Electron Ising Nematic in High-T_c Superconductors

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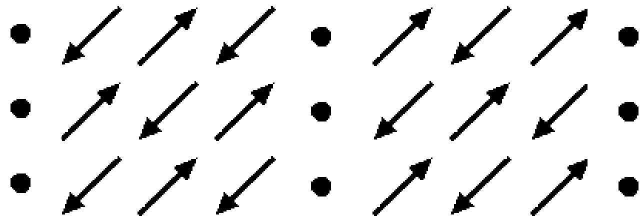
Issues



stripes

Why do we care?

Novel electronic phases: liquid crystals

May shed light on High Tc

Issues about stripes in HTSC:

Are they there?

Are they ubiquitous?

What constitutes evidence of them?

Hard to detect!

Disorder   (chemical dopants)

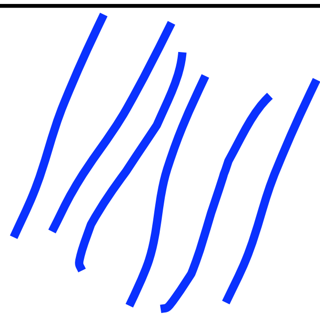
Rounds transitions

Destroys order!

> How do we define and detect “order”
> in the presence of severe disorder effects?

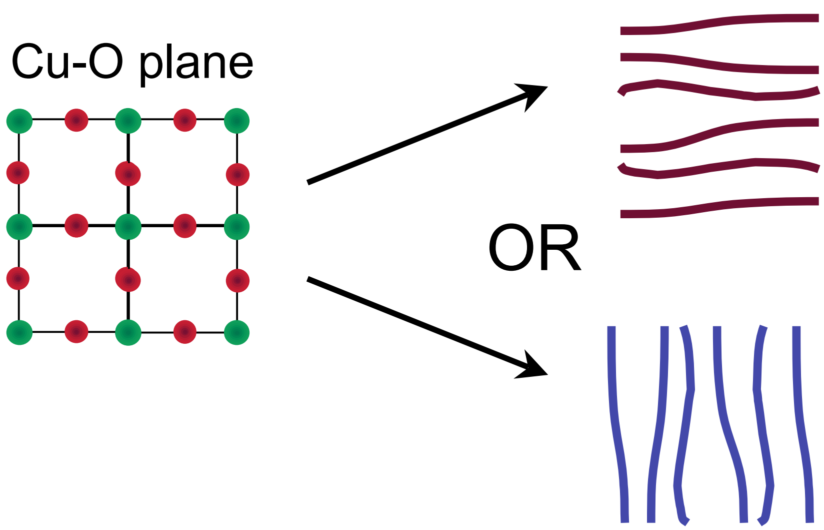
Stripes → Random Field Ising Model

Stripes break orientational symmetry



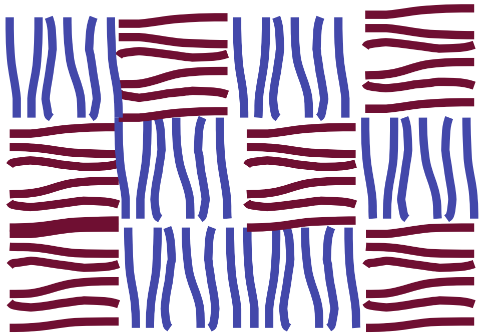
NEMATIC

Stripes lock to a crystal direction



ISING NEMATIC

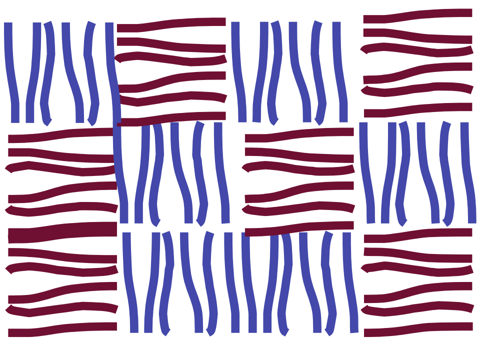
Disorder favors one direction locally



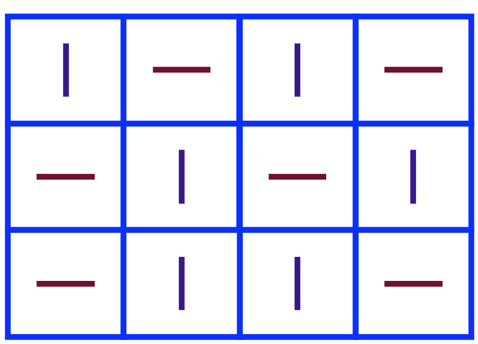
RANDOM FIELD ISING MODEL

$$H = -J \sum_{<i,j>} \sigma_i \sigma_j - \sum_i (H + h_i)\sigma_i$$

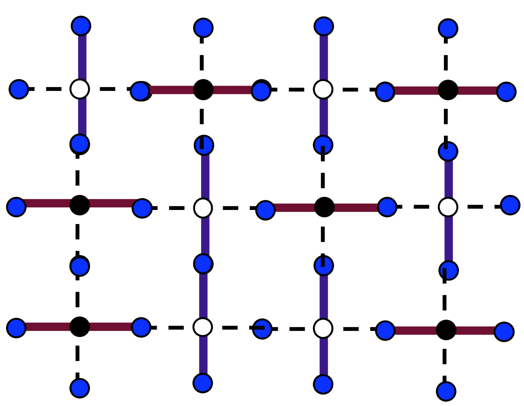
Random Field Ising Model $\rightarrow$ Transport



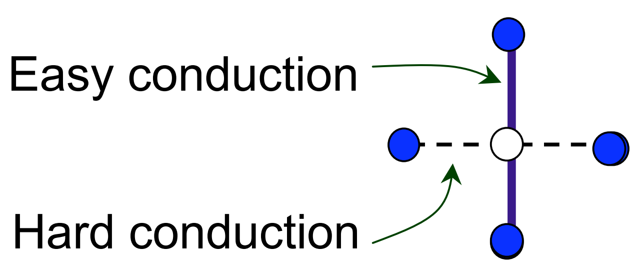
Nematic
Stripe Patches



Random Field
Ising Model

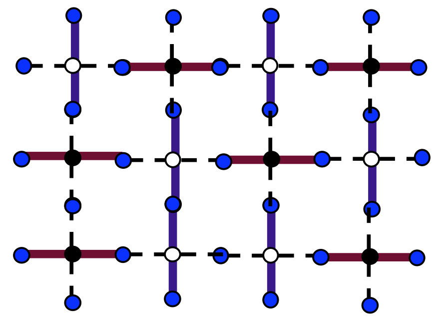


Resistor Network



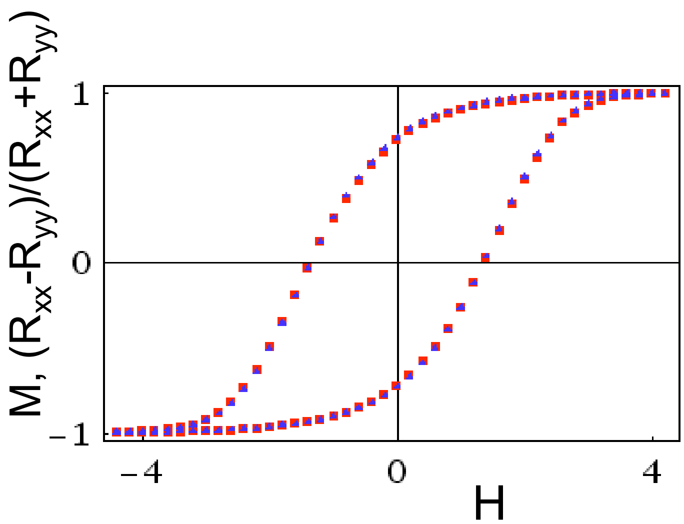
Macroscopic Resistance Anisotropy

$$R_a = \frac{R_{xx} - R_{yy}}{R_{xx} + R_{yy}}$$



Resistance Anisotropy
and RFIM Magnetization exhibit hysteresis

"Magnetization" = orientational order

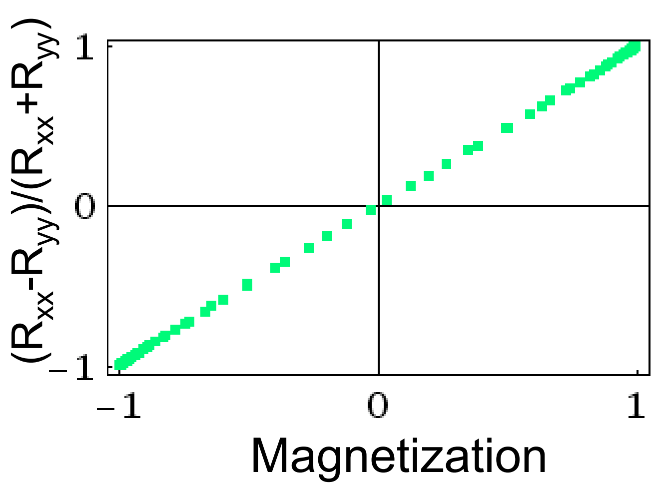


Magnetization

$(R_{xx}-R_{yy})/(R_{xx}+R_{yy})$

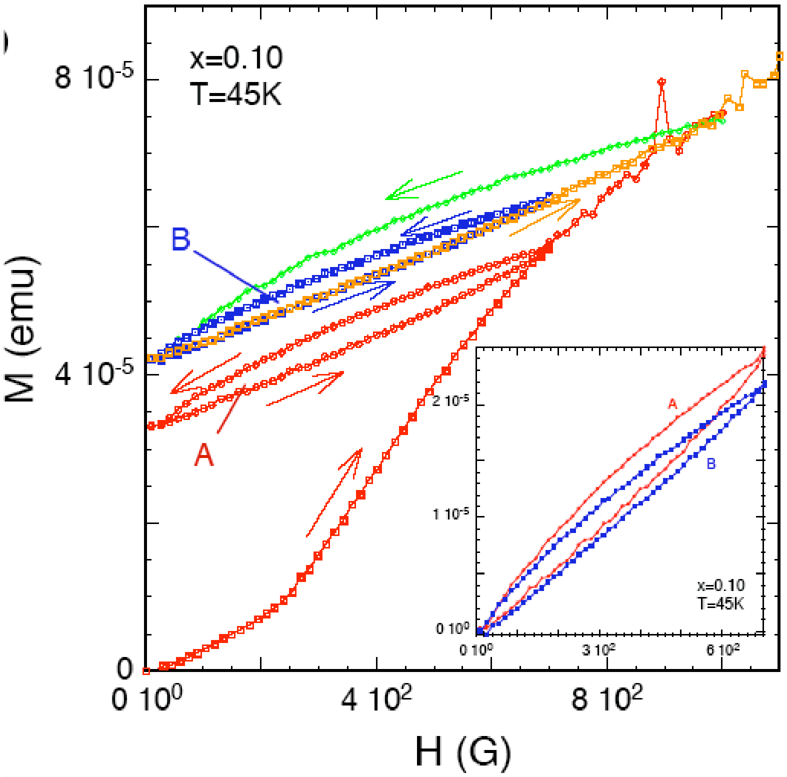
LXL = 300X300

T=0; R = 2.8 J; $R_{large}/R_{small} = 2$



Resistance Anisotropy Tracks Magnetization ≈ linearly

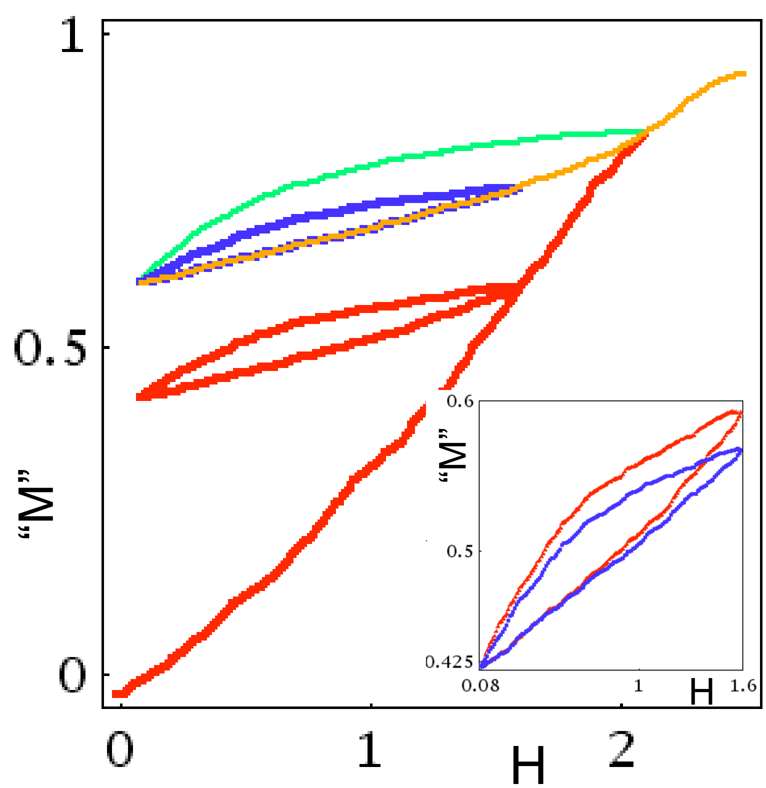
Hysteresis Subloops



Experiment

LSCO, X=.10
ZFC, ZFW
T=45K

Panagopoulos *et al.*, cond-mat/0412570

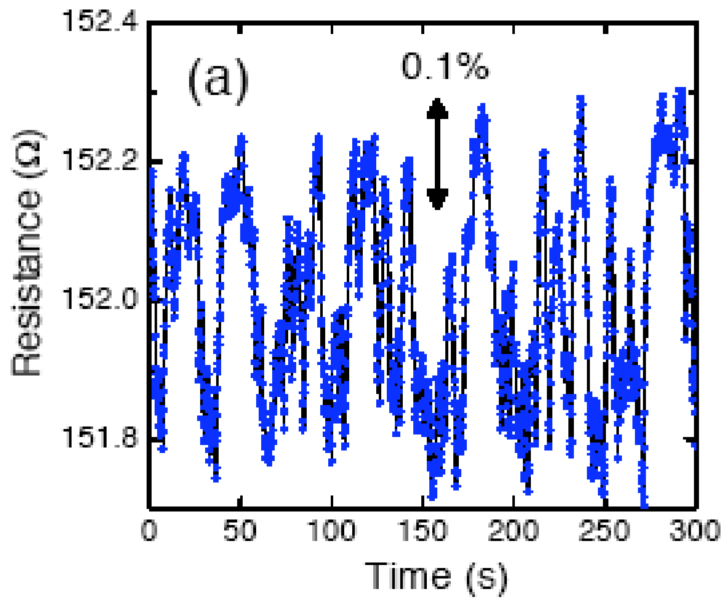


Theory

- Return Point Memory (subloops close)
- Incongruent Subloops →Interactions important

•Disorder R=2.8J, T=0,
Size = 100X100

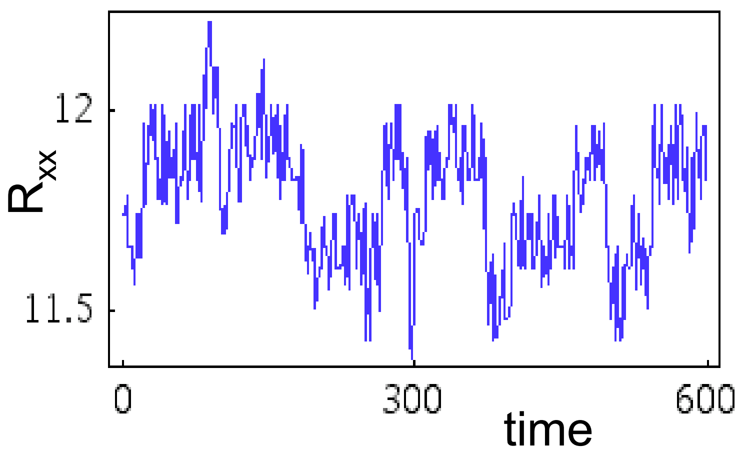
Transport



Experiment

YBCO nanowire
underdoped
T=100K
500nmX250nm

Bonetti, Caplan,
Van Harlingen, Weissman
PRL 2004

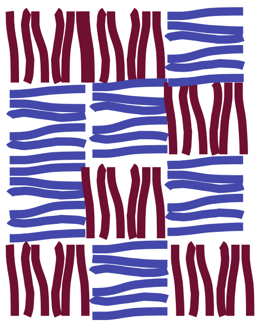


Theory

- Local patch anisotropy: 2
- Size: 10X10 patches
- Disorder R=2.8 J
- T = .5 J

- Stripe correlation length
  ~ 40nm (from neutron data)

Conclusions



Stripes + Host crystal + Disorder
= Random Field Ising Model

Predictions for Transport:

R_{xx}-R_{yy} (orientational order)

- Hysteresis
- Return Point Memory at low T
- Subloops
  - Incongruent ⇒ Interactions important

R_{xx}

- Switching noise in small systems
- Characteristic Power spectra