the tricrystal (100) $SrTiO_3$ substrate, with four epitaxial $YBa_2Cu_3O_{7-\delta}$ rings.

ARPES

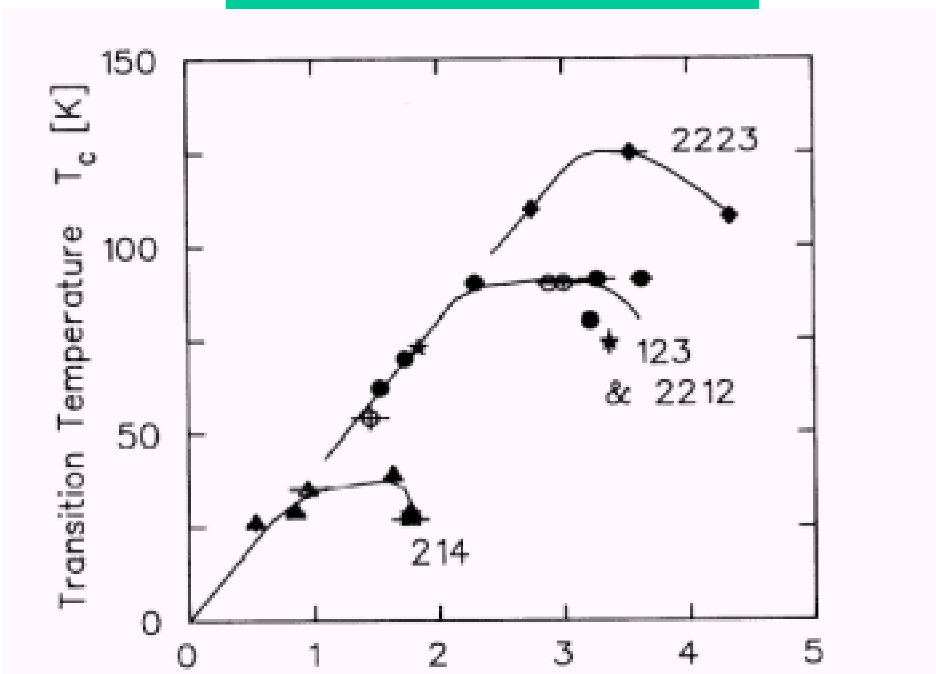
$$\Delta_k \propto \cos(k_x) - \cos(k_y)$$

Shen, Campuzano



Low Superfluid Density

Uemura's Plot (89)



superfluid density, doping x ⟶

$$\rho_c \propto 1/\lambda^2$$

$$\rho_c \approx T_c \propto x$$

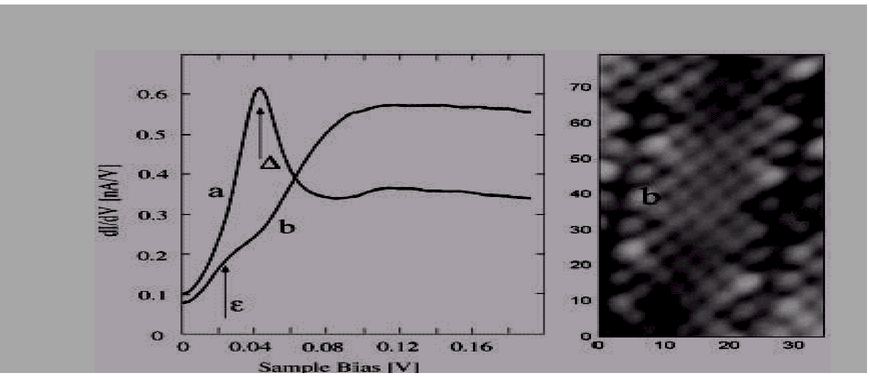
unconventional relation

BCS (conventional) $\rho_c \approx \hbar^2 n / m \approx \varepsilon_F >> T_c$

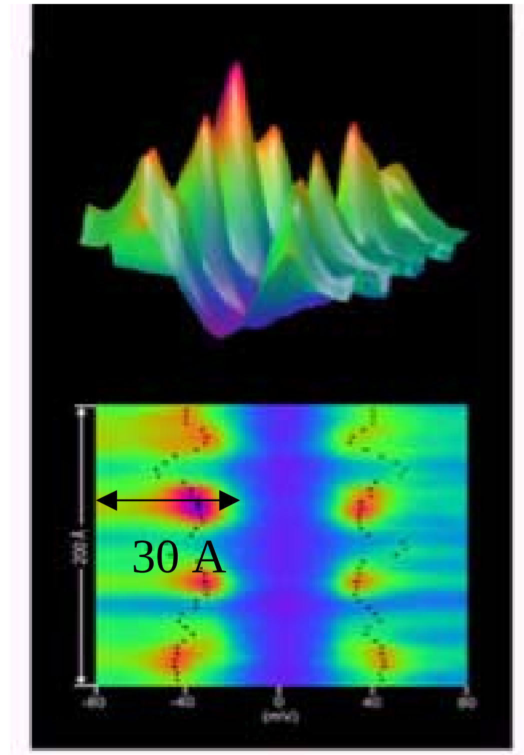
weakly doping dependent

Short Coherence Length

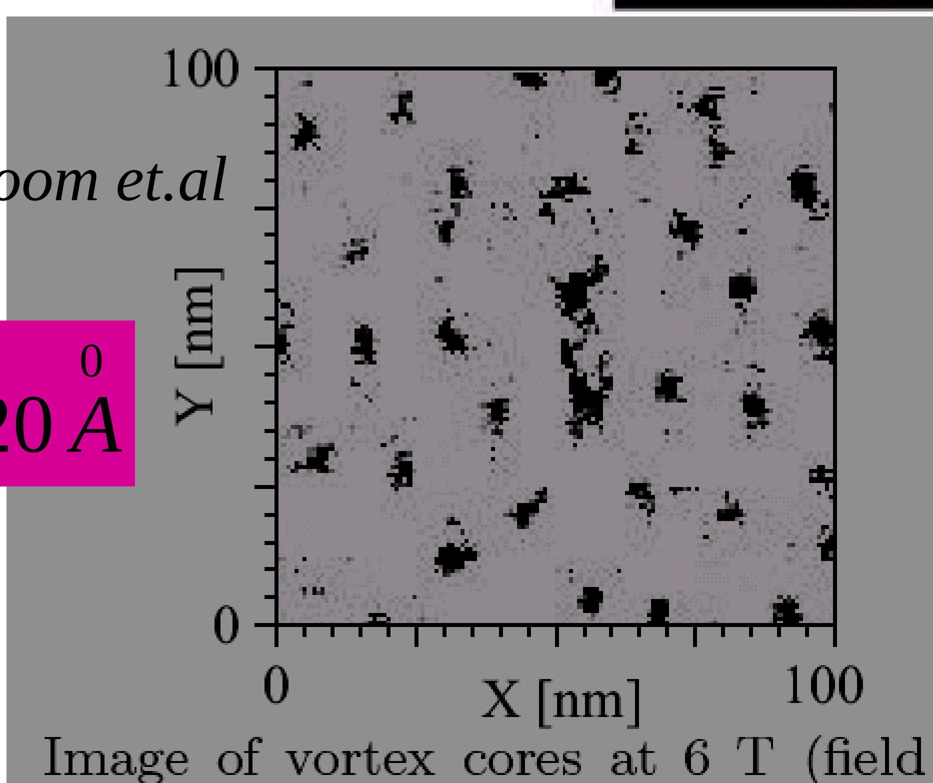
Tunneling Microscopy



Howald et.al (Stanford)



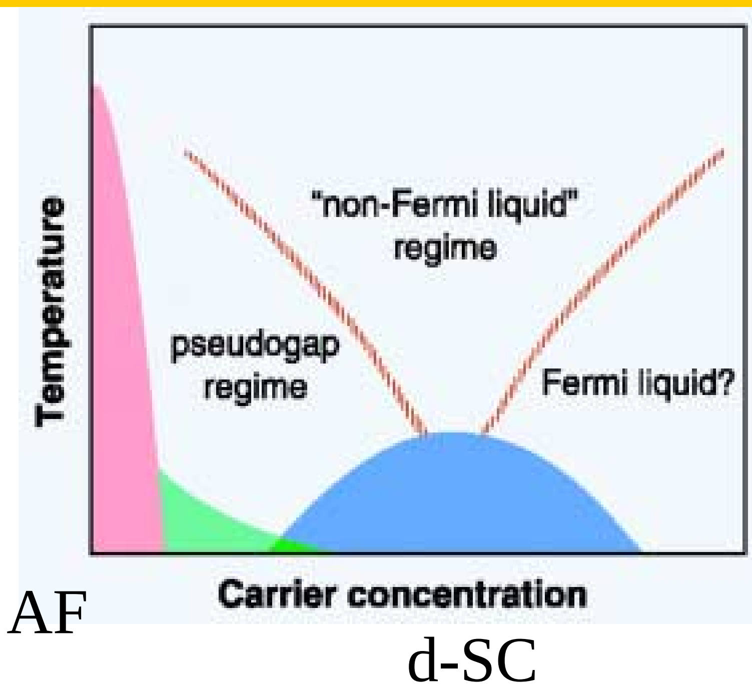
Pan et.al (Berkeley)



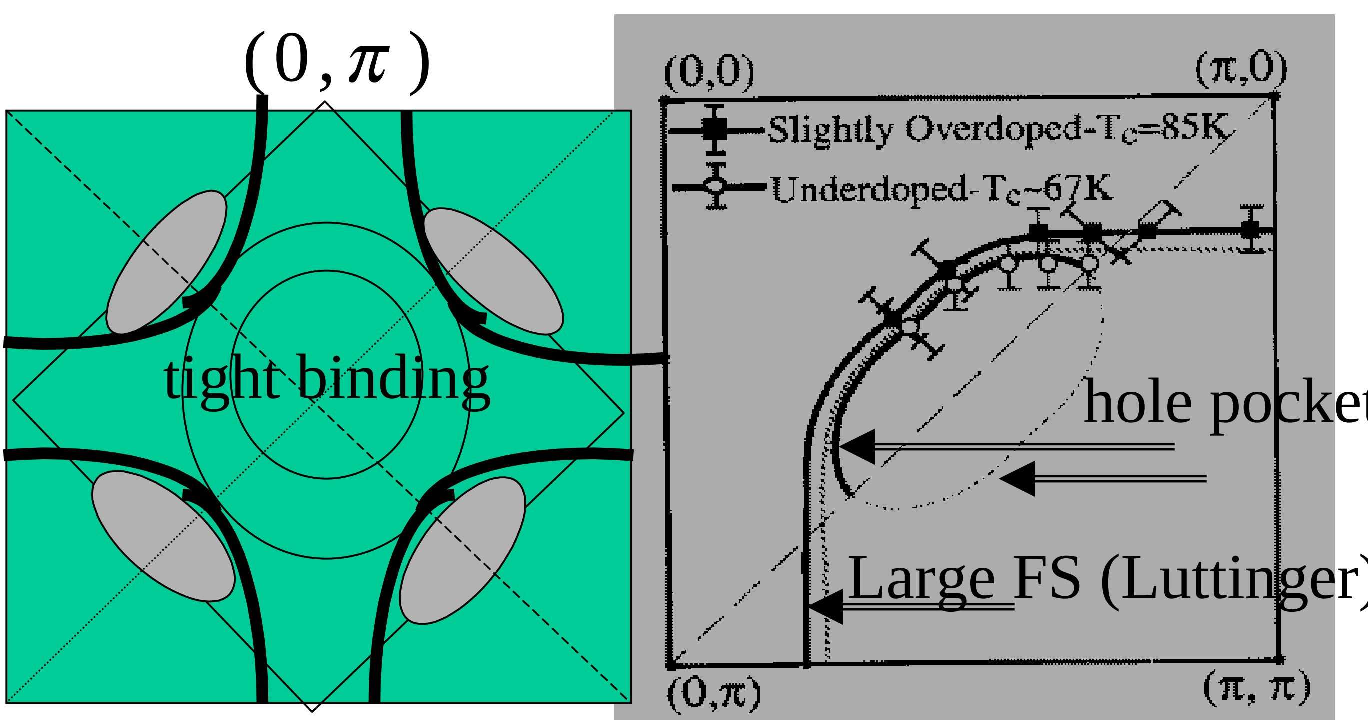
Hoogenboom et.al

$$\xi \approx 20 \overset{0}{A}$$

Abnormal “Normal State”



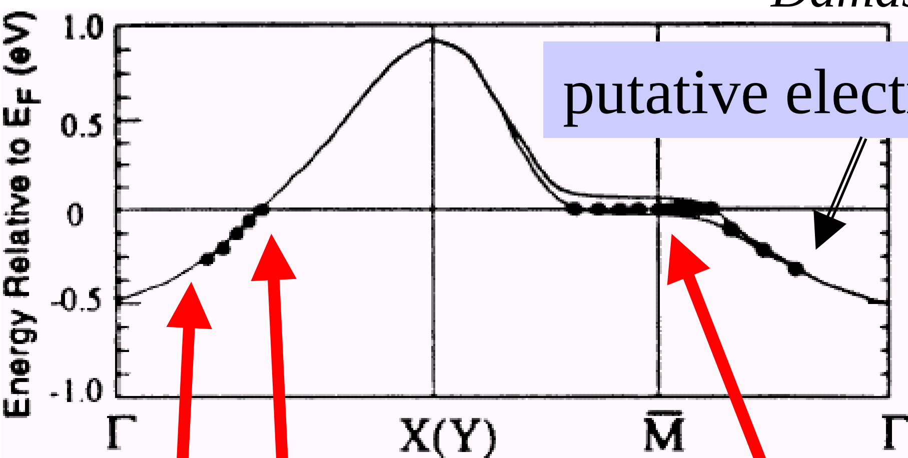
“Fermi surface” above Tc: *Fuzzy Notion*



Abnormal "Normal State" cont'd

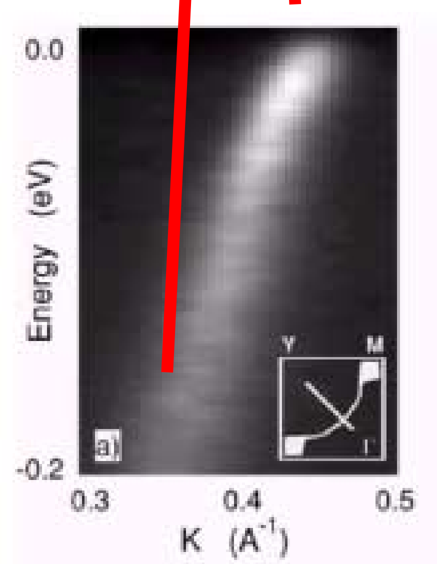
Mysteries of ARPES

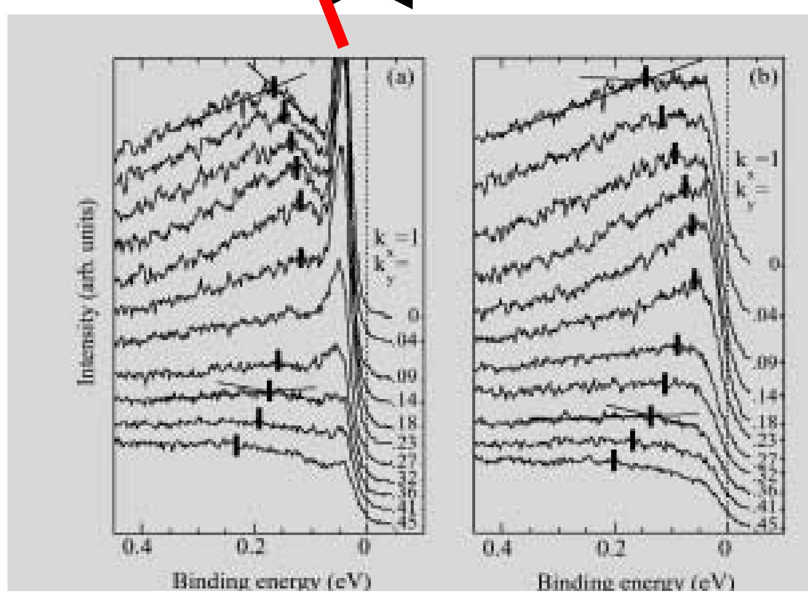
Damascelli, Lu& Shen



putative electron dispersion

"pseudogap"





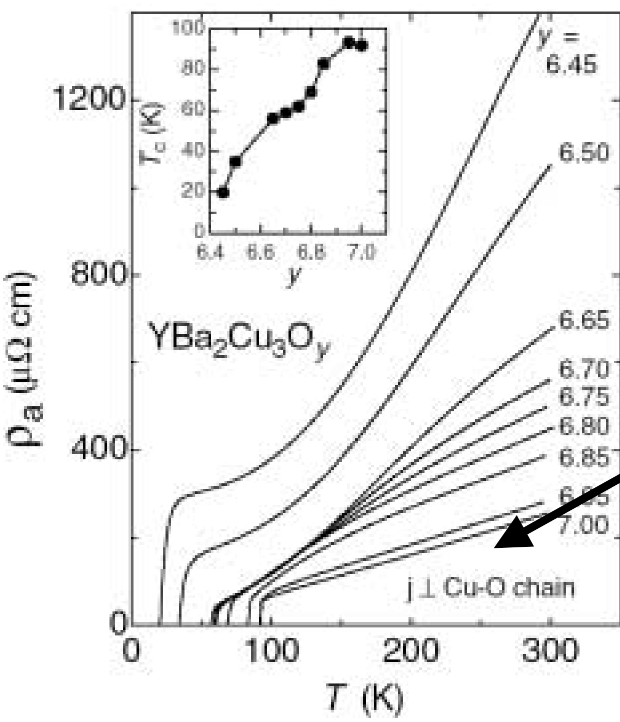
Optimally doped

Underdoped

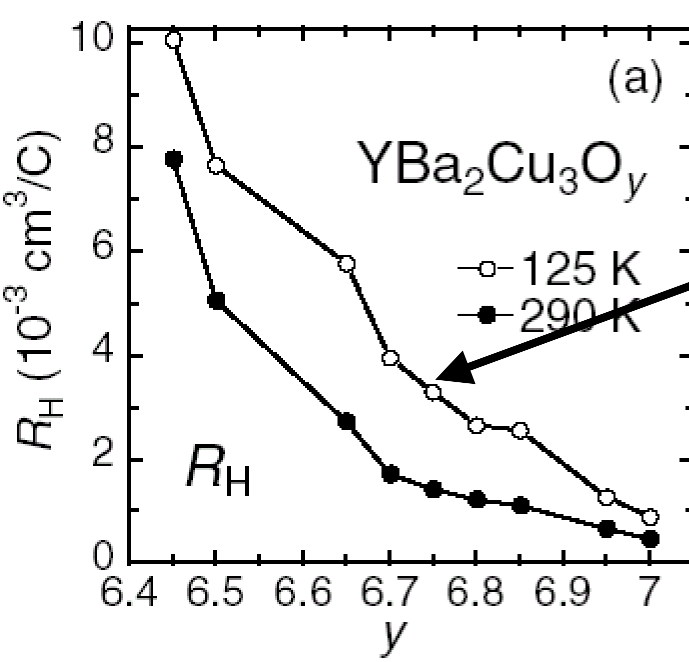
Very diffuse spectral peaks

→ spin/charge separation?

Weird Transport



linear-T resistivity



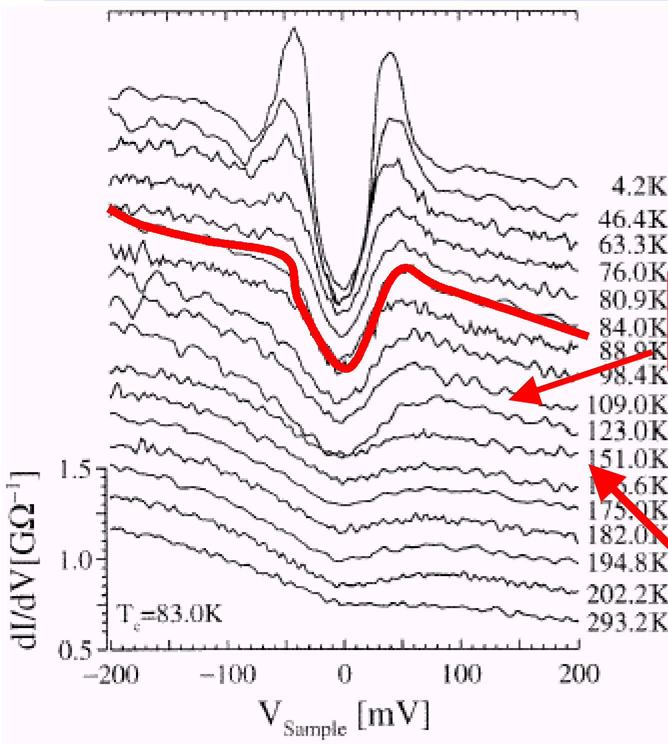
hole carrier number increasing with y

Segawa&Ando Prl ‘01

More: Nernst Effect, Hall angle, (Ong)

Pseudogap temperature

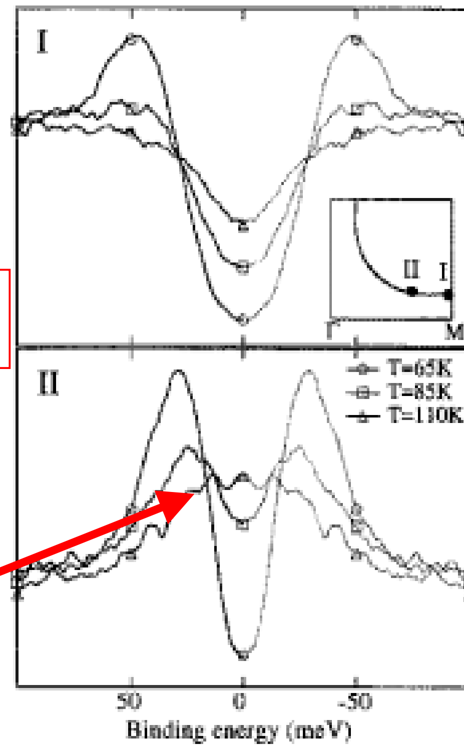
tunneling gap above Tc



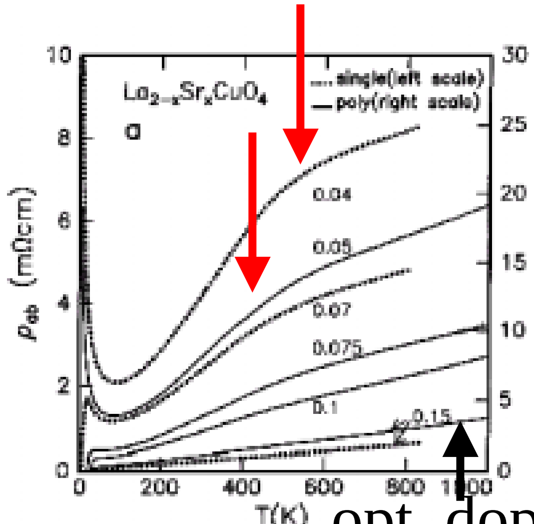
T>Tc

T*

ARPES gap above Tc



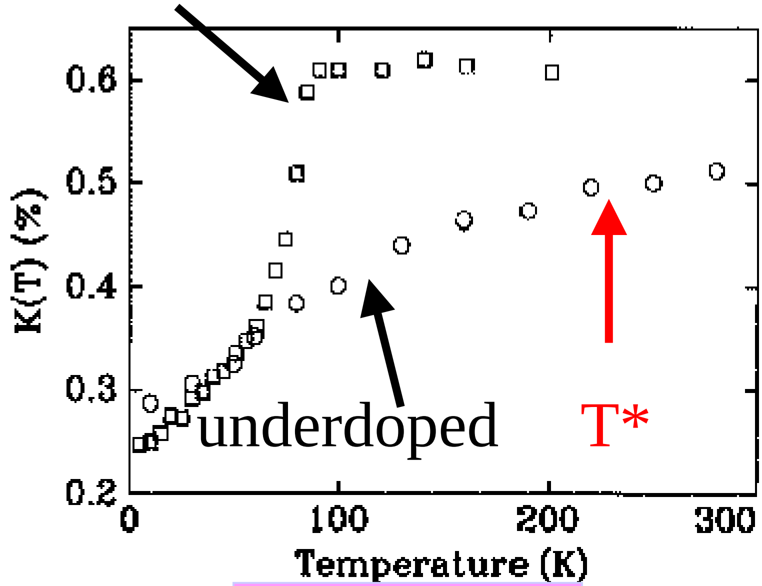
T*



opt. doped

resistivity

opt. doped

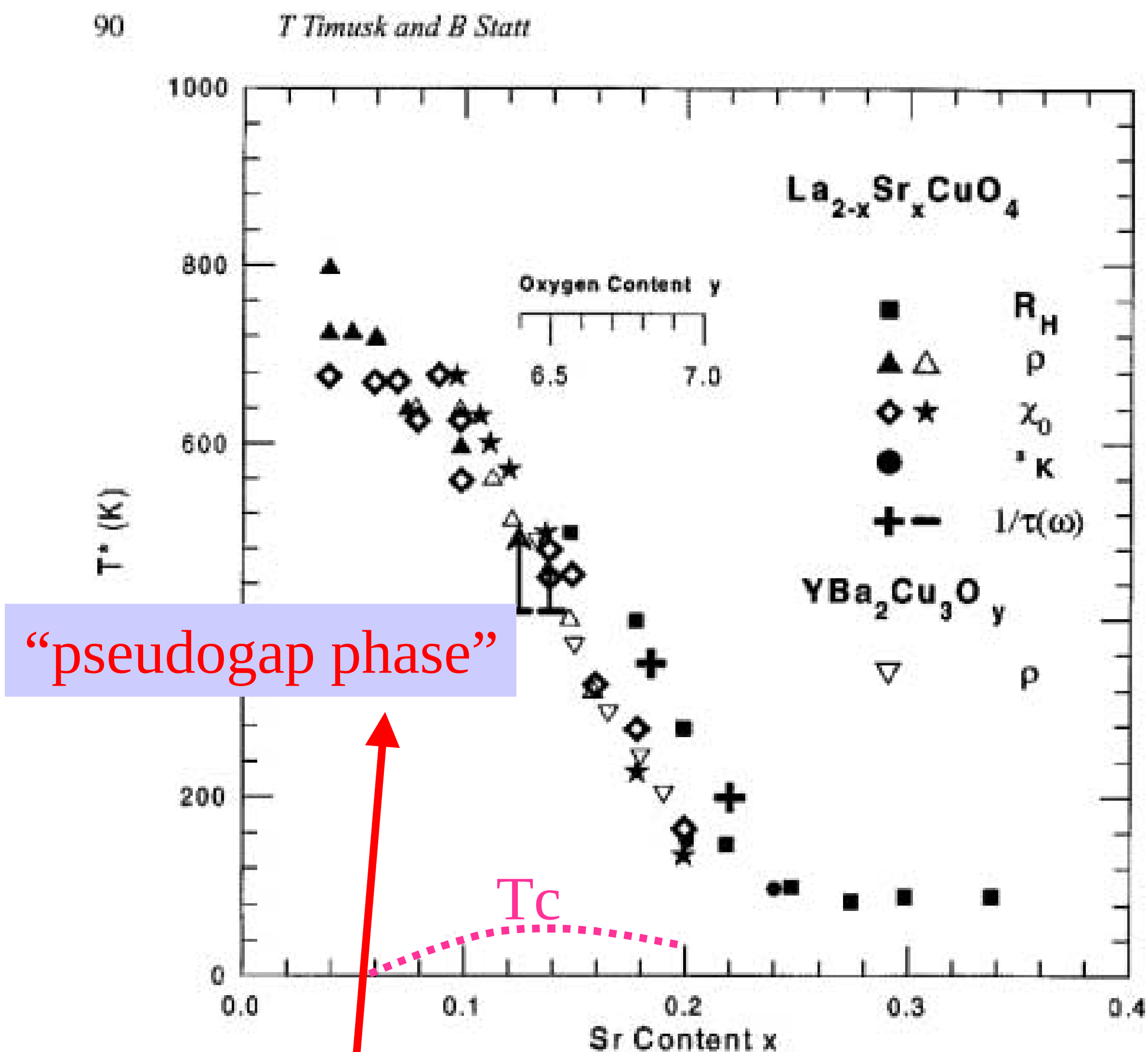


underdoped

T*

Knight shift

T^* versus doping

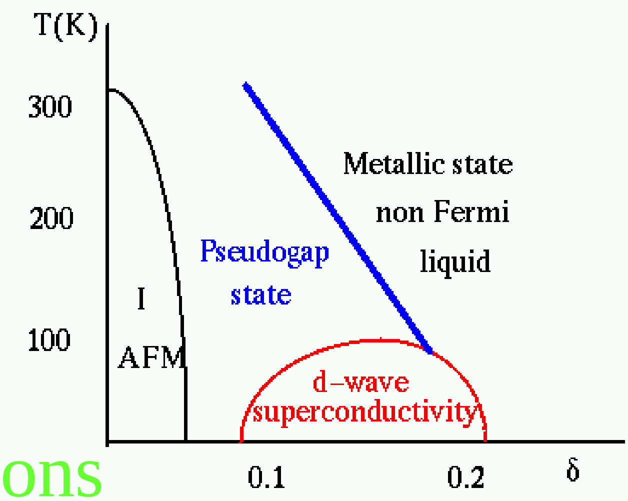


What’s going on?

- Gauge field fluctuations (*Lee*, *Wen*) ?
- Z_2 symmetry breaking (*Senthil*, *Fisher*) ?
- DDW(*Nayak*, *Chakravarty*, *Laughlin*)?
- Fluctuating stripes (*Zachar*, *Emery*, *Kivelson*)?

……

High Tc Phemomenology: Summary of Problems



unconventional SC

spin fluctuations

"Hi Tc"

d-wave superconductivity

Low Superfluid Density

Short Coherence Length

Non Fermi Liuid

Abnormal "Normal State"

Mysteries of ARPES

Weird Transport

Pseudogap temperature

T* versus doping

IN NEED OF A MODEL & ITS SOLUTION

Part II: Microscopic Theory