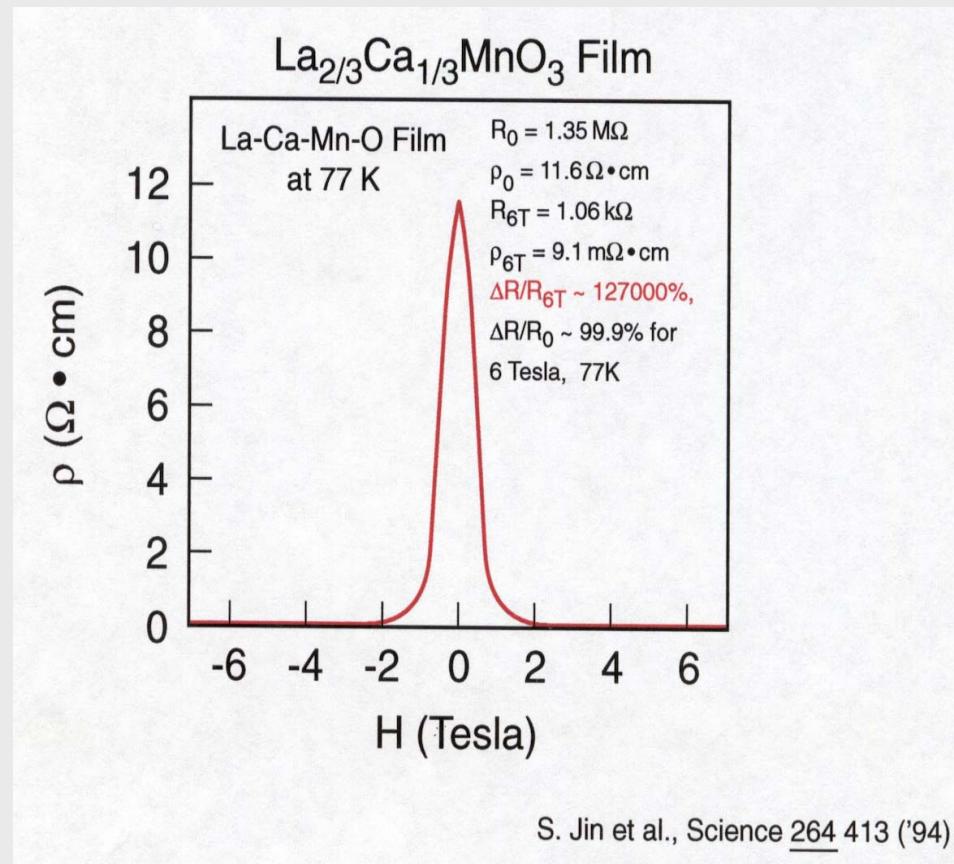


# **Application of xray submicrobeam to mesoscale physics in strongly correlated electrons**

**Yeong-Ah Soh**  
**Dartmouth College, USA**

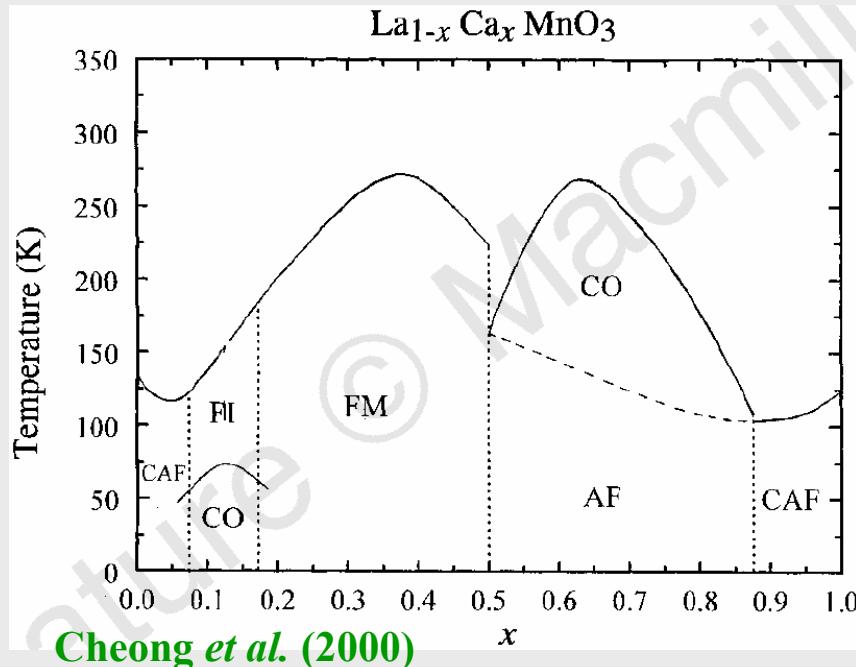
# CMR - colossal magnetoresistance

- Magnetoresistance of thin films first reported in 1993 (Chahara; von Helmolt)
- Very large magnetoresistance reported by Jin in 1994; colossal magnetoresistance

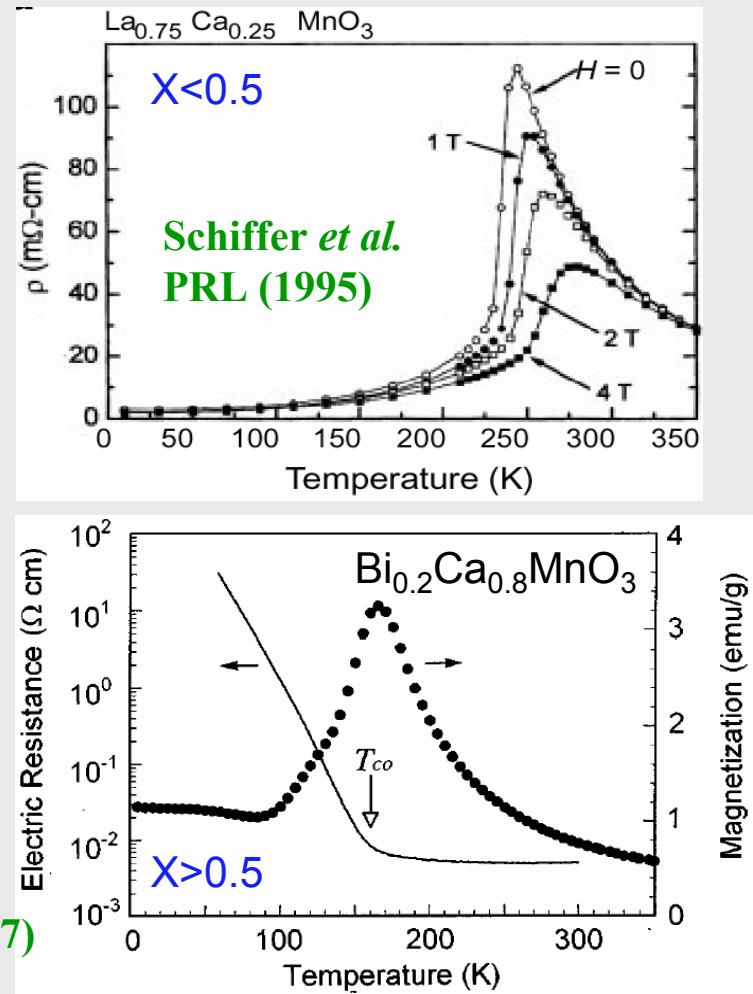


# Manganites - phase diagram

Interplay of spin, charge, and lattice degree of freedom

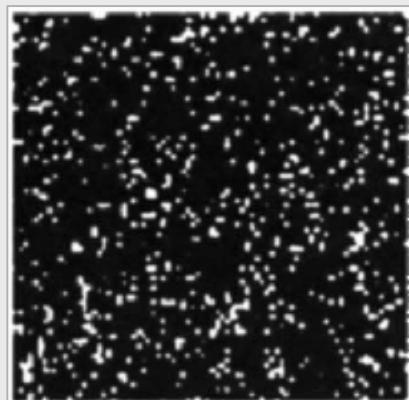


Murakami *et al.* PRB (1997)



# Phase separation? Intrinsic or extrinsic?

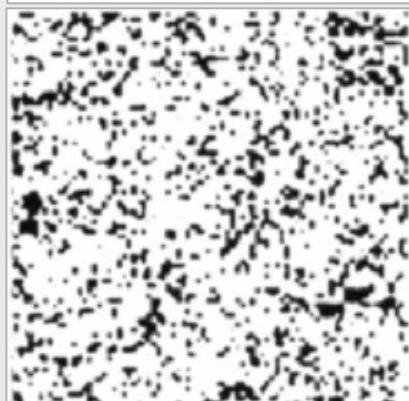
◆  $\text{La}_{0.7} \text{Sr}_{0.3} \text{MnO}_3$   $500 \times 500 \text{ nm}^2$



278 Kelvin

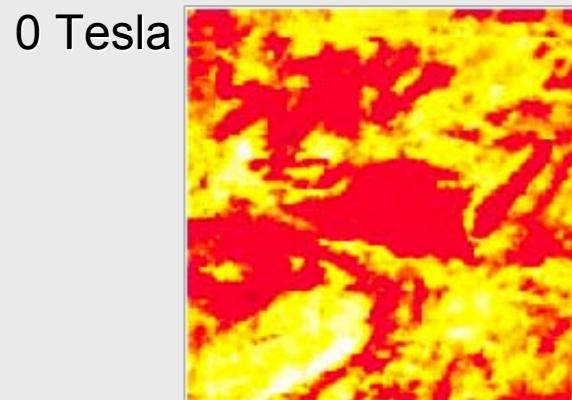
conductivity  
■ Insulating  
□ Metallic

87 Kelvin

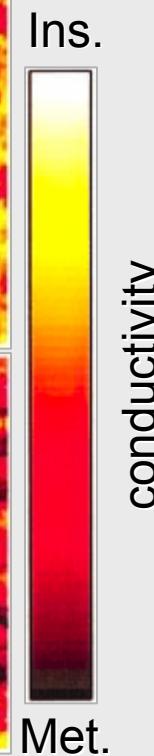


Becker et al. PRL 89 (2002)

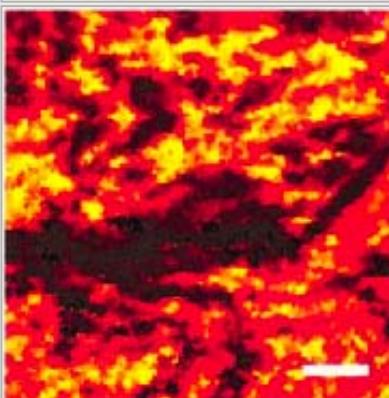
◆  $\text{La}_{0.73} \text{Ca}_{0.27} \text{MnO}_3$   $610 \times 610 \text{ nm}^2$



0 Tesla

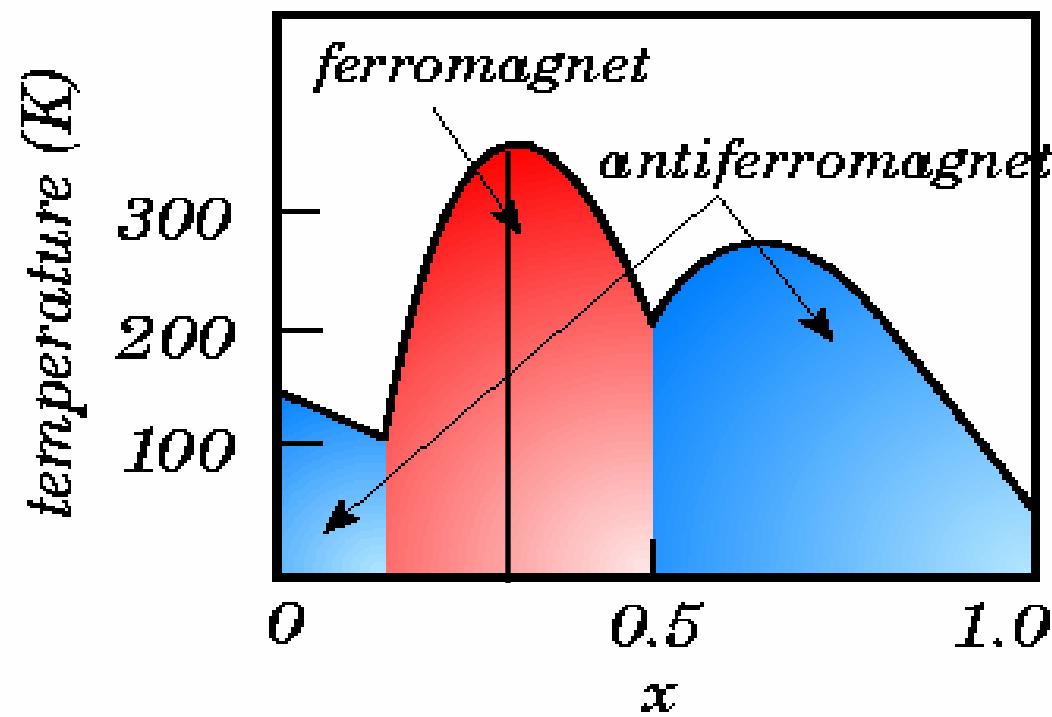


9 Tesla



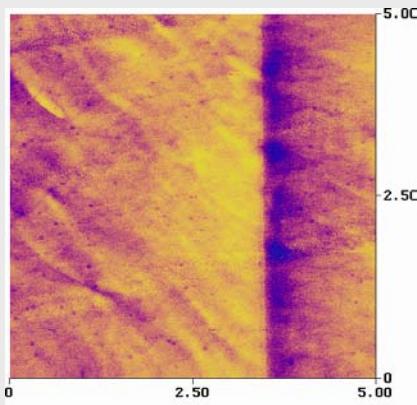
Fäth et al. Science 285 (1999)

# $\text{La}_{1-x}\text{Sr}_x\text{MnO}_3$ phase diagram

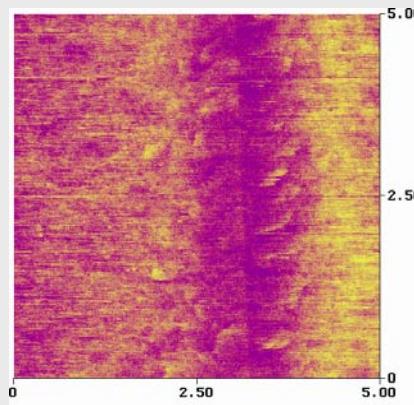


# Evolution of New Magnetic Region near Artificial Grain Boundary

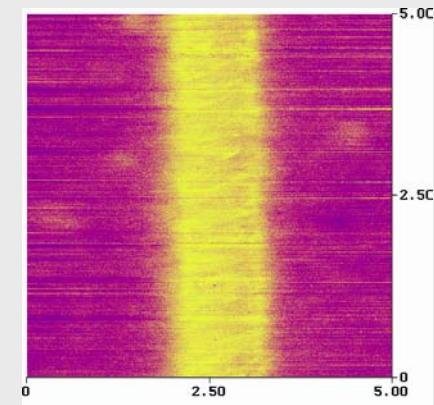
$\text{La}_{0.7} \text{Sr}_{0.3} \text{MnO}_3$



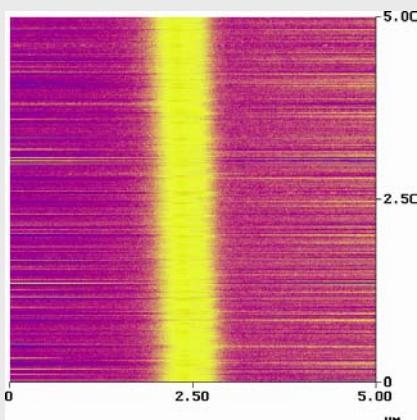
300 K



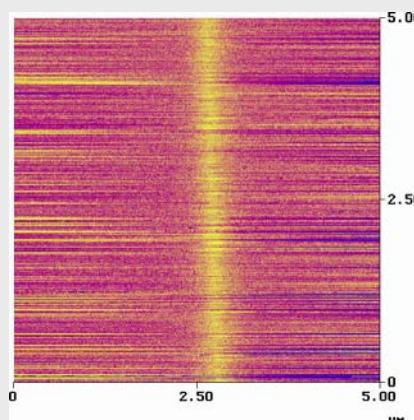
350 K



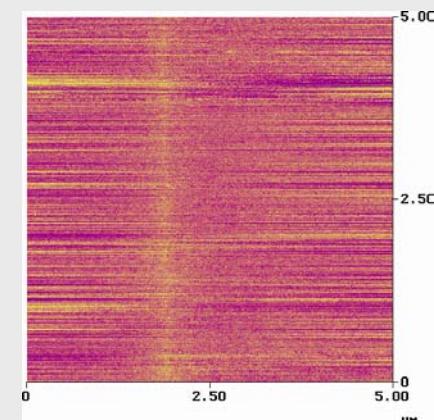
355 K



360 K

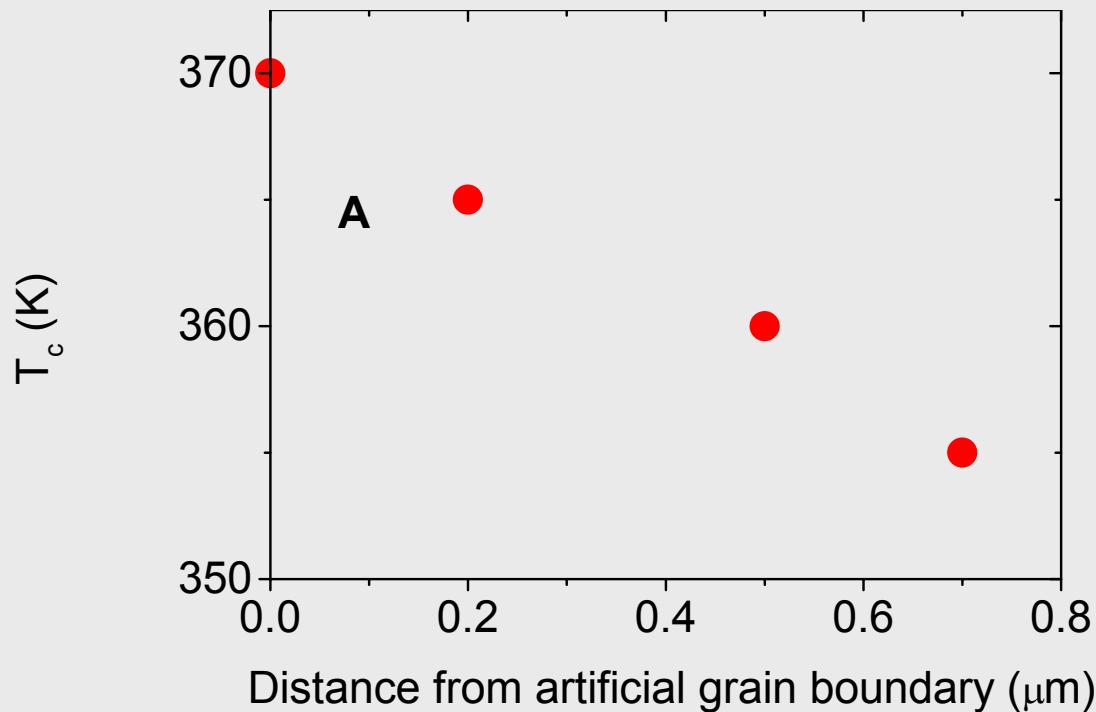


365 K



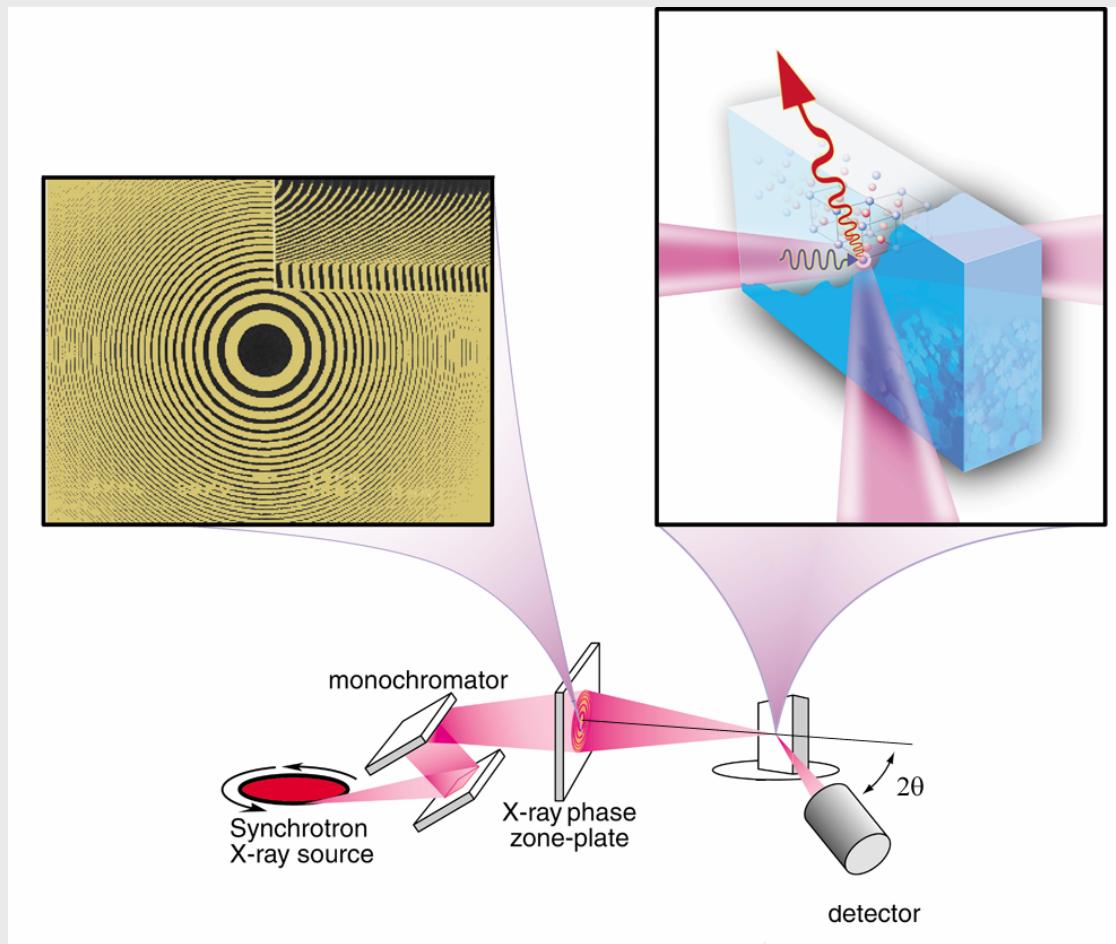
370 K

# Gradient of $T_c$ away from grain boundary



Y.-A. Soh et al., PRB (Rapid Comm.) 63, 020402 (2001)

# X-ray Microprobe at the APS

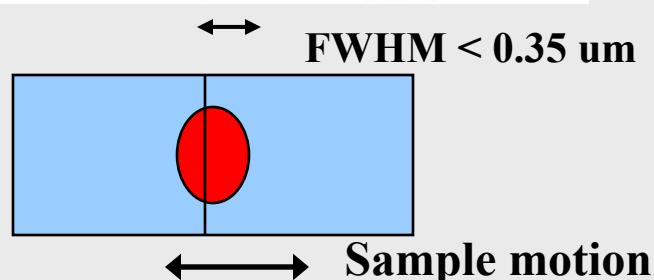
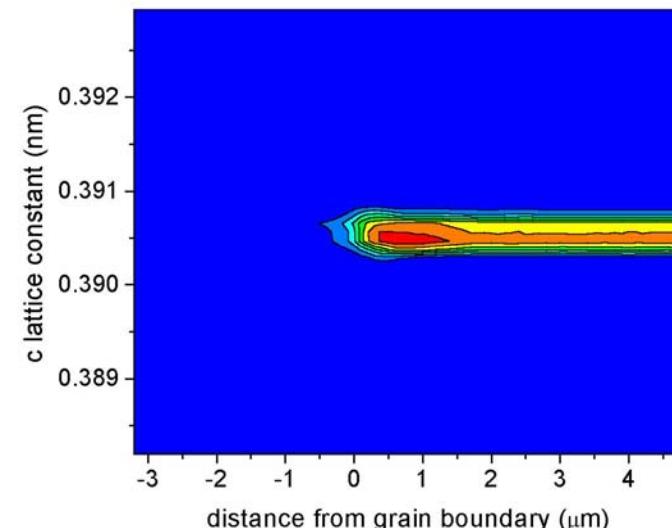
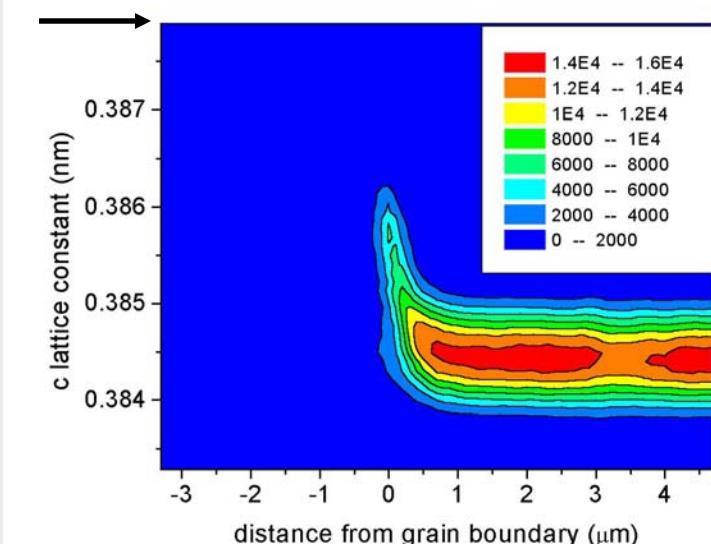


# Strain measurement across the grain boundary

(featured in Physics Today Jan. 2003)

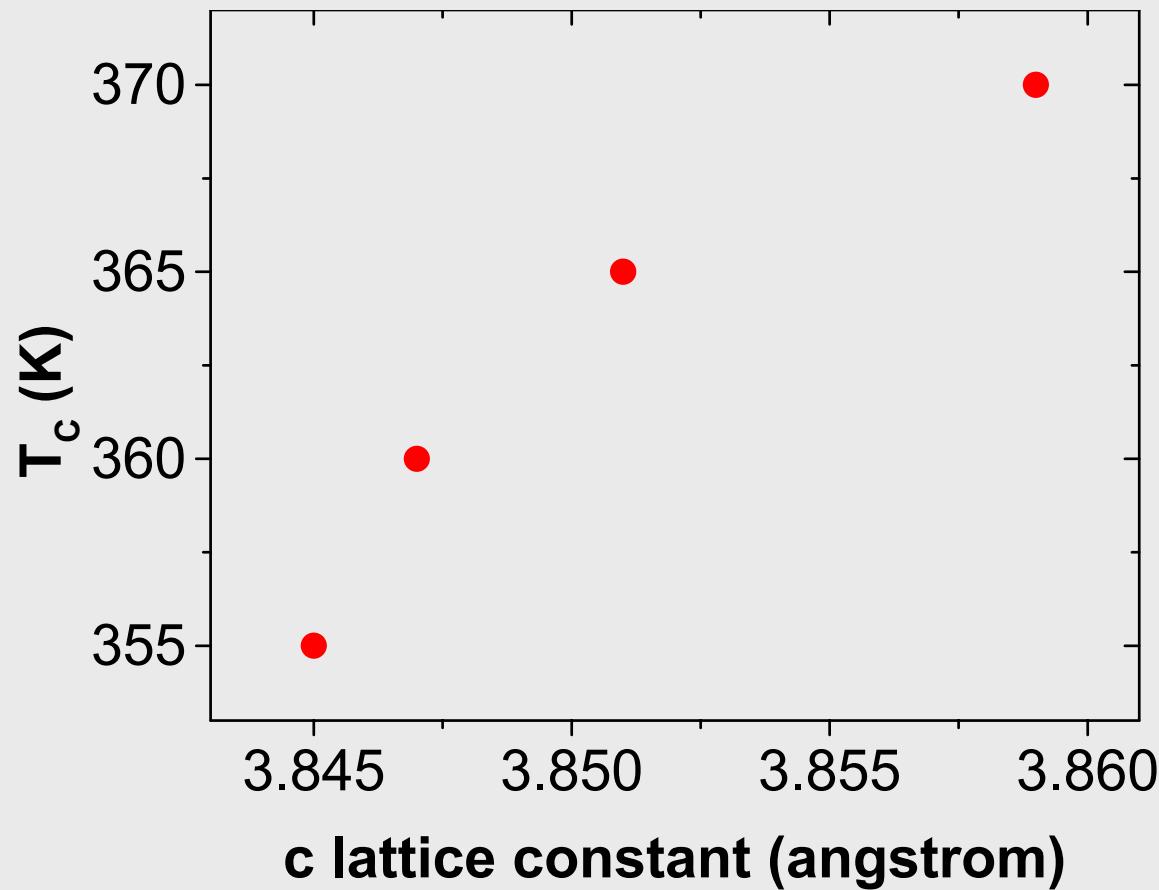
## (002) reflection

bulk lattice constant



2 theta resolution < 0.06 deg  
Rocking curve width < 0.03 deg

## Strain dependence of $T_c$ at grain boundary



# Summary

- First explicit demonstration of effect of **lattice** on the **magnetic** properties on a mesoscopic length scale via MFM and x-ray microscopy on same sample
- Can explain phase coexistence in manganites
- Wealth of problems in strongly correlated electron systems exist where xrays will play a big role

# Collaborators

- **G. Aeppli (UCL)**
- **P. G. Evans (U of Wisconsin)**
- **Z. Cai, B. Lai, , E. D. Isaacs (Argonne National Lab)**
- **C.-Y. Kim (Northwestern University)**
- **N. D. Mathur, M. G. Blamire (Cambridge)**