XMaS the UK-CRG	**Experiment title: Incommensurate Charge order critical scattering in $La_{2-x}Sr_xNiO_4$ (x=0.2)**	**Experiment number**: 28-01-77/83
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Shifts: 18	**Local contact(s)**: Dr. S.D. Brown	*Received at XMaS:*

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Report:

The single crystal of $La_{2-x}Sr_xNiO_{4+\delta}$ with x=0.2(.01) used in this experiment was grown at the University of Oxford. Thermo-gravimetric data on the crystal indicated that the crystal has an oxygen content of δ=0.02(.01). The crystal was mounted having its [100] axis vertical and [010] axis in the sample surface directed to the incident beam. A Ge (111) single-crystal analyser was used in triple crystal geometry to obtain higher wave vector resolution and lower background. The sample was mounted in a closed cycle Displex cryostat and the sample mosaic width was determined to be ~0.03° (FWHM). The experimental resolution function measured at the Bragg reflection (4,0,–4) was ξ_H~0.00173Å^{-1}, ξ_K~0.00133Å^{-1}, and ξ_L 0.00346Å^{-1} at the low temperature. We observed charge ordering satellite reflections at (h±2ε,k,l) and the twin position (h,k ±2ε,l) with l being odd integer value in agreement with the proposed charge ordering wave vector q=(2ε,0,1) with ε=0.25 (not 0.20 as expected). Measurements were made on the (4.5,0,-3),(4.5,0,-5), and (4,0.5,–5) satellites in the temperature range 10-250K. The charge-ordering transition temperature depends on the hole concentration n_h=x+δ. In x=0.33 this transition occurs at ~240K [1] and in x=0.225 at ~150 K [2]. The intensity of the charge ordered satellites is very weak (about 10 cps.), much weaker than the commensurate x=0.33 sample. This made it difficult to detect charge stripe satellites and impossible to detect spin stripe satellites, expected to be ~100 times weaker than the charge stripe reflections.

The intensity of the charge-order satellite (4.5,0,-5) as a function of temperature is shown in Figure 1, the other peaks behaving similarly. Neutron diffraction measurements by Lander *et al.* [3] have showed the transition temperature from the high-temperature tetragonal (*I4/mmm*) phase to a low-temperature orthorhombic (*Bmab*) structure occurs at 120 ± 5 K. Another feature of Figure 1 is the decrease of the

intensity below 50 K. The reason for this is not yet clear, but it probably indicates a decrease in the amplitude (electron density difference) between the stripes. Figure 2 shows the width (FWHM) of the charge satellite (4.5,0,-5) as a function of temperature. The width in the *L* direction has been added to the graph with a reduced scale to allow comparison with the width in the *a*-*b* plane. The width starts to increase at around 100 K, above 120 K corresponding to critical fluctuations of the charge ordering. The minimum width (longest correlation length) is found at 60 K, corresponding to the greatest intensity of Figure 1. Below this temperature the width increases, probably due to spin order, which frustrates the charge stripe order. The correlation lengths are very short (less than 40 Å) even around 60 K. The correlation length along the *L* direction is of the order of the lattice spacing indicating a charge stripe glass. These results are significantly different to those of the commensurate (x=0.33) material, suggesting a complex series of behaviour with stoichiometry.

The incommensurability against temperature is displayed in Figure 3. The incommensurability has a very complicated behaviour. Its line shape exactly follows the intensity and width. It is nearly constant only in a very short temperature range, indicating stability of the charge stripes in this range. The small deviation from 0.25 is due to the small amount of the excess oxygen from the stoichiometry. Sachan *et al* [4] mentioned that the value of ε is almost exactly ¼ but our results show the commensurate value 0.25 is only approached in the temperature range 35 – 70 K. Above and below this range there is a general trend to be incommensurate with a wave vector greater than 0.25. Our results especially at low temperatures are different with the published neutron results on this sample.

References

1 C–H. Du, P.D. Hatton *et al* . Phys. Rev. Lett. 84, 3911, 2000

2 J.M. Tranquada *et al*. Phys. Rev. B, 54, 12318, 1996

3 G.H. Lander *et al*. Phys. Rev. B, 43, 448, 1991

4 V. Sachan *et al*. Phys. Rev. B, 51, 12742, 1995

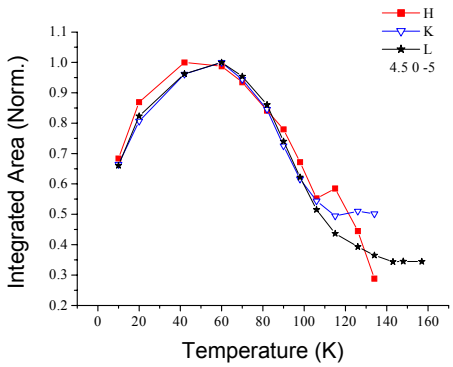

Figure 1

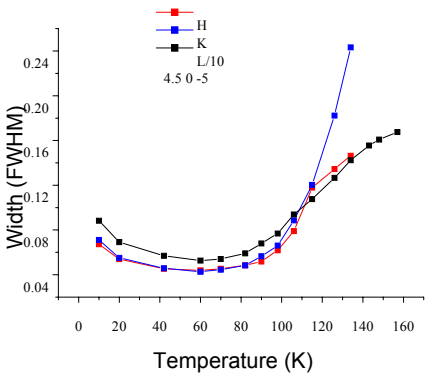

Figure 2

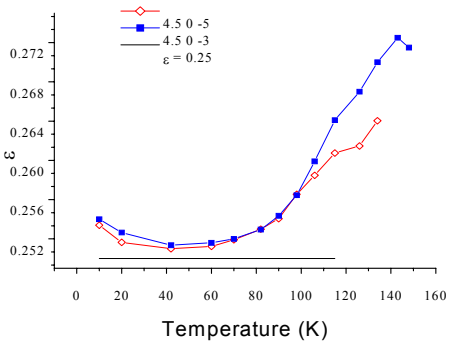

Figure 3