ESRF	**Experiment title:** Role of strain on charge and orbital ordering in $La_{1-x}Sr_xMnO_3$.	**Experiment number:** He-611
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Report (preliminary):

During this experiment we studied two epitaxial thin films of $La_{1-x}Sr_xMnO_3$. The films were grown on $SrTiO_3$ substrates by pulsed laser ablation and have a mosaic spread of ~ 0.02°. The first film was grown on a (100) oriented substrate and was 3600Å thick. The composition of the film was $La_{0.875}Sr_{0.125}MnO_3$ The second film was grown on a $(110)_c$ oriented substrate and was 1000Å thick (subscript c stands for cubic, o for orthorhombic). The composition of the film was $La_{0.9}Sr_{0.1}MnO_3$. Bulk $La_{0.875}Sr_{0.125}MnO_3$ adopts an orthorhombic Pbnm structure from far above room temperature down to below 10K[1]. At room temperature it shows a small orthorhombicity which increases by a factor of ten when it undergoes a Jahn-Teller (JT) order transition at T=270K. At145K the orthorhombicity decreases again because of a charge order transition at which the Mn^{3+} /Mn^{4+} ions order [1-3]. As is known from electron diffraction, films on $(100)_c$ oriented substrates grow with a $(001)_o$ surface normal (Pbnm notation), whereas films on $(110)_c$ grow with a $(100)_o$ orientation, which is equivalent to $(110)_c$ pseudocubic[4]. $SrTiO_3$ is a perfect cubic perovskite with lattice parameter 3.905Å. The measured lattice parameters of the film are a=b=3.905 Å and c=7.77 Å. Orbital order was successfully measured at the "forbidden" $(003)_o$ reflection. This was the first time that orbital ordering was measured in thin films and also along the $(00l)_o$ direction. The features characteristic of resonant scattering from orbital ordering[5] were observed. Strong enhancement at the Mn-K absorption edge, rotation of the polarization of the scattered radiation by 90° with respect to the incident one, but no oscillatory azimuthal dependence. Temperature dependence of the $(003)_o$ reflection is shown in Fig.1. From the figure we can observe that the orbital ordering transition is clearly second order in the film, while it is first order in the bulk. The orbital

ordering transition temperature in the bulk is T_{OO}=270K, while in the film intensity is still present at T=300K. Very weak intensity was found at certain positions with reduced wave vector $(0.25,0.25,0)_o$ and $(0,0,0.5)_o$, corresponding to the bulk positions. The intensities were so weak, that they have to be collected in a separate experiment. Resolution limited diffraction peaks were found at $(0.5,0.5,4)_o$ and $(0.5,0.5,3)_o$. The temperature dependence of the $(0.5, 0.5,4)_o$ peak is reported in Fig.2. The temperature dependence is somewhat reminiscent of the bulk charge order temperature dependence for x=0.11, which undergoes a strong 1st order transition at 122K [2,6], whereas for x=0.125 it occurs at 145K [4]. The origin of this reflection in not completely understood at the moment, and further experiments are in progress to characterize in detail the crystal structure, including tilting and distortions of the octahedra.

The second film was studied briefly, in order to determine if the azimuthal dependence of the orbital ordering is dependent on the particular orientation of the film. The interesting result is that indeed on a $(110)_c$ oriented substrate the orbital ordering of the film shows the same oscillatory azimuthal dependence as reported previously on bulk studies[6,7] (Fig.3). The line in fig. 3 is a first fit of the peak intensity of $(300)_o$ to $\sin^2(\psi)$, ψ being the azimuthal angle. Data analysis and theoretical calculations are in progress to account for this phenomenon.

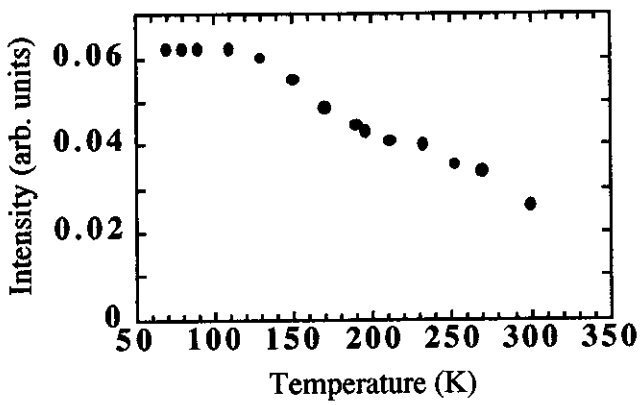

Fig.1. Temperature dependence of the $(003)_o$ orbital ordering peak.

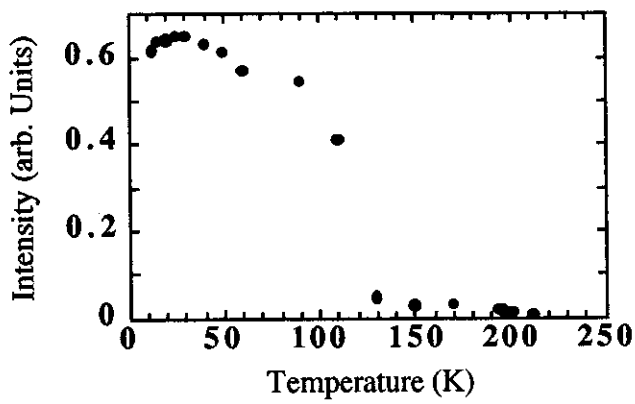

Fig.2. Temperature dependence of the $(0.5,0.5, 4)_o$ diffraction peak.

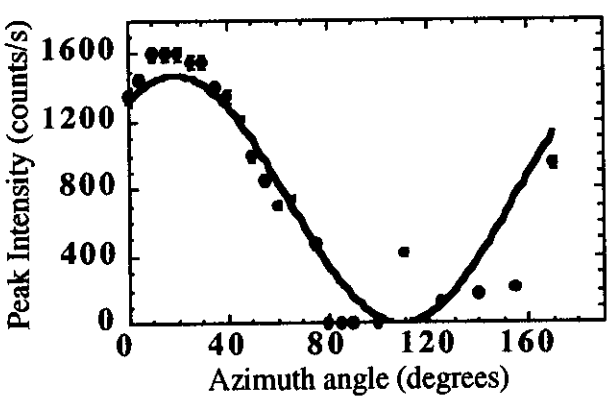

Fig.3. Azimuthal dependence of $(300)_o$ of the $(110)_c$ oriented film

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