Striping in Cuprates

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Outline

- Introduction
- Basics of Striping
- Implications to Superconductivity
- Experimental Findings
- Conclusion

Introduction

- Superconductivity
  - Discovered in 1911: still a mystery
  - Related interesting phenomena
    - Striping

Basics

- Used in 1990s to describe electrical/ magnetic property interactions
- What is striping?
    - 1D periodic ordering in 2D plane
        - Charge, spin, both

Basics

- Electronic behaviour: 2 regimes
  - Kinetic energy dominated
  - Potential energy dominated
- Between 2 regimes: stripes
  - neither rigid lattice, nor delocalized

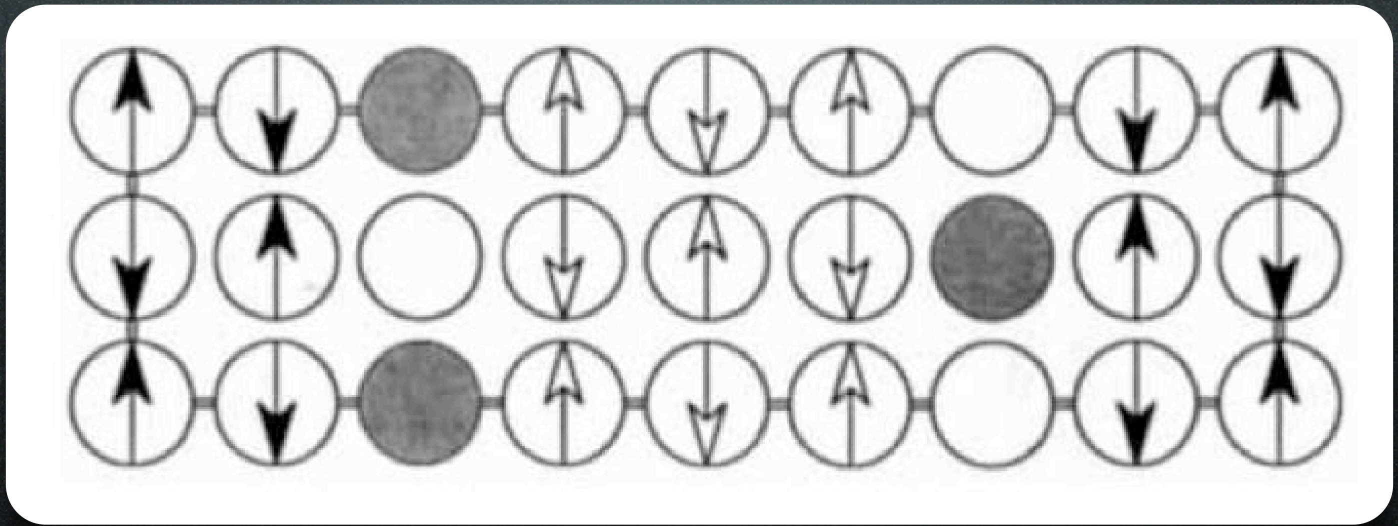
Where Is Striping Found?

- High T_C superconductors: Cuprates
- Cuprates
  - 2D layered structure: sheets between doping material
  - AFM spin orientation

What is Striping?

- Doping can introduces spinless free-charges
  - Movement frustrated by spins
- Holes orient in 1D stripes to allow movement at lower energy cost
- No holes in regions between stripes
  - Spins in AFM order

What is Striping?

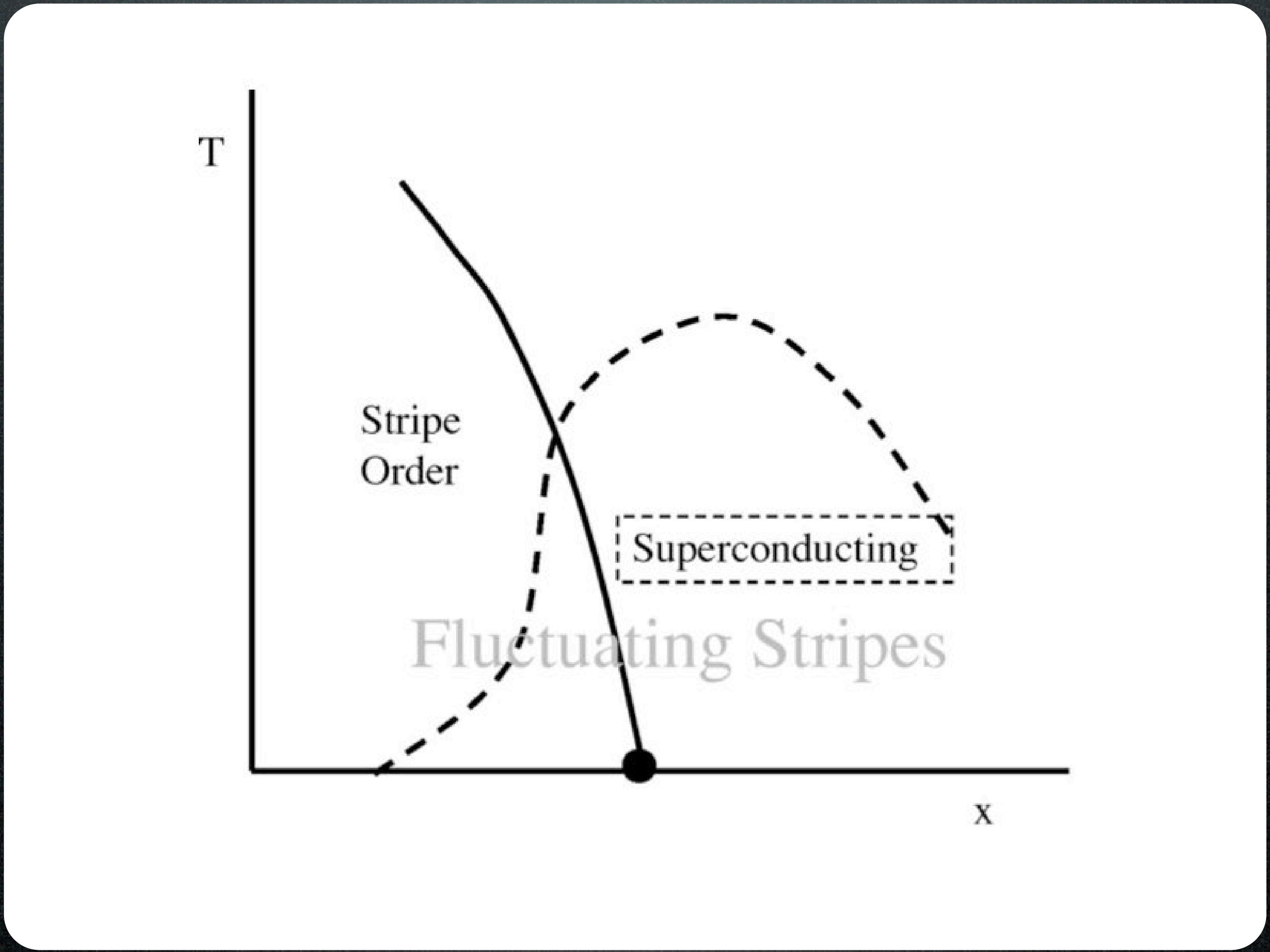


- Electronic behaviour is quasi-1D
  - Coulomb coupling falls off exponentially
- Anisotropic: metal or insulator

Implications to Superconductivity

- Cuprates doped below SC level show striping
    - Doping corresponds to low T_C
    - Striping competes with SC, with some overlap

Implications to Superconductivity



- Only small overlap

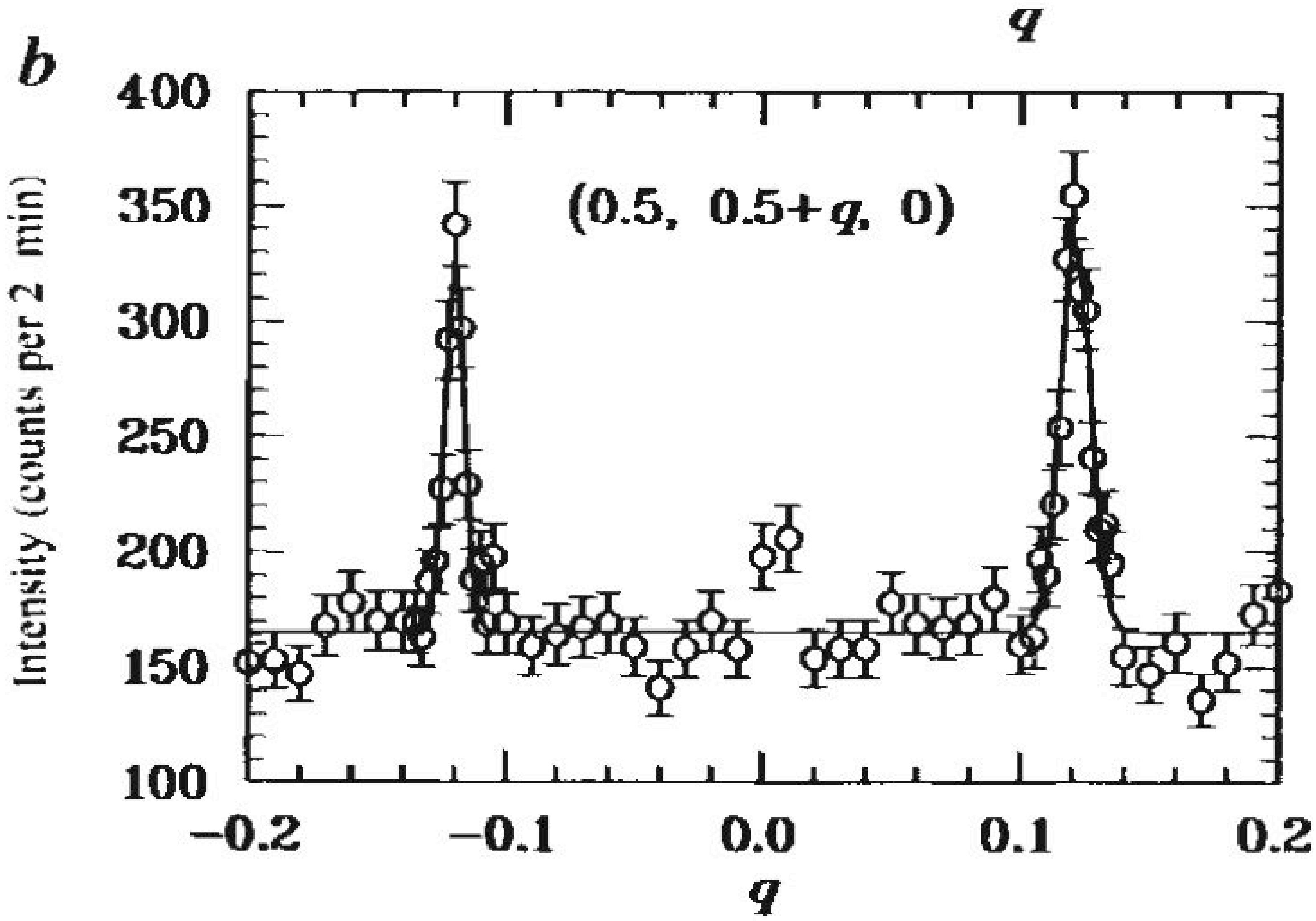
Experimental Findings

- Striping initially difficult to detect
  - Believed that stripes are mobile in the lattice
- Tranquada et al.: appropriate doping can immobilize stripes
  - Neutron scattering on $La_{1.48}Nd_{0.4}Sr_{0.12}CuO_4$

Experimental Findings

- $La_{1.48}Nd_{0.4}Sr_{0.12}CuO_4$
  - $\sim 0.1cm^3$ sample at 11 K
  - Observed diffraction peaks corresponding to Cu spin ordering

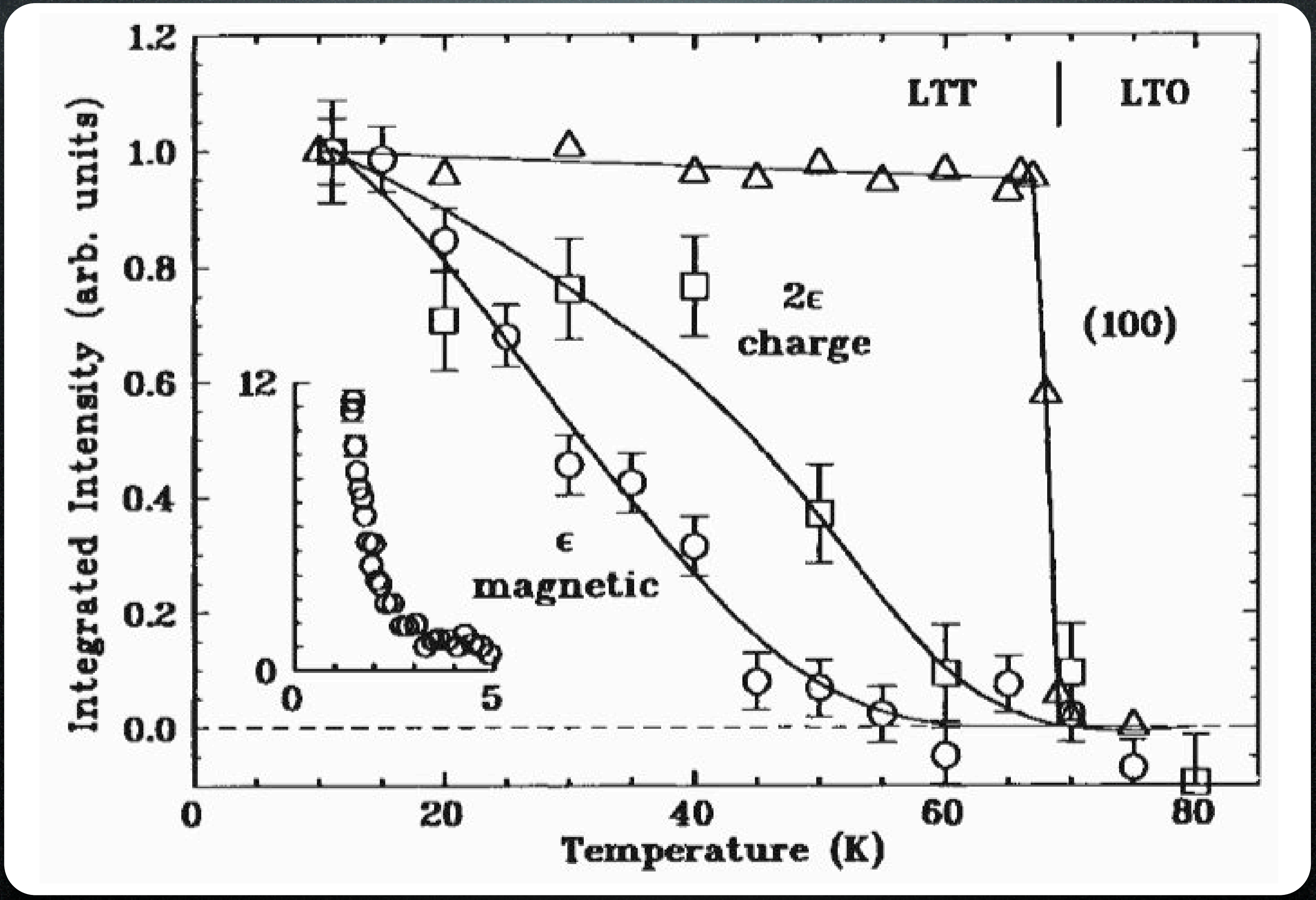
Experimental Findings



Experimental Findings

- Diffraction peaks characterized by temperature
    - Magnetic stripes found below 3 K
    - Both stripes disappear before 70 K

Experimental Findings



$La_{2-x}Ba_xCuO_4$

- 4-probe resistivity measurements
  - Stripe ordered phase measurements
- Striping frustrates 3D SC, not 2D
  - In-plane resistivity: SC
  - Out -of-plane resistivity: non-SC

$La_{2-x}Ba_xCuO_4$

- Spin incommensurability
  - Periodicity of spins are not aligned with lattice
  - Also seen in $YBa_2Cu_3O_{7-x}$
    - May be common feature of cuprates

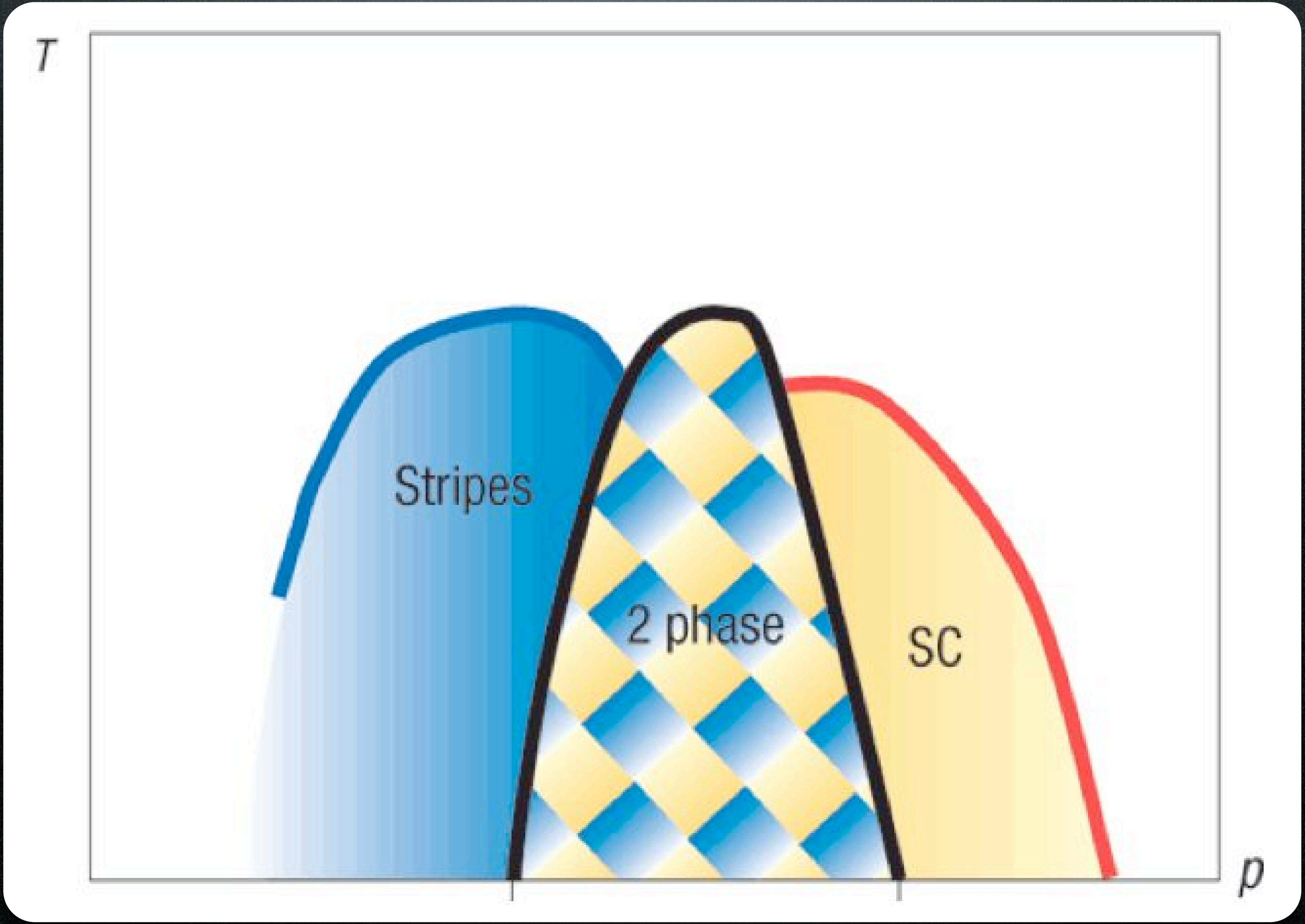
More Experiments!

- U. of Connecticut group: phase separation
- Used $La_{2-x}Sr_xCuO_{4+y}$
  - Excess oxygen gives T_C of 40 K
- Observed simultaneous phase separation

Simultaneous Phases

- Competing phases coexist in sample:
  - Stripe ordered region with SC suppressed
  - SC region exhibiting no stripe ordering

Simultaneous Phases



Conclusions

- Anisotropic ordering of charge/spin
- Striping is competing phase with SC
  - Exists in same temperature/doping regime
- Much work is needed to understand its mechanism and role in SC

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