ESRF	**Experiment title:** The effects of anisotropic strain at the Mn sites in ultrathin $La_{0.7}Sr_{0.3}MnO_3$ thin films	**Experiment number**: HE-1957
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Report:

The aim of our experiment was to study the effect of the strain induced by the substrate on the electronic properties on $La_{0.7}Sr_{0.3}MnO_3$ (LSMO) thin films. We used X-ray Absorption Spectroscopy (XAS) and Resonant Inelastic X-ray Scattering (RIXS) measurements. The change in the MnO_6 octahedra distortion (out-of-plane compression in case of $SrTiO_3$ substrate and elongation in case of $LaAlO_3$ substrate) influences the *3d* states population, which can be monitored by linear dichroism (LD) in XAS. Moreover the variations in the Mn-O distances induced by the strain can affect the *dd* excitation energy and the degree of hybridization of Mn *3d* and O *2p* states, thus modifying the RIXS spectra.

First of all, we recorded LD-XAS spectra at the Mn L-edge and O K-edge, by using two orthogonal linear polarization, vertical (V) and horizontal (H), of the synchrotron radiation with an incident angle of 20° from the sample surface. We measured 4 LSMO films grown on STO with the same thickness but different degree of oxygenation, 7 fully oxygenated LSMO films grown on STO and 4 on LAO with different thickness, 2 LSMO films grown on STO with Nb and $SrRuO_3$ buffer layers. In addition we measured as a reference the pure STO and LAO substrates and a MnO bulk single crystal. In figure 1 (left panel) we show the results at Mn L-edge of LSMO films with a thickness of 100 unit cells (u.c.) and different oxygenation, as deduced by the different metal-insulator transition temperatures (T_{MI}). Moreover, on the right panel of figure 1 we show the results obtained on LSMO films on LAO, optimally oxygenated and with different thickness. The different LD behaviour in case of STO and of LAO is a consequence of the different preferential occupation of the x^2-y^2 and the $3z^2$-r^2 orbitals, respectively. Those results are confirmed by the spectra recorded at the O K-edge and they are in agreement with our theoretical calculations. Details of this study are reported in the paper we have recently published [C. Aruta, G. Ghiringhelli, A. Tebano, N.G. Boggio, N.B. Brookes, P.G. Medaglia and G. Balestrino, Phys. Rev. B **73**, 235121 (2006)]. In addition, we have submitted for publication a manuscript where we explain the intensity behaviour of the LD spectra as a function of thickness in the framework of strain driven competition and nano-scale coexistence of the orbital ordered $3z^2$-r^2 antiferromagnetic-insulating and the orbital disordered ferromagnetic metallic phases.

Furthermore, we have studied the *dd* and charge transfer excitations of $LaMnO_3$ (LMO, bulk single crystal cleaved in air) and on two selected LSMO thin films (100 u.c. thick) grown on LAO (LSMO324) and on STO (LSMO286) substrates. We have measured RIXS spectra excited at 3 different energies below the main

L_3 peak of Mn, in the region where the emission spectra have a predominant Raman character. The F excitation is on the main L_3 peak, excitations E and D are 1 eV and 2 eV below excitation F, respectively.
The combined energy resolution measured from the elastic peak was 450 meV: we had to reduce the resolving power of the instrumentation for intensity reasons, but for LMO we could check that with 320 meV resolution no clear sharpening of the spectra features could be observed. All the measurements were made at room temperature.

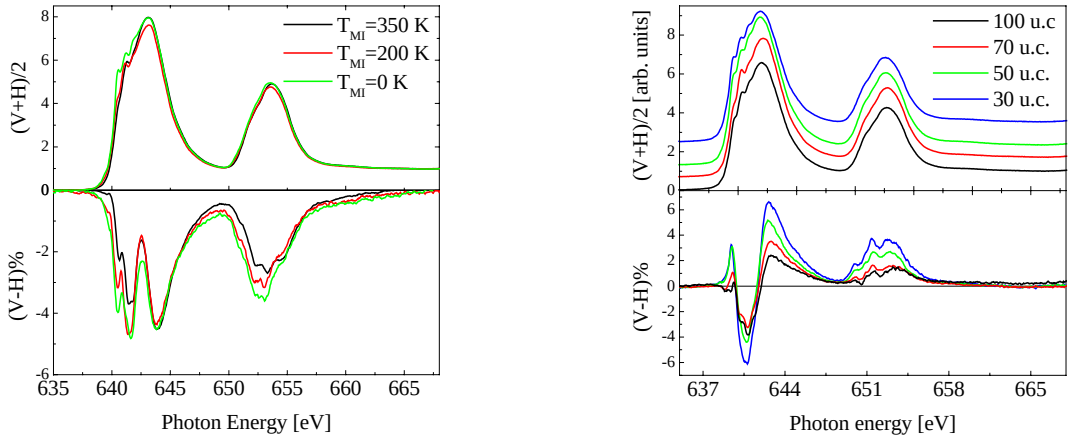

FIGURE 1 Average between experimental XAS signals taken in V- and H-polarizations (V+H)/2 and LD=V-H spectra in percent of the absorption data of LSMO strained films.

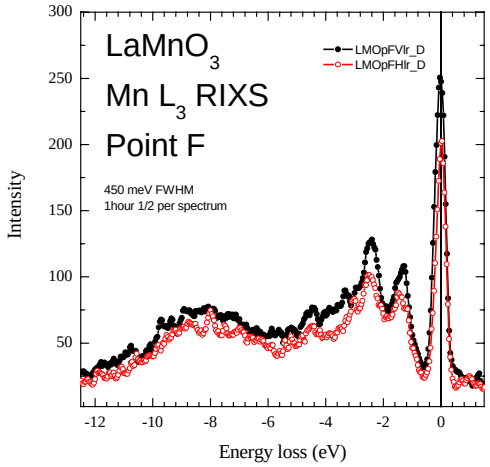

FIGURE 2: The RIXS spectra of LMO as excited on the main L_3 peak of Mn. The *dd* excitations dominate the energy interval from 0 to 6 eV loss, whereas charge transfer excitations and fluorescence characterize the 6 eV to 12 eV range. The black and red curves correspond to linear polarization of the incident photons perpendicular and parallel to the scattering plane respectively.

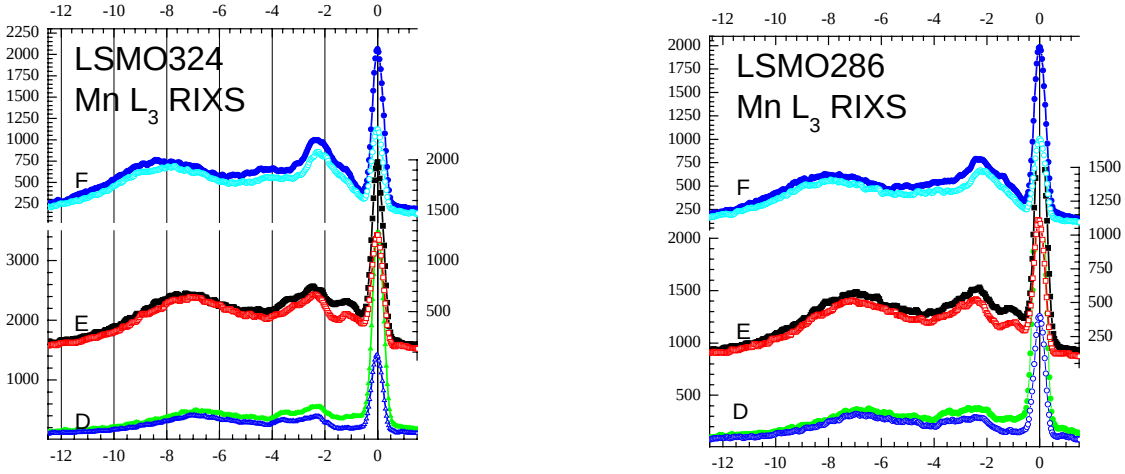

FIGURE 3: The RIXS spectra of LSMO films measured with three different excitation energies and with two linear polarizations. We can notice that the spectra are very similar in shape, indicating that only minor differences in the average crystal field of Mn^{3+} ions correspond to the different strain conditions. On the other hand we can notice that in the film grown on LAO the *dd* features are sharper and stronger than in in that grown on STO, indicating a lower degree of hybridization and a higher localization of the 3*d* states. On the other hand both LSMO samples give RIXS spectra rather similar to those of LMO (insulating antiferromagnetic material), but characterized by broader features and higher intensity of the charge transfer/fluorescence peak.