Spin correlations in Charge Ordered Oxides

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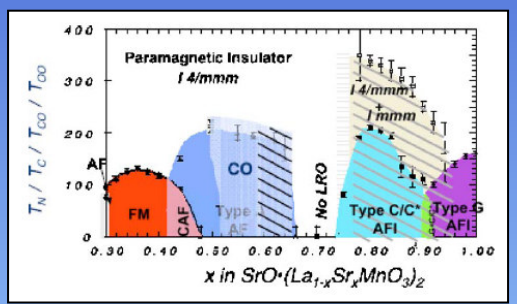
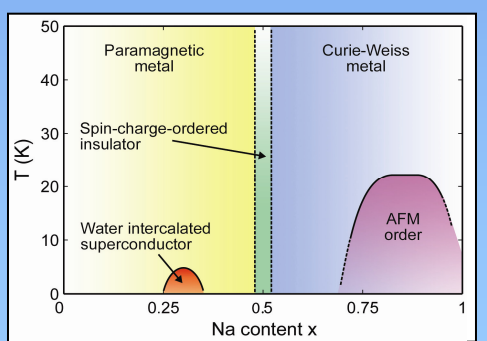
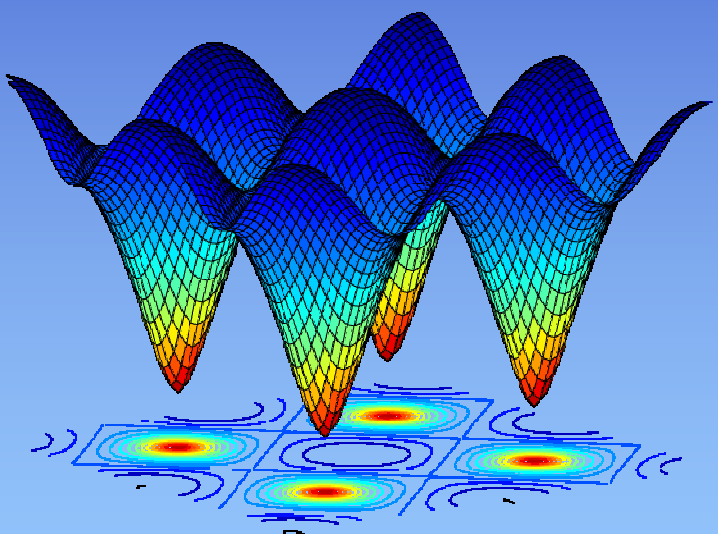
Oxides have many ordered phases:



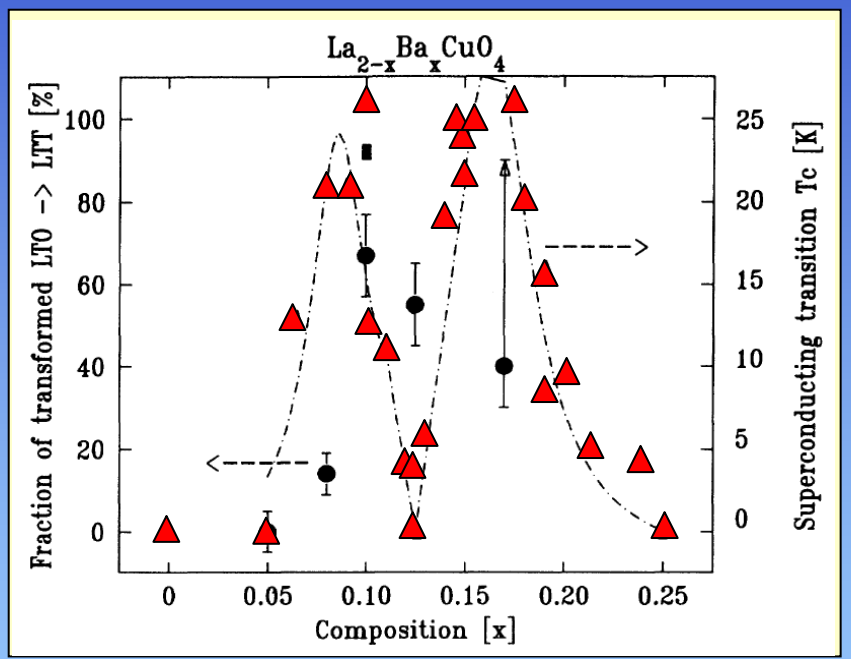
$La_{2-2x}Sr_{1+2x}Mn_2O_7$



Na_xCoO_2



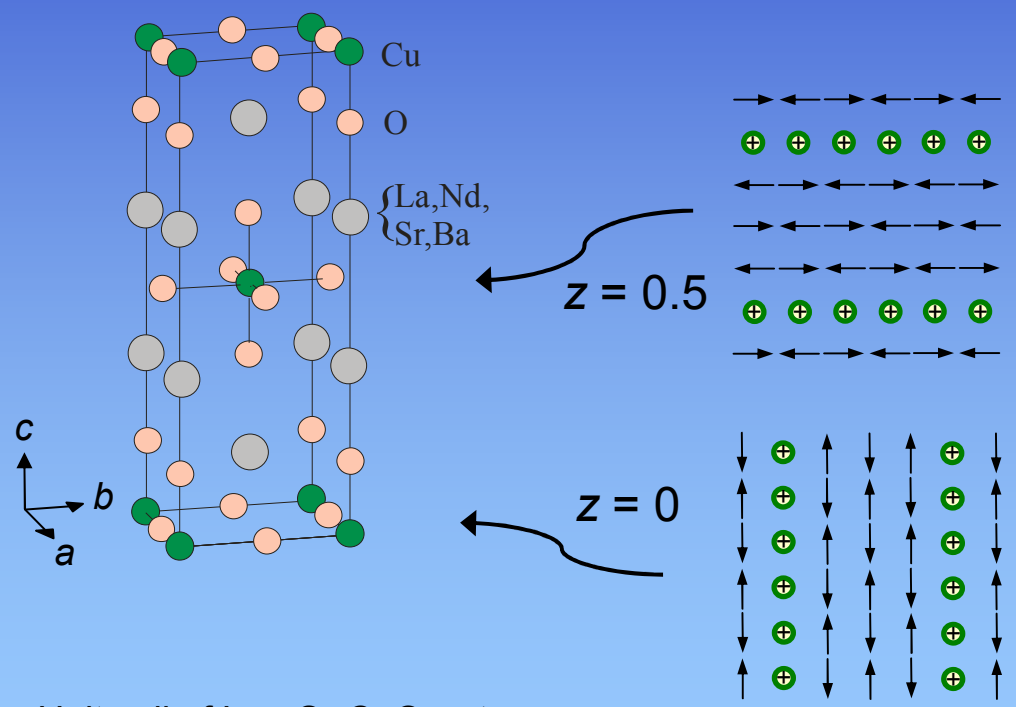
1/8 anomaly in $La_{2-x}Ba_xCuO_4$



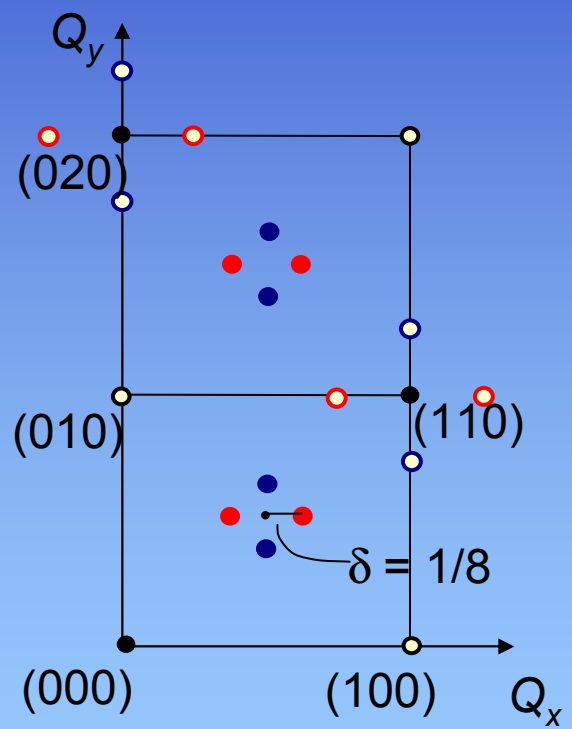
J.D. Axe *et al.*, PRL **62**, 2751 (1989)

Spin–Charge order at 1/8 doping

Observed in $La_{2-x}Ba_xCuO_4$ and $La_{1.6-x}Nd_{0.4}Sr_xCuO_4$ at $x = 0.125$



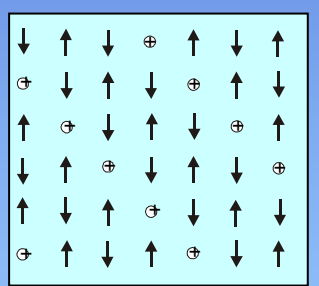
Unit cell of $La_{2-x}Sr_xCuO_4$, etc

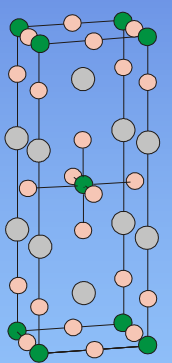


J.M. Tranquada *et al.*, Nature **375**, 561 (1995)

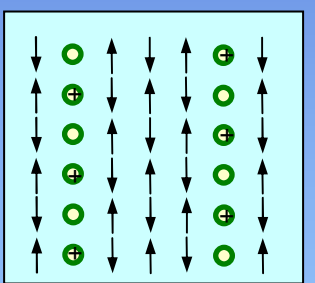
Stripe order in cuprates and nickelates

Stripe ordered
$La_{2-x}Sr_xNiO_4$



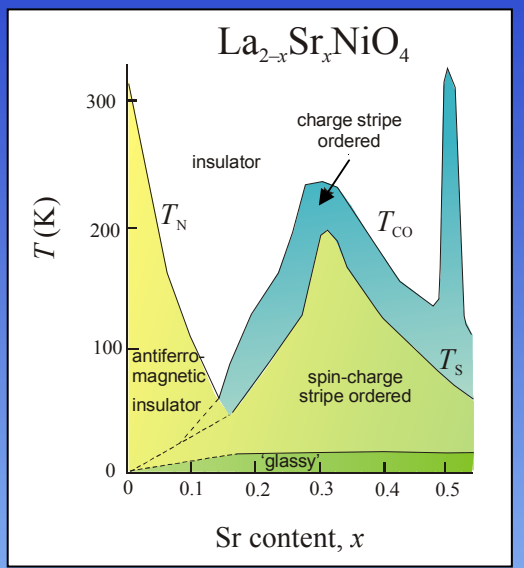


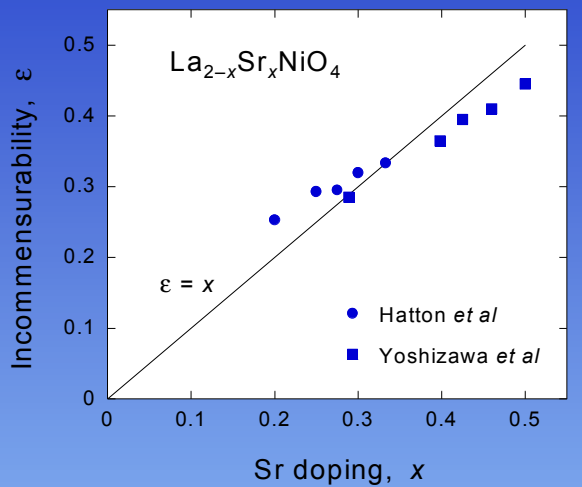
Stripe ordered
superconducting
$La_{1.6-x}Sr_xNd_{0.4}CuO_4$



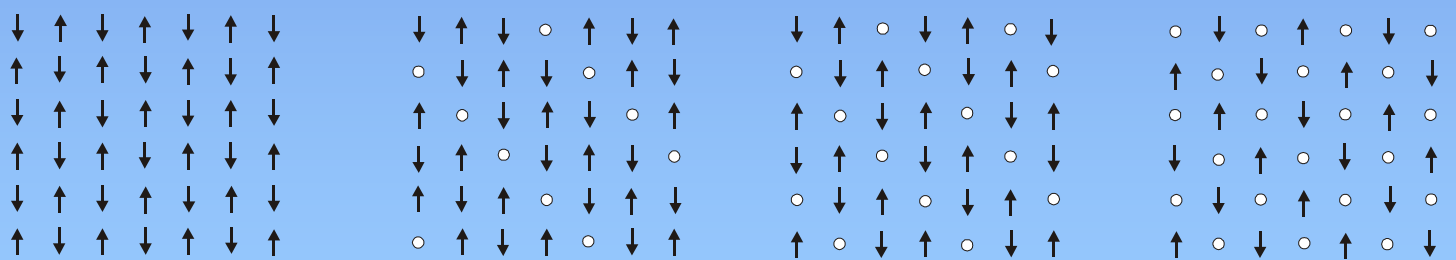
Stripe order in $La_{2-x}Sr_xNiO_4$

(Tranquada *et al*, Cheong *et al*, Yoshizawa *et al*)





$x = 0$ $x = 1/4$ $x = 1/3$ $x = 1/2$

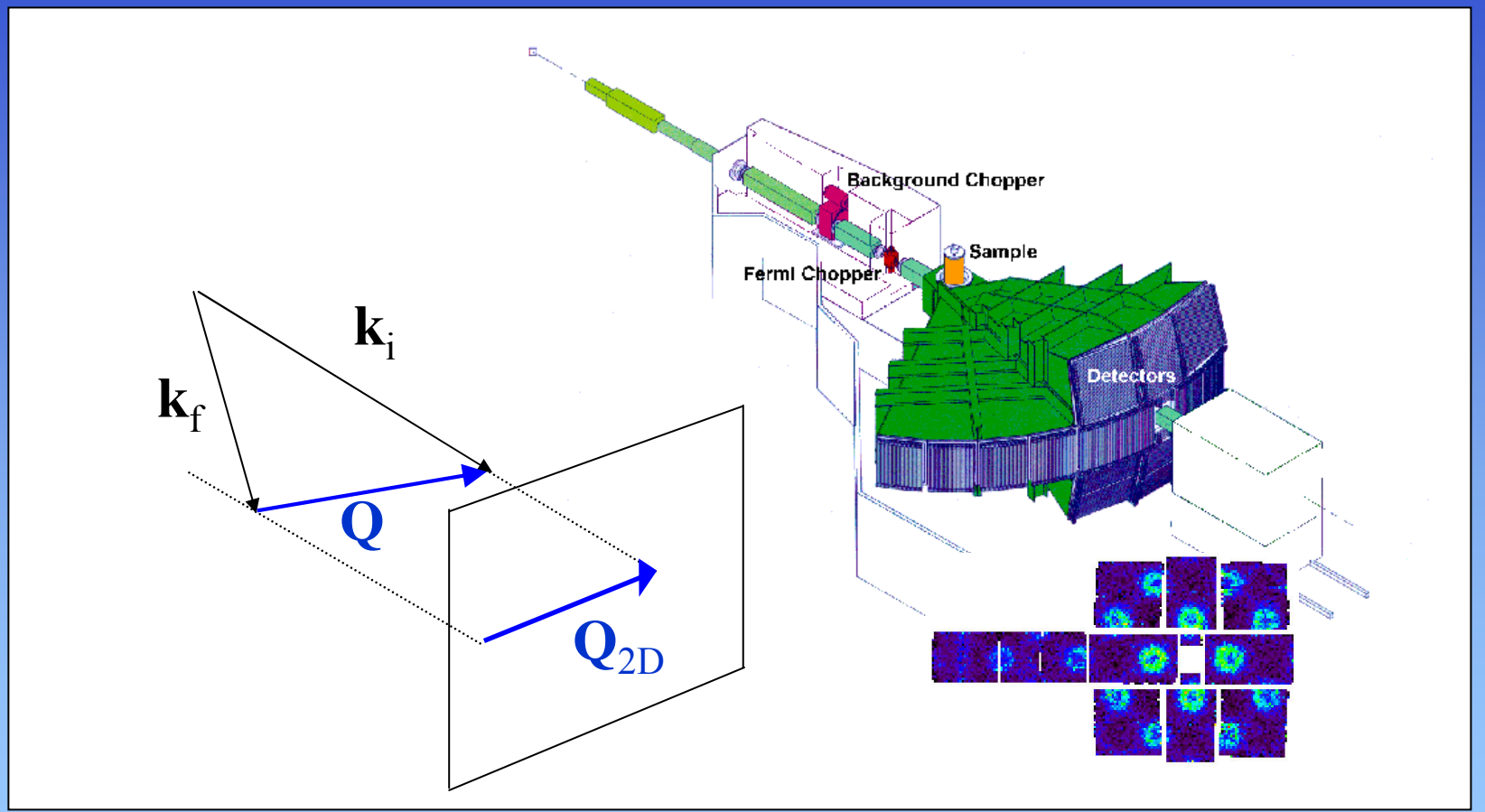


ideal stripe structures

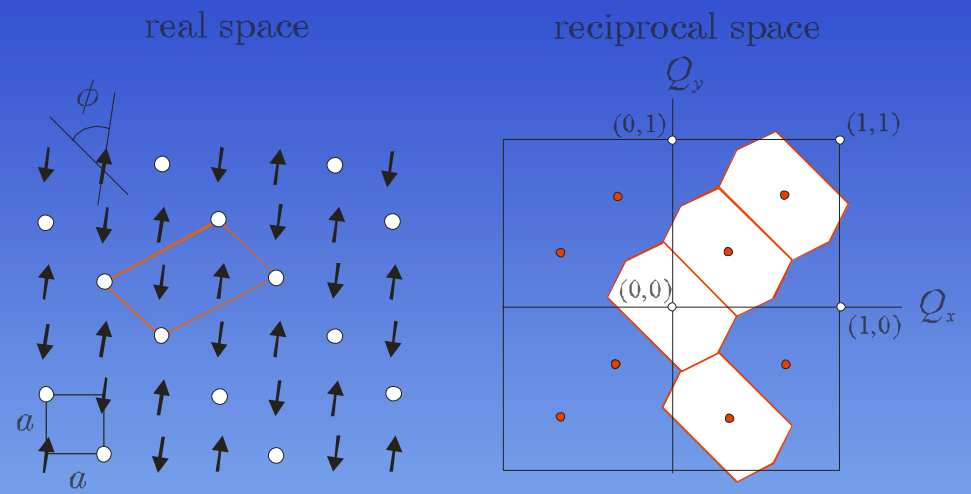
● Ni^{2+} ($S = 1$)

○ Ni^{3+} ($S = ½$)

MAPS neutron spectrometer at ISIS

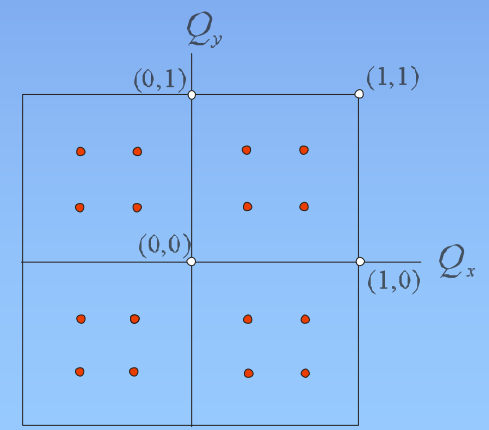


Spin and charge order in $La_{5/3}Sr_{1/3}NiO_4$

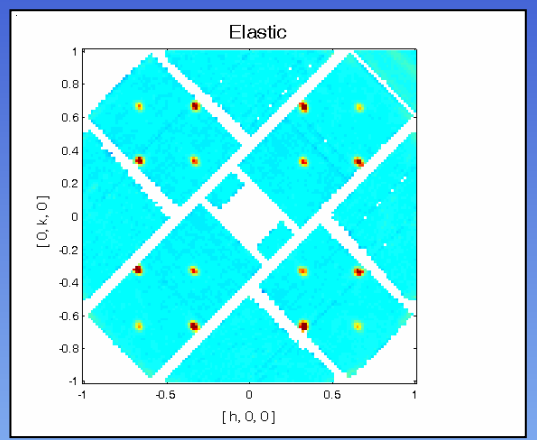


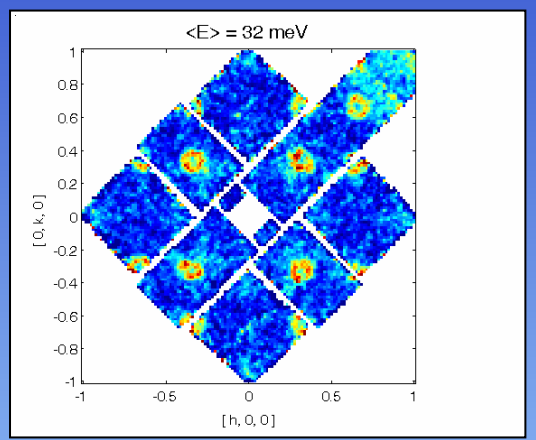
single crystal

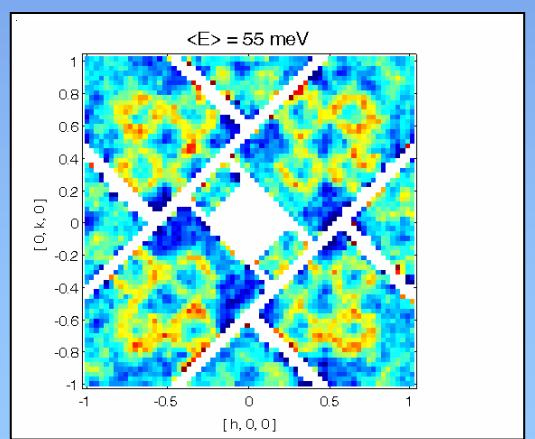
twinning

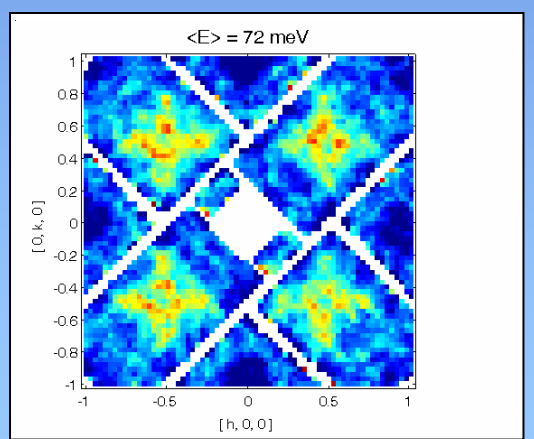


Data from MAPS spectrometer at ISIS



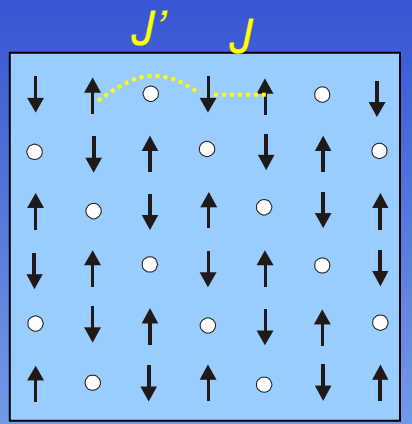




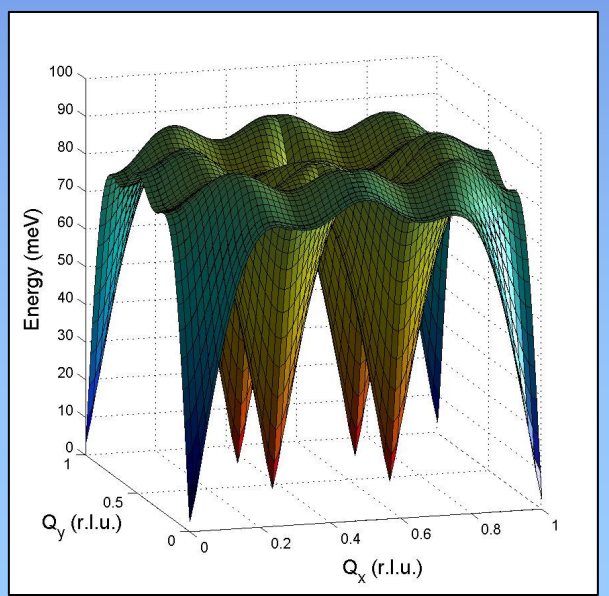


Spin wave model for $La_{5/3}Sr_{1/3}NiO_4$

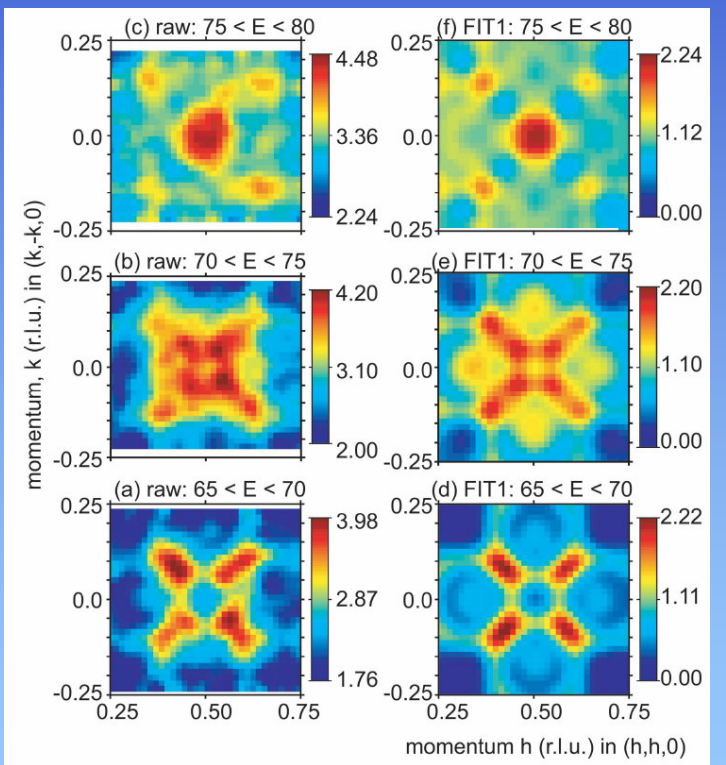
ATB *et al*. Phys. Rev. B **67**, 100407(R) (2003)
H. Woo *et al*. Phys. Rev. B **72**, 64437 (2005)



$J = 15 \pm 1.5$ meV
$J' = 7.5 \pm 1.5$ meV
$K_c = 0.07 \pm 0.01$ meV

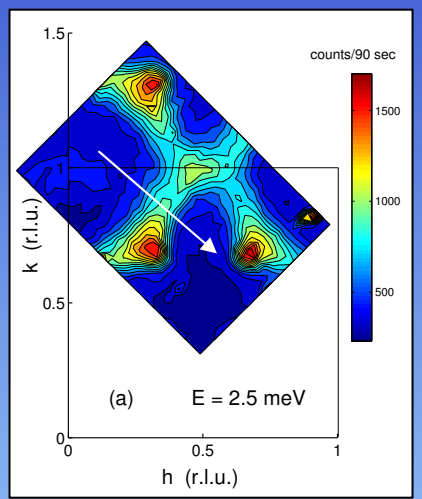


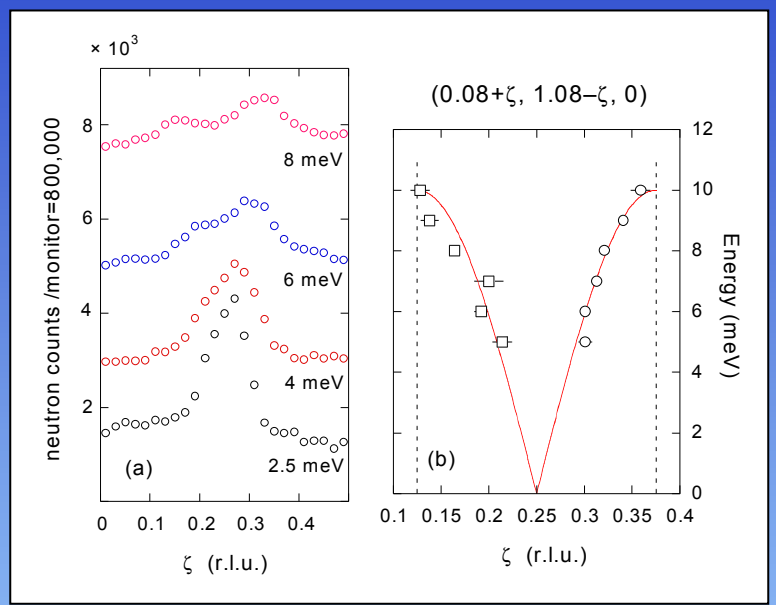
data model



Low energy quasi-1D spin fluctuation in $La_{5/3}Sr_{1/3}NiO_4$

Diffuse inelastic scattering

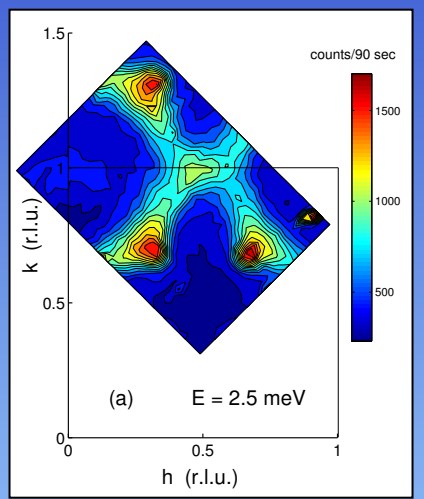




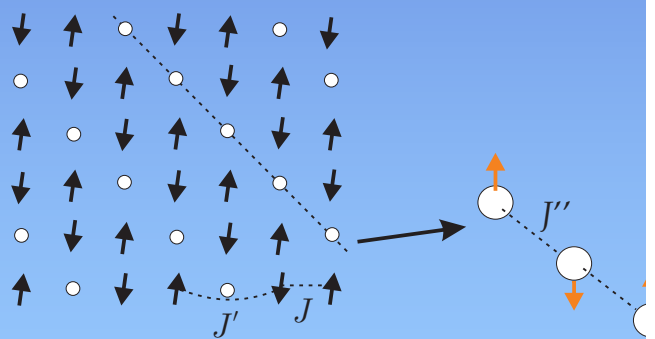
ATB *et* al., Phys. Rev. Lett. **91**, 257201 (2003)

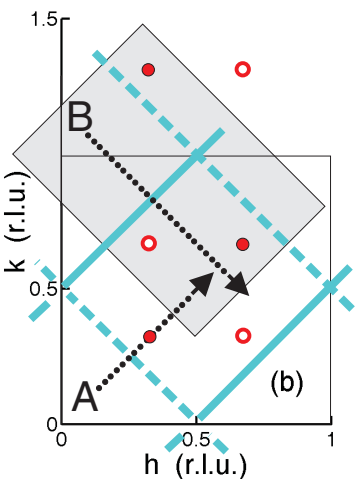
Low energy quasi-1D spin fluctuation in

Diffuse inelastic scattering



Consistent with quasi-1D
correlations along the ch



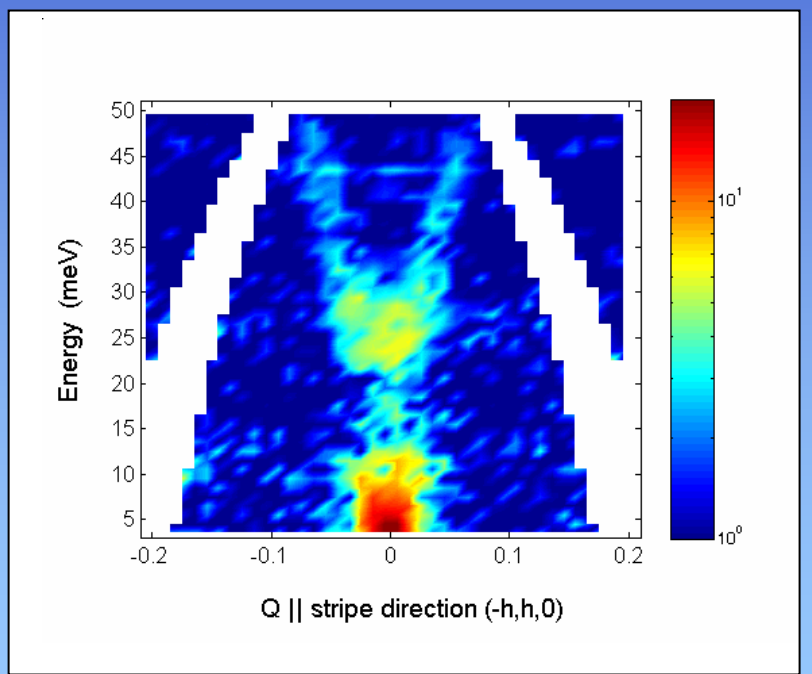


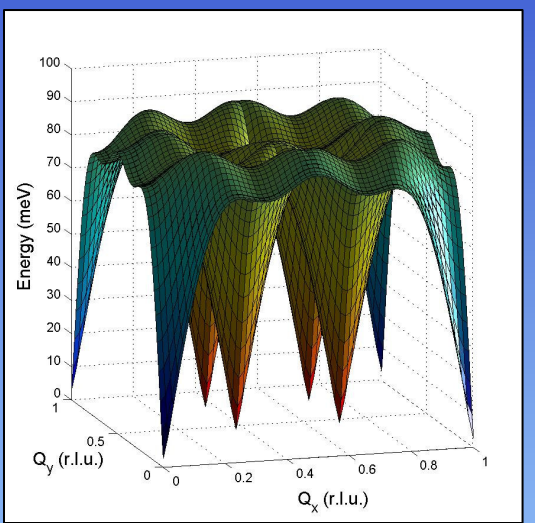
ATB *et* al., Phys. Rev. Lett. **91**, 257201 (2003)

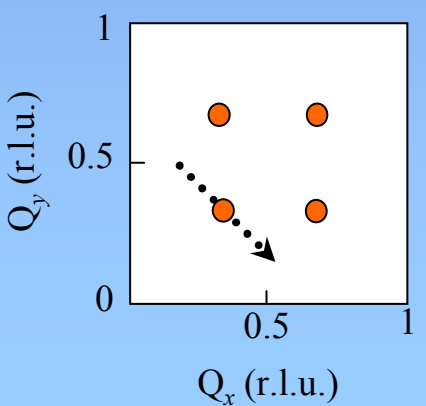
Mystery 'resonance-like' feature in spin excitation spectrum of $La_{5/3}Sr_{1/3}NiO_4$

ATB *et al*. Phys. Rev. B **67**, 100407(R) (2003)
H. Woo *et al*. Phys. Rev. B **72**, 64437 (2005)

unpolarized neutrons
(MAPS time-of-flight, RAL)







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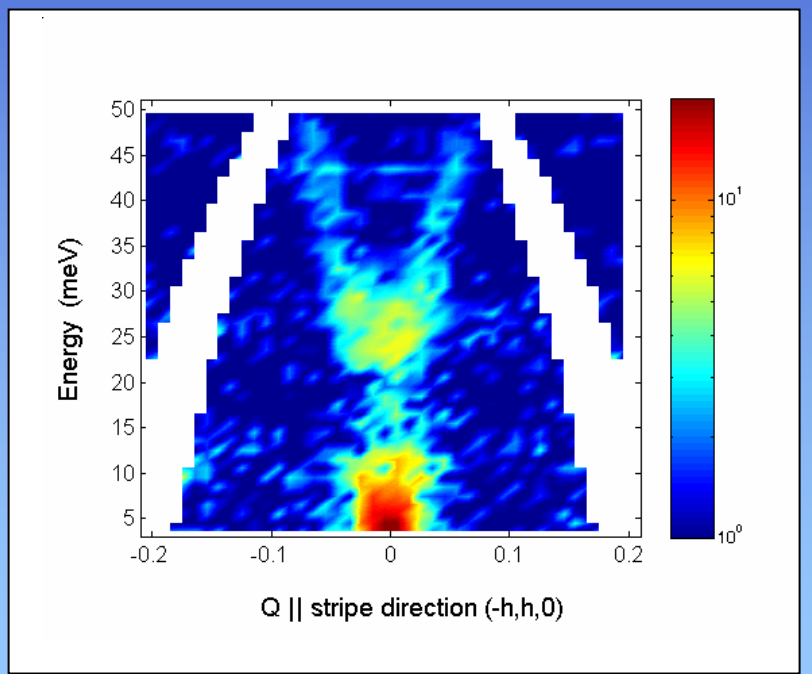
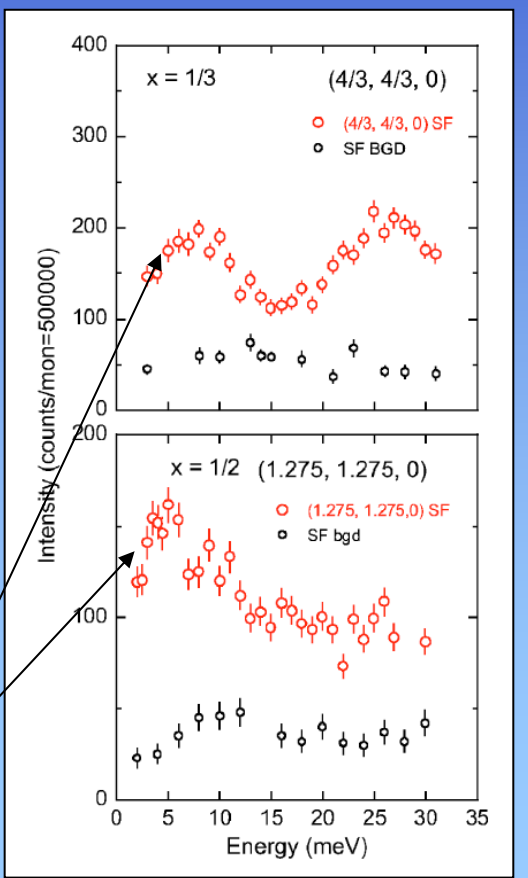


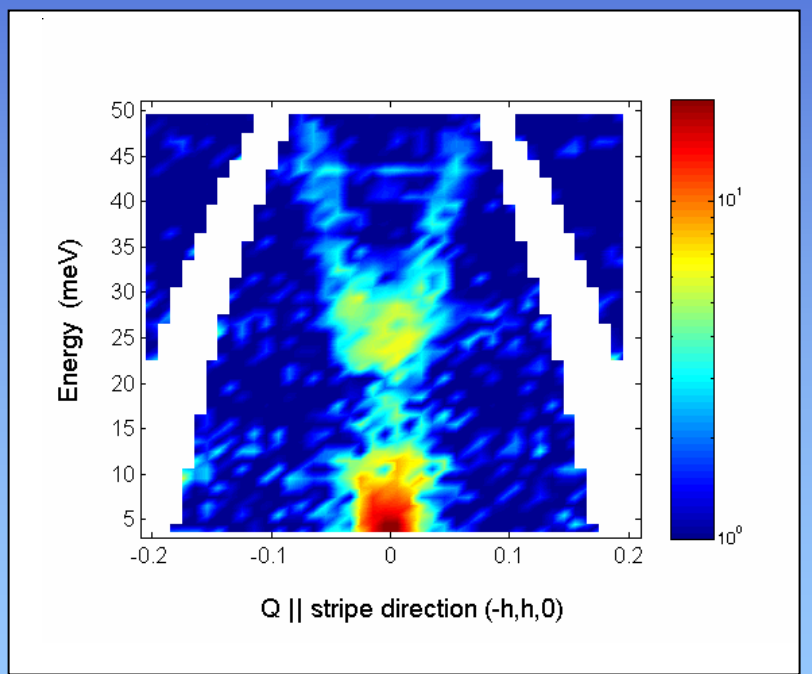
polarized neutrons
(IN20 triple-axis, ILL)



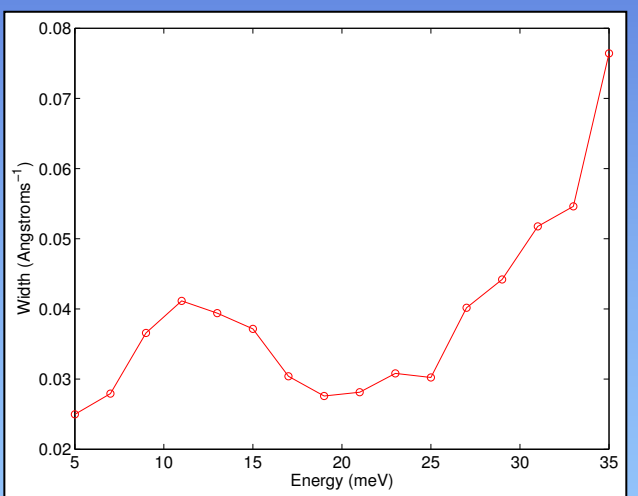
Out-of-plane
anisotropy gap

Mystery ‘resonance-like’ feature in spin excitation spectrum of $La_{5/3}Sr_{1/3}NiO_4$

ATB *et al*. Phys. Rev. B **67**, 100407(R) (2003)
H. Woo *et al*. Phys. Rev. B **72**, 64437 (2005)



Q width



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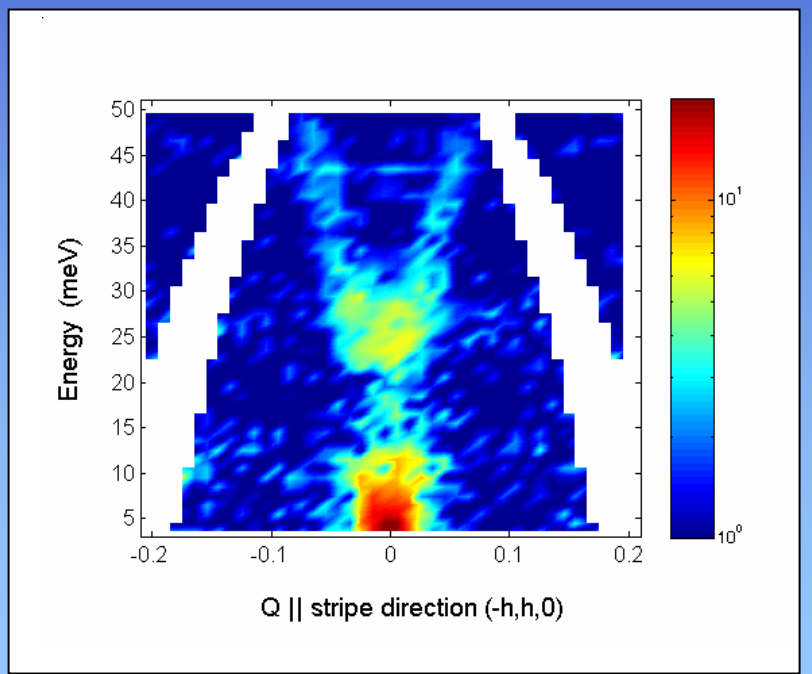
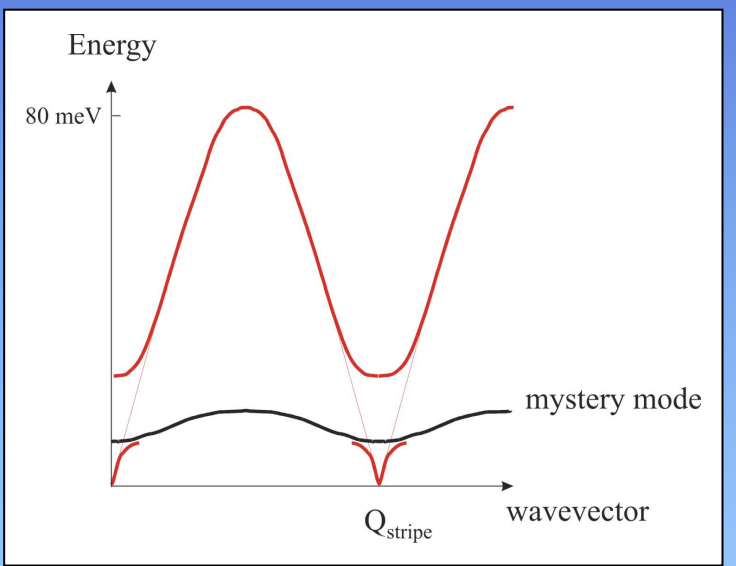
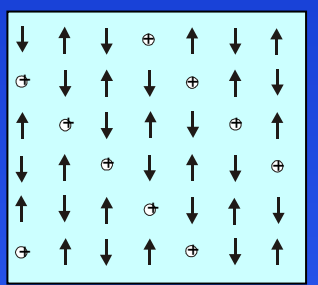




Summary

Stripe ordered nickelates:

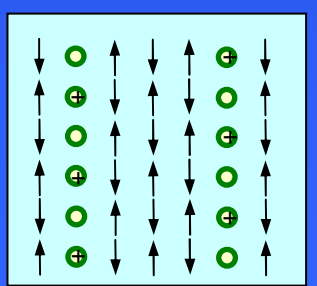
$La_{2-x}Sr_xNiO_4$



- High energy spin excitations: spin wave model
- Low energy 1D AFM correlations along stripes
- Resonant mode at 25 meV: origin?

Stripe ordered cuprates:

$(La,Nd)_{2-x}Sr_xCuO_4$



- Superconductivity-induced gap
- Magnetic order not affected by superconductivity
- Magnetic order and superconductivity coexist

collaborators

Paul Freeman Russell Ewings D. Prabhakaran [nickelate crystals]	Oxford University
Niels Christensen Johan Chang Henrik Rønnow Joel Mesot	PSI, Switzerland
Des McMorrow	UCL
N. Momono [cuprate crystals M. Oda [cuprate crystals]	Hokkaido Univ, Sapporo
Hyunje Woo John Tranquada	Brookhaven Nat. Lab.
Chris Frost Toby Perring	ISIS Facility
Mechthild Enderle Jiri Kulda Arno Hiess Anne Stunault	Institut Laue–Langevin,