

KITP Program: Exotic order and criticality in Quantum matter, UC Santa Barbara, June 15, 2004

Mott criticality and spin liquid state revealed in quasi-2D organics

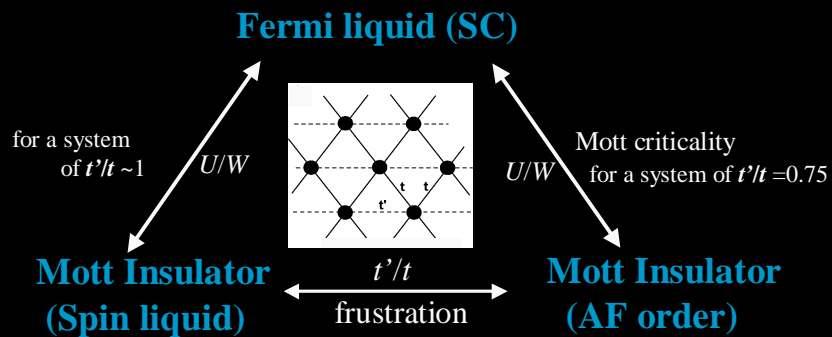
K. Kanoda (Univ. Tokyo & CREST)

Collaborators

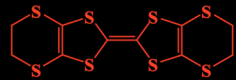
K. Miyagawa (Univ. Tokyo)
F. Kagawa (Univ. Tokyo)
Y. Shimizu (Univ. Tokyo & Kyoto Univ.)
Y. Kurosaki (Univ. Tokyo)
T. Itou (Univ. Tokyo & CREST)
M. Maesato (Kyoto Univ.)
G. Saito (Kyoto Univ.)
A. Kawamoto (Hokkaido Univ.)

Outline

- Introduction: κ -(ET)₂X ~ anisotropic triangular lattice
- Mott transition in 2D \rightarrow Criticality in 2D
- AF order vs Spin liquid in Mott insulators
- Transition from Spin liquid to Fermi liquid (SC)



Introduction

$ET =$ 

$\kappa-(ET)_2X$

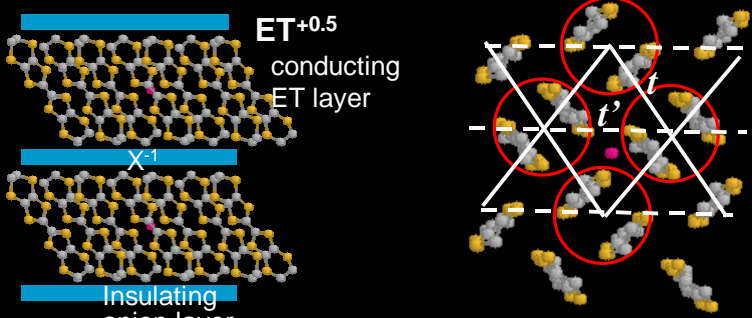
ET dimers form anisotropic triangular lattice

$ET^{+0.5}$ conducting ET layer

X^{-1}

Insulating anion layer

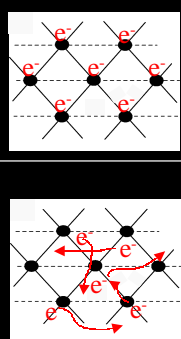
$t'/t : 0.5 \sim 1.0$ for various X



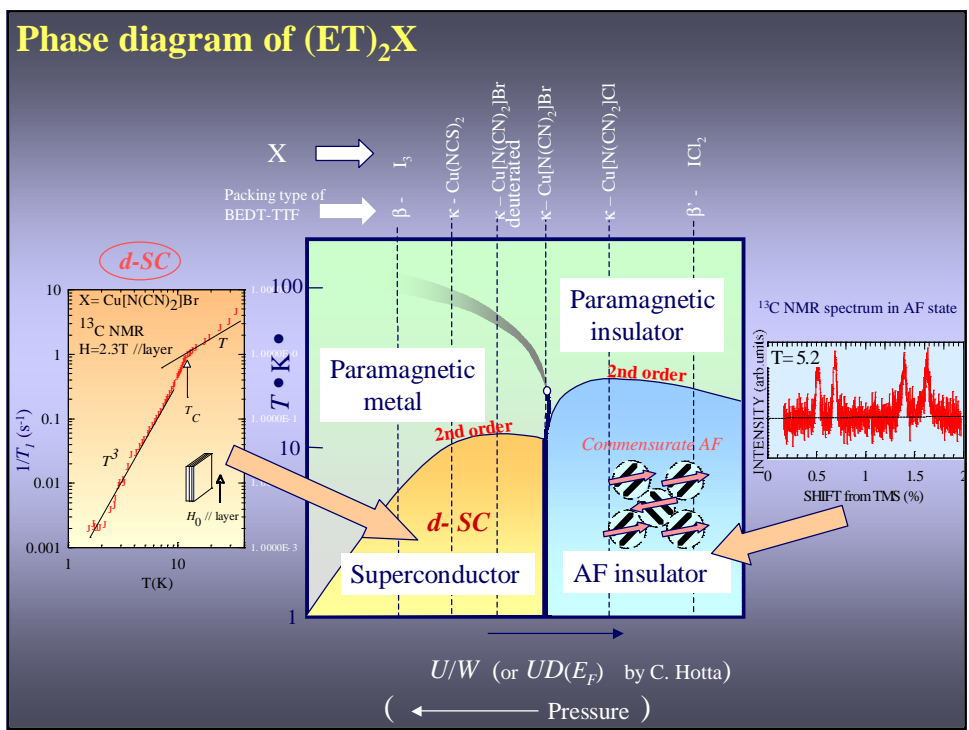
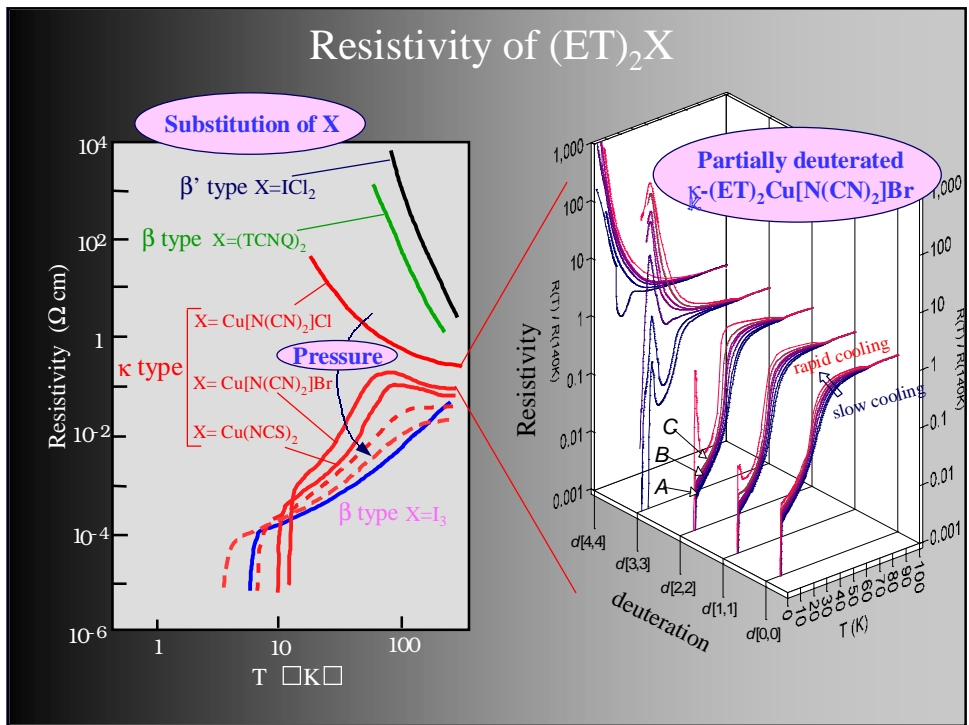
$\kappa-(ET)_2X$ is situated around Mott transition

X^-	Ground State	U/t	t'/t
$Cu_2(CN)_3$	Mott insulator	8.2	1.06
$Cu[N(CN)_2]Cl$	Mott insulator	7.5	0.75
$Cu[N(CN)_2]Br$	SC	7.2	0.68
$Cu(NCS)_2$	SC	6.8	0.84
$Cu(CN)[N(CN)_2]$	SC	6.8	0.68
$Ag(CN)_2 \cdot H_2O$	SC	6.6	0.60
I_3	SC	6.5	0.58

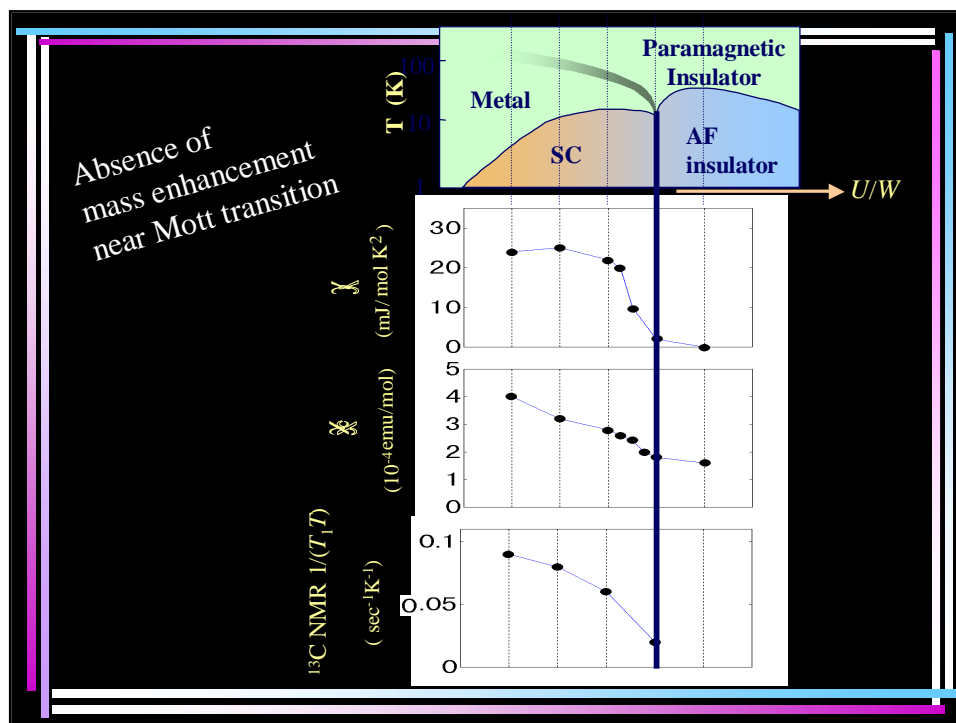
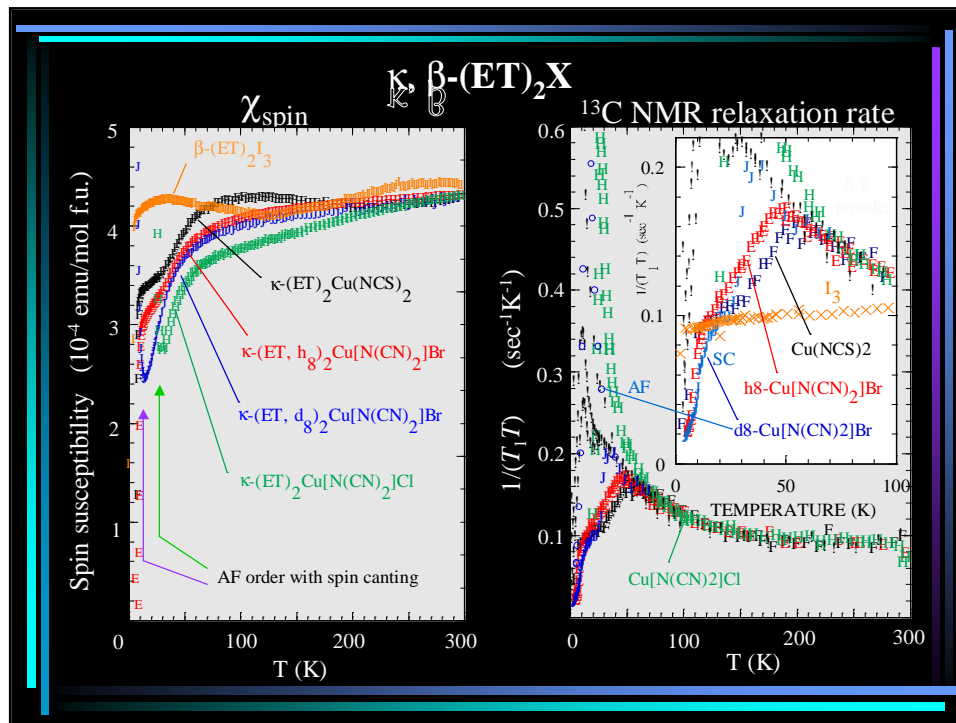
Pressure

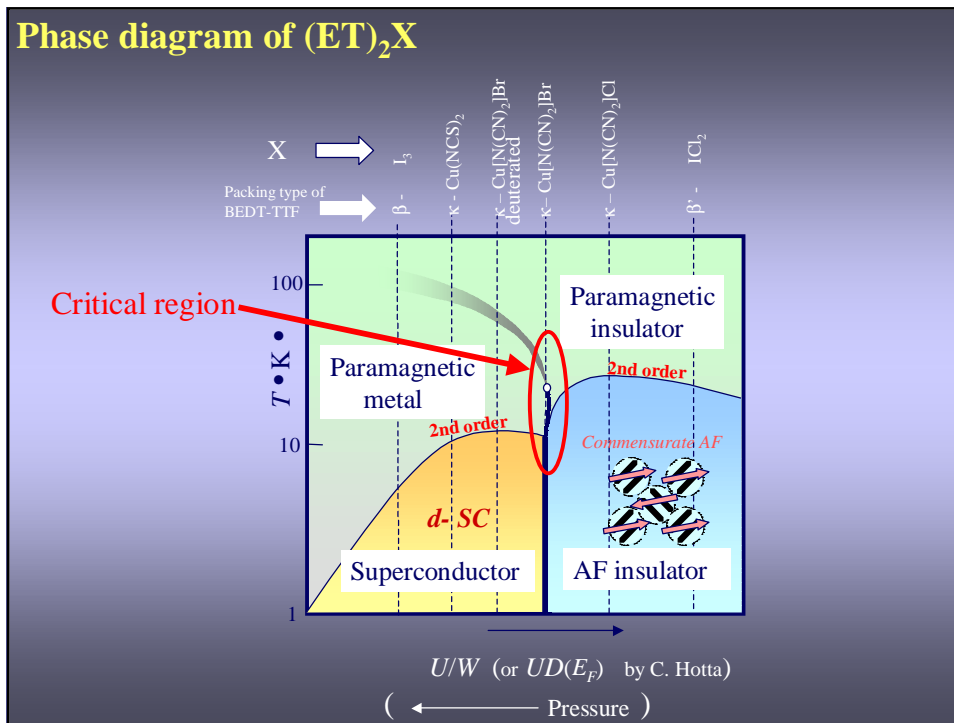


Mott Criticality and Spin Liquid State Revealed in Quasi-2D Organics



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Criticality of Mott transition; theoretical

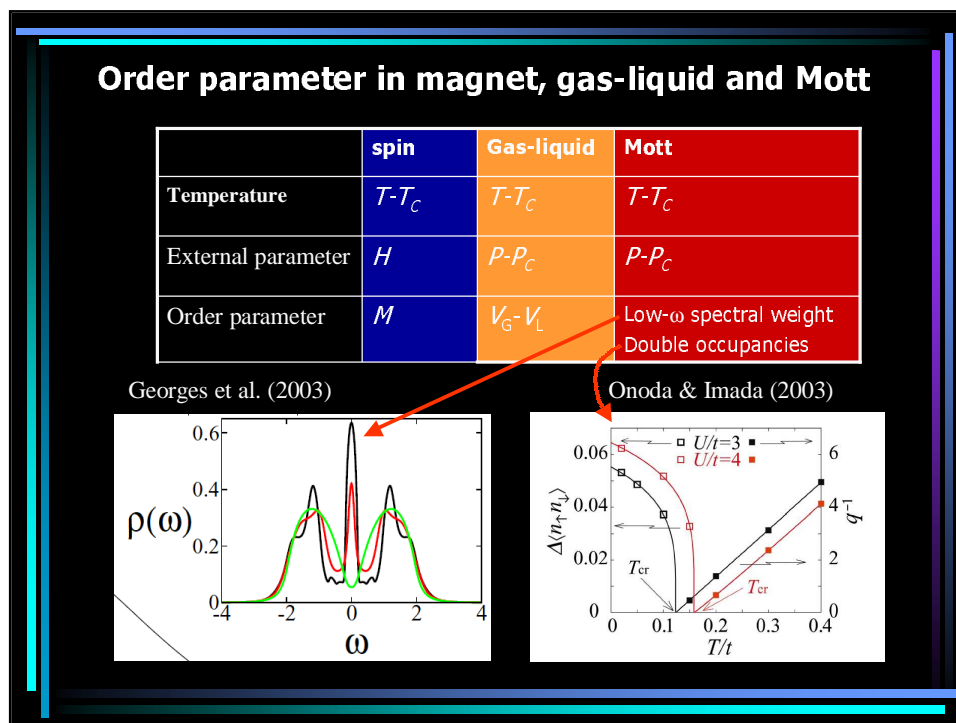
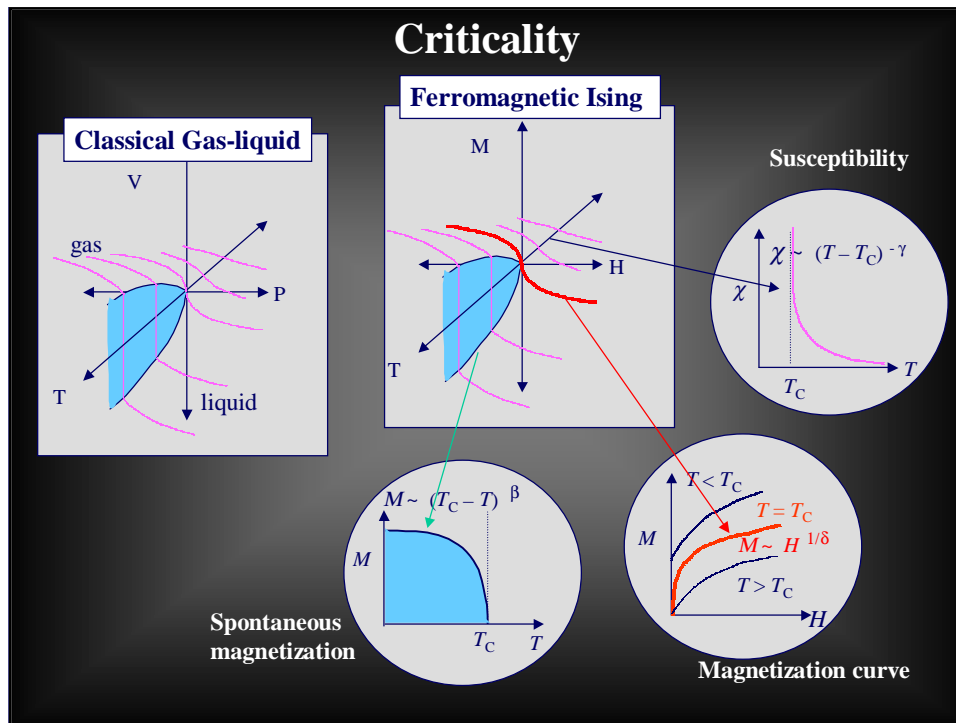
1979 Castellani et al.,
analogy with the classical liquid-gas transition

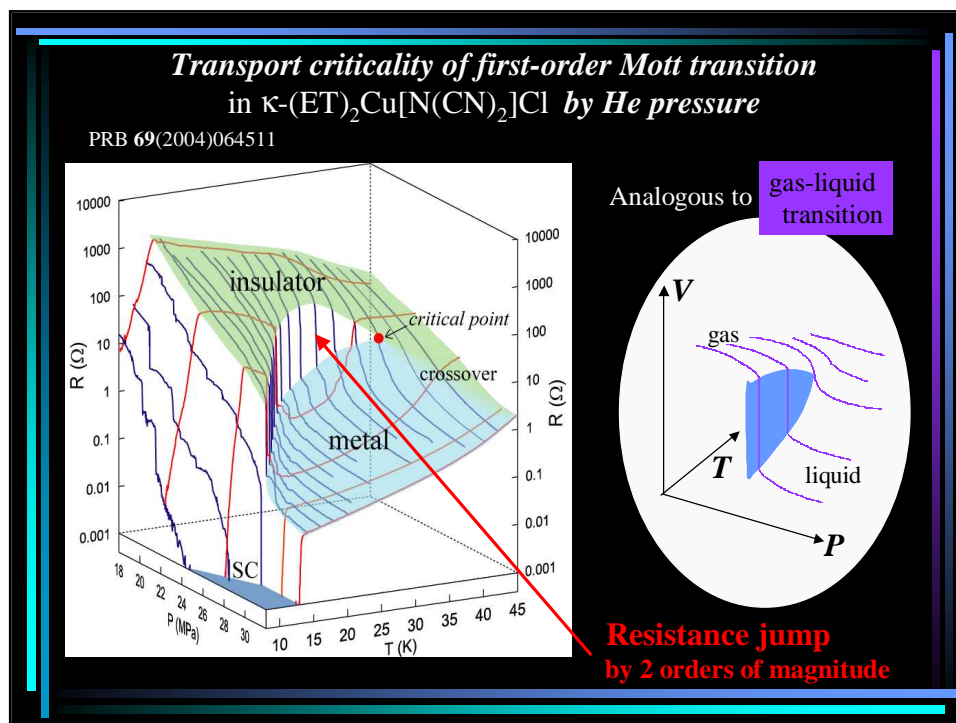
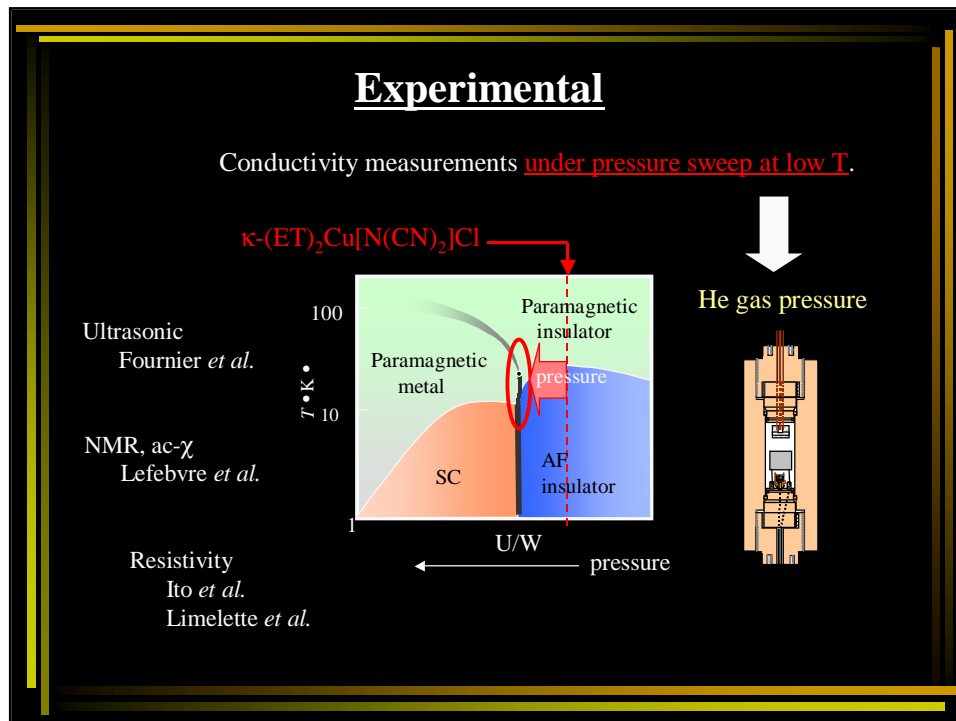
□□□□ Georges et al,
□□□□ Kotliar et al
.....
dynamical mean-field theory (DMFT)

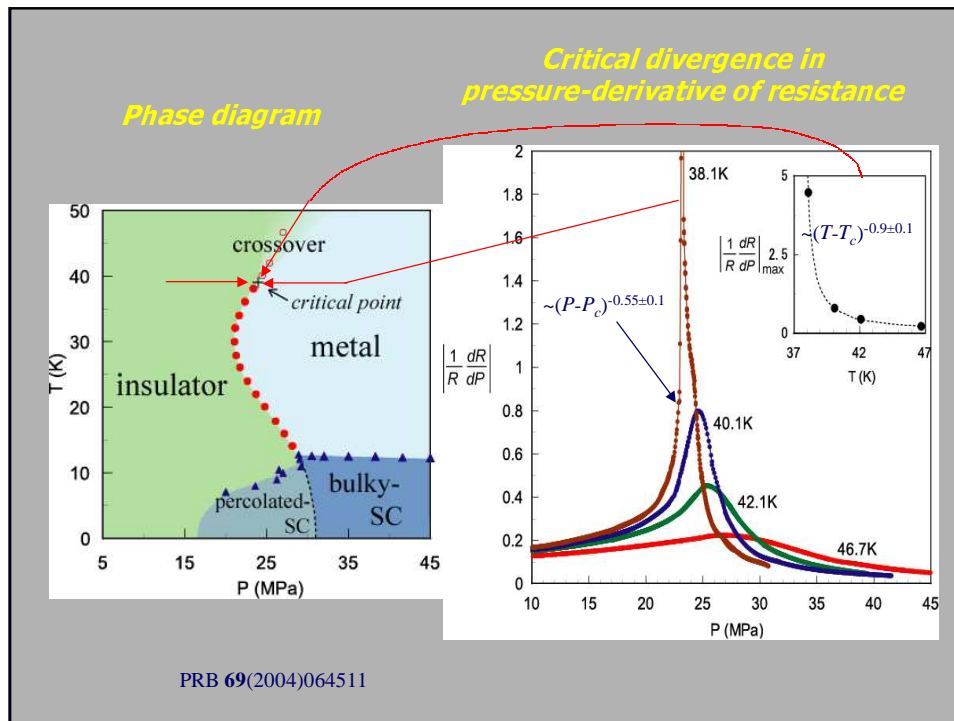
Fluid of **double occupancies** and **holes**

→ the Ising universality class

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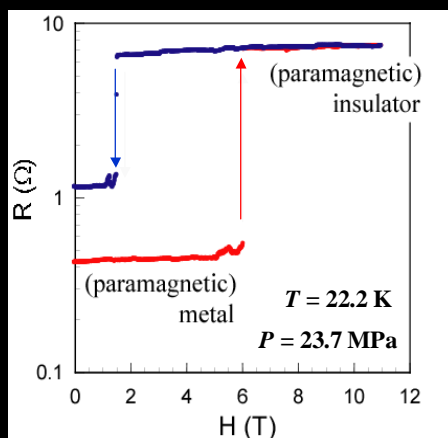
Conclusion on Mott criticality

1. First-order transition with a critical endpoint
2. Around the endpoint,
 - Conductivity shows critical behavior
 - Unusual critical exponents
 - They satisfy the scaling relation
 - All data are on the two scaling functions



MT in 2D belongs to a new universality class ?

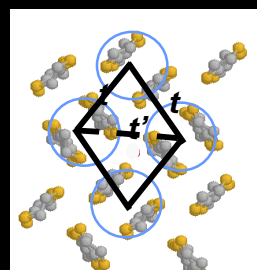
Field-induced Mott transition

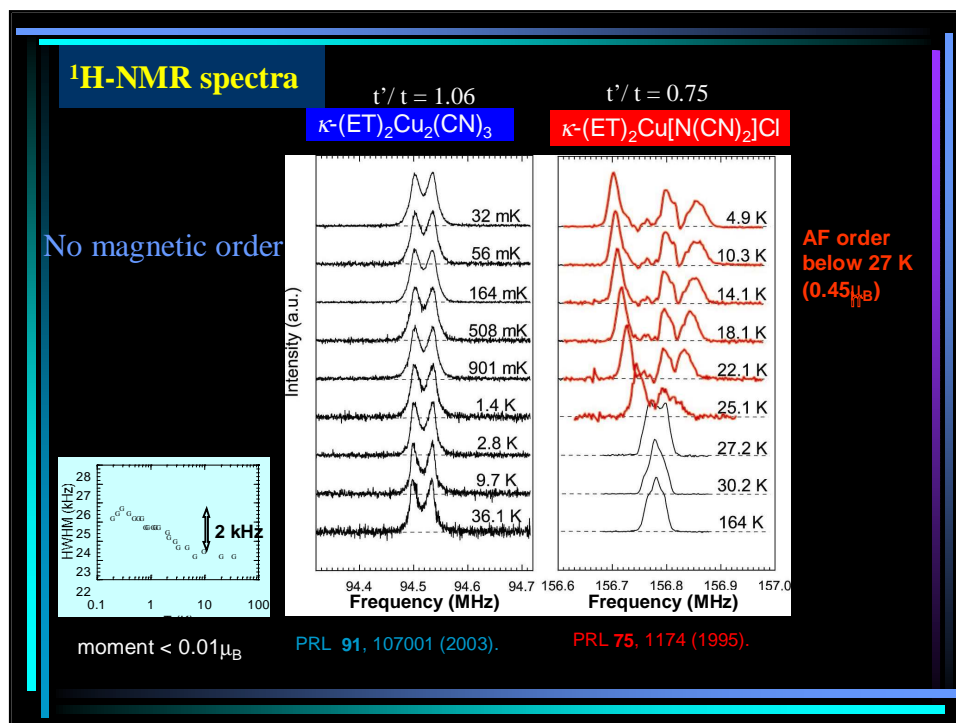
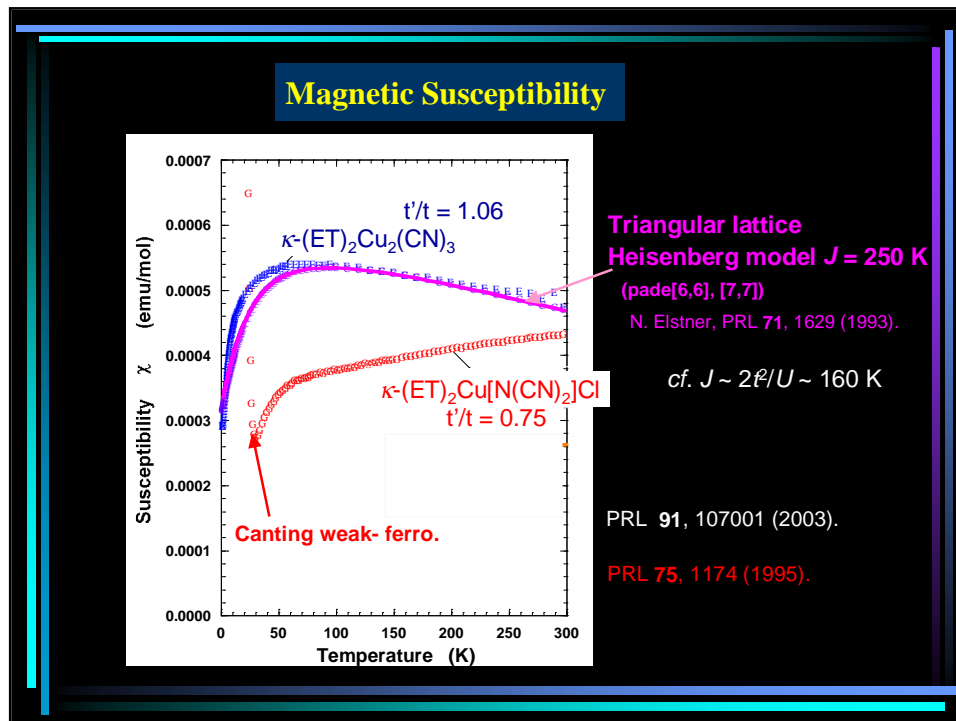


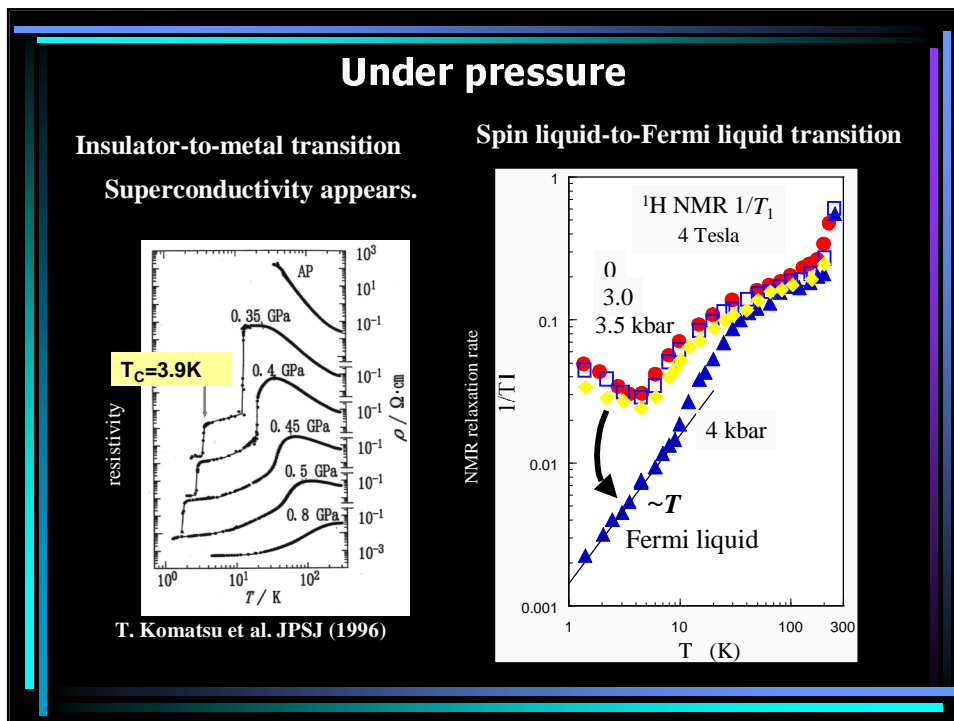
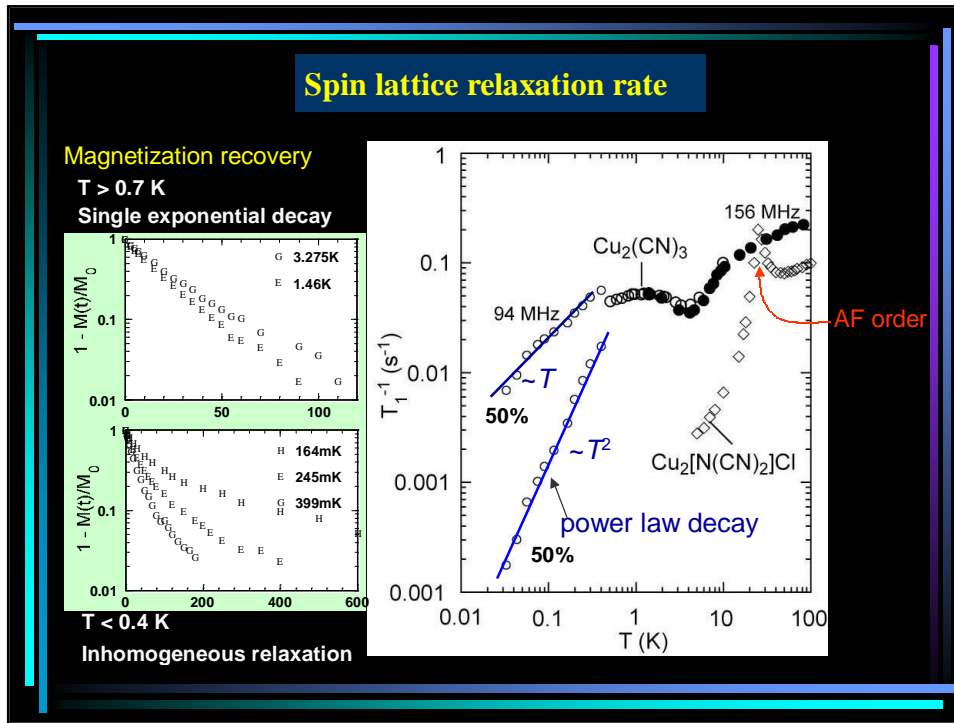
Spins on triangular lattice in Mott insulator



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I ₃	SC	6.5	0.58







Conclusion on triangular-lattice Mott insulator

- No indication of long-range order
down to 32 mK in spite of $J = 250$ K
 - Magnetic field induces inhomogeneity
(Spatially varying staggered, spiral, or spin glass ?)
- cf.* No magnetic moment detected by μ SR at 0 Tesla (S. Ohira *et al.*)

→ Spin liquid state in k - $(\text{ET})_2\text{Cu}_2(\text{CN})_3$

- Spin liquid neighbors Fermi liquid
and possibly SC phase