Transport phenomena and magnetic crystalline Structure of Manganites

Project Coordinator

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Team Work

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Outline

1 Introduction

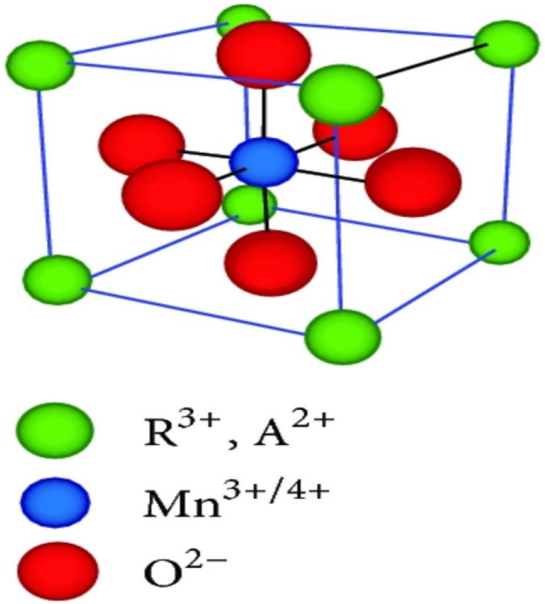
2 Objectives

3 Equipment Description

4 Results

5 Conclusion

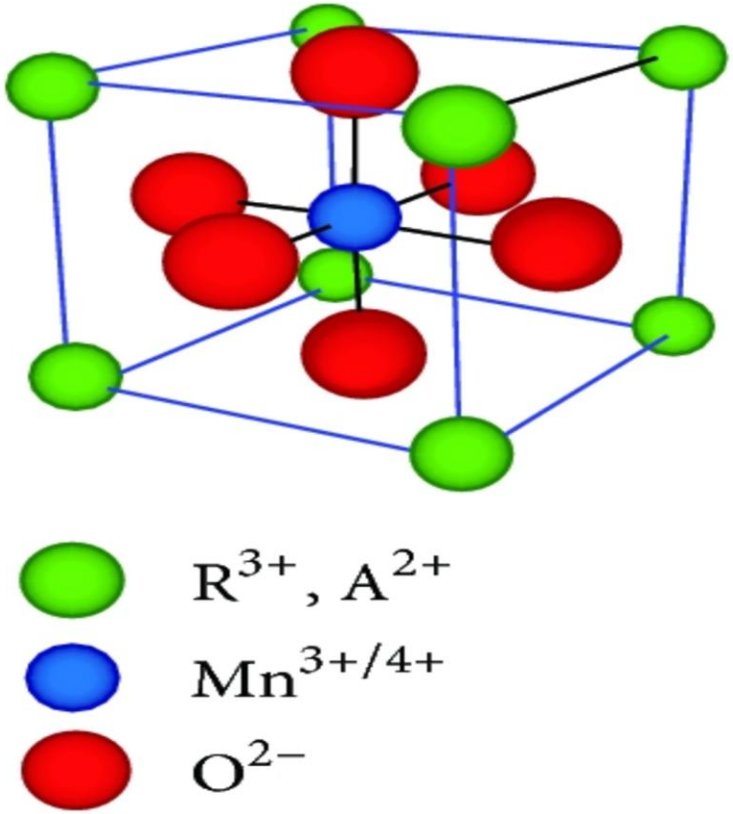
Perovskite Structure



$CaTiO_3$

- ✓ **A cations (*Ca*)**
- ✓ **B cations (*Ti*)**

Manganites



$R_{1-x}A_xMnO_3$

R rare-earth cation

A alkali or alkaline earth cation

Objectives

- ✓ Structural analysis of manganites using XRD
- ✓ Investigate the magnetic and transport phenomena of manganites using VSM and four point probe

$La_{0.7}Ca_{0.3-x}Sr_xMnO3$ Preparation

1. Weighting of the sample

2. Milling and Grinding

3. Temperature treatment at (800 °C)

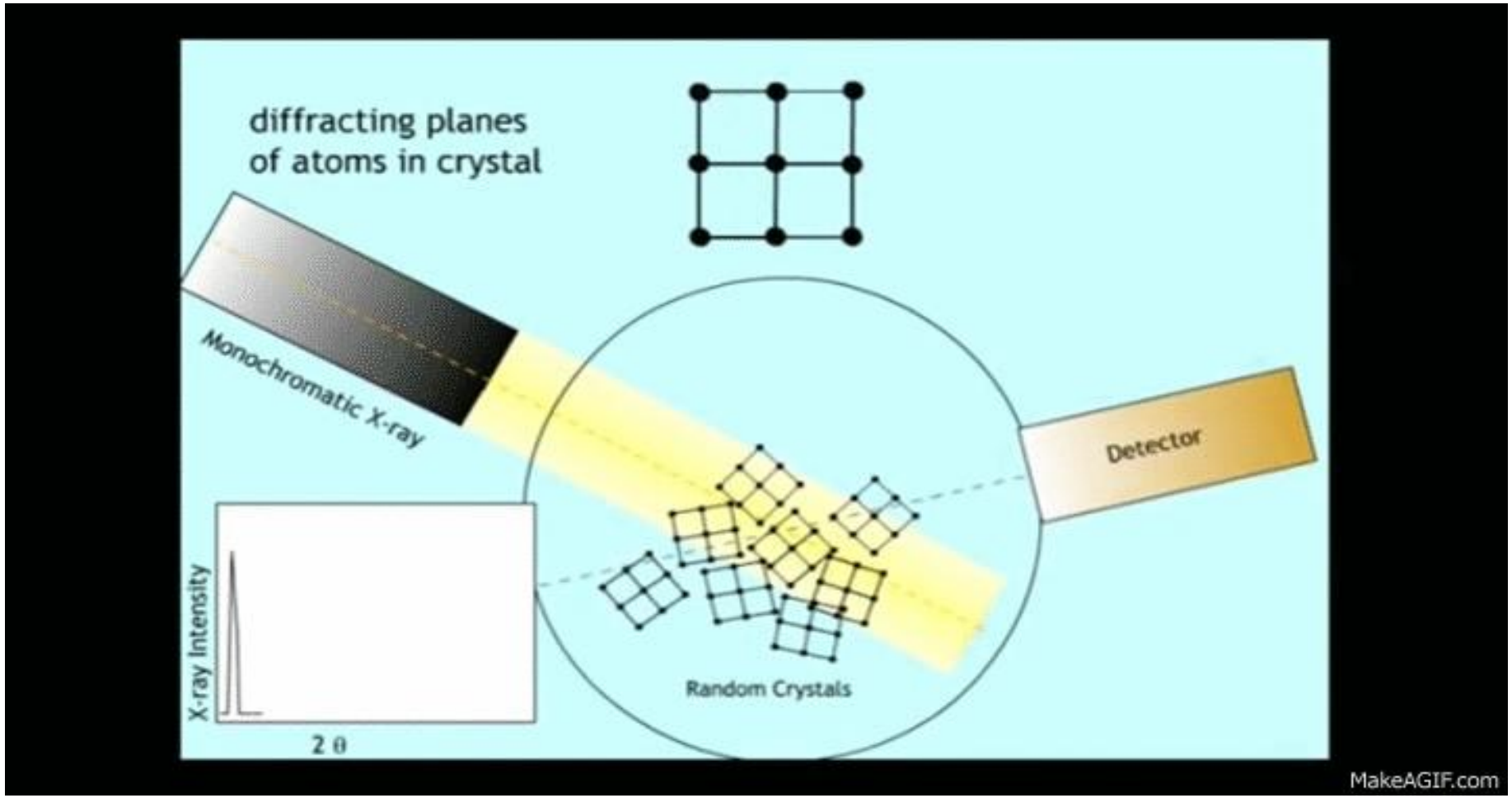
4. Preliminary investigation by XRD

5. Higher temperature sintering (1200 °C)

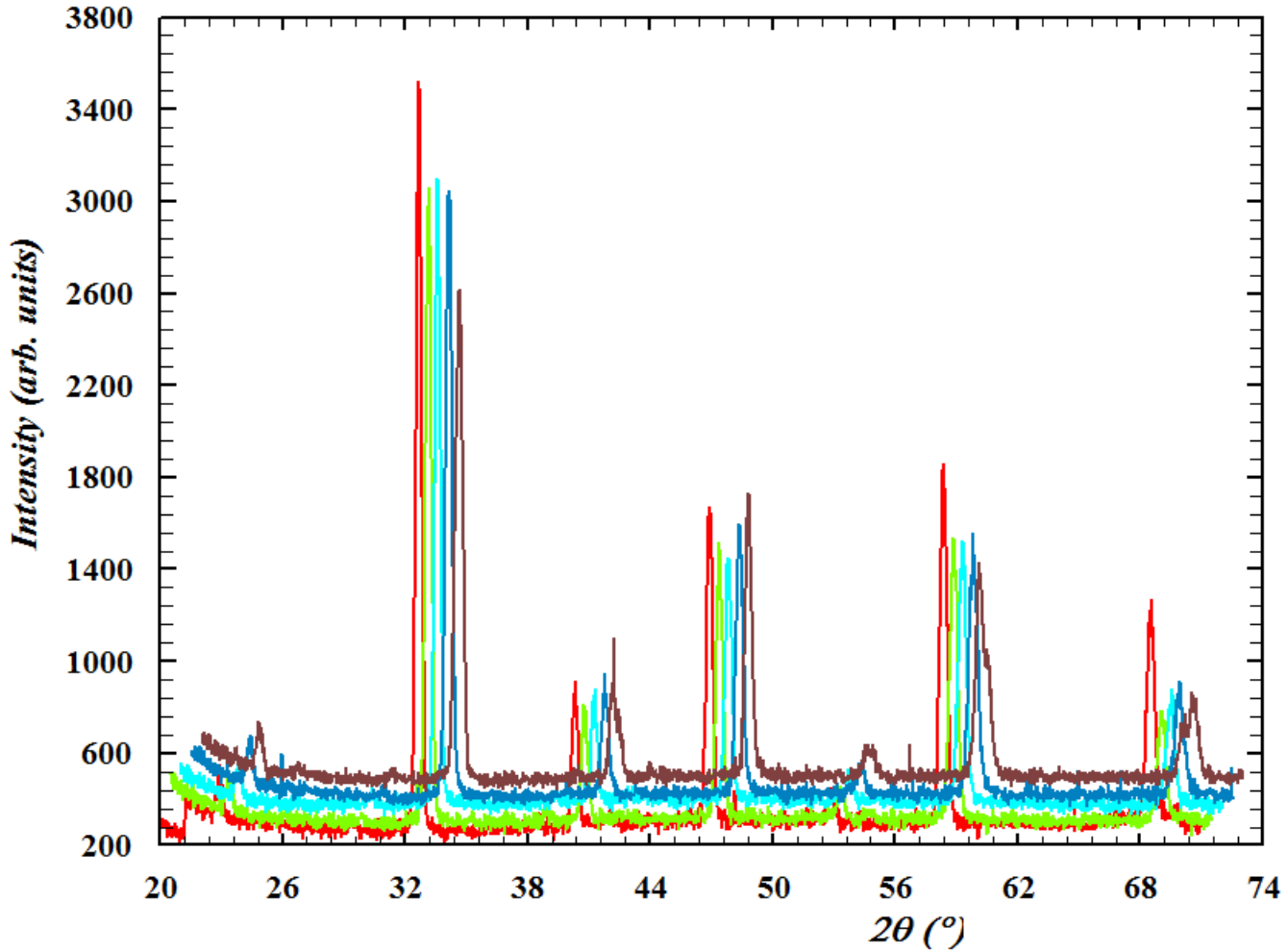
Calculation of the precursors necessary to obtain the $La_{0.7}Ca_{0.3-x}Sr_xMnO_3$ (LCSMO) manganites

x	m_{La2O3}	m_{CaCO3}	m_{SrCO3}	m_{Mn2O3}	Σ	m_{LCSMO}
0.03	5.081	1.204	0.197	3.517	224.42	9.999
0.06	5.049	1.064	0.392	3.495	225.849	10
0.09	5.017	0.925	0.585	3.473	227.275	10
0.12	4.986	0.788	0.775	3.452	228.701	10.001
0.24	4.865	0.256	1.512	3.368	234.407	10.001

X-Ray diffraction



XRD of $La_{0.7}Ca_{0.3-x}Sr_xMnO3$



The difractograms of the sintered samples. The red difractogram belongs to the sample corresponding to x=0.03, while the brown difractogram correspond to x=0.24

Software Programs

- ✓ Full Prof suite code
- ✓ Cristalographica
- ✓ CelRef3
- ✓ Powder cell

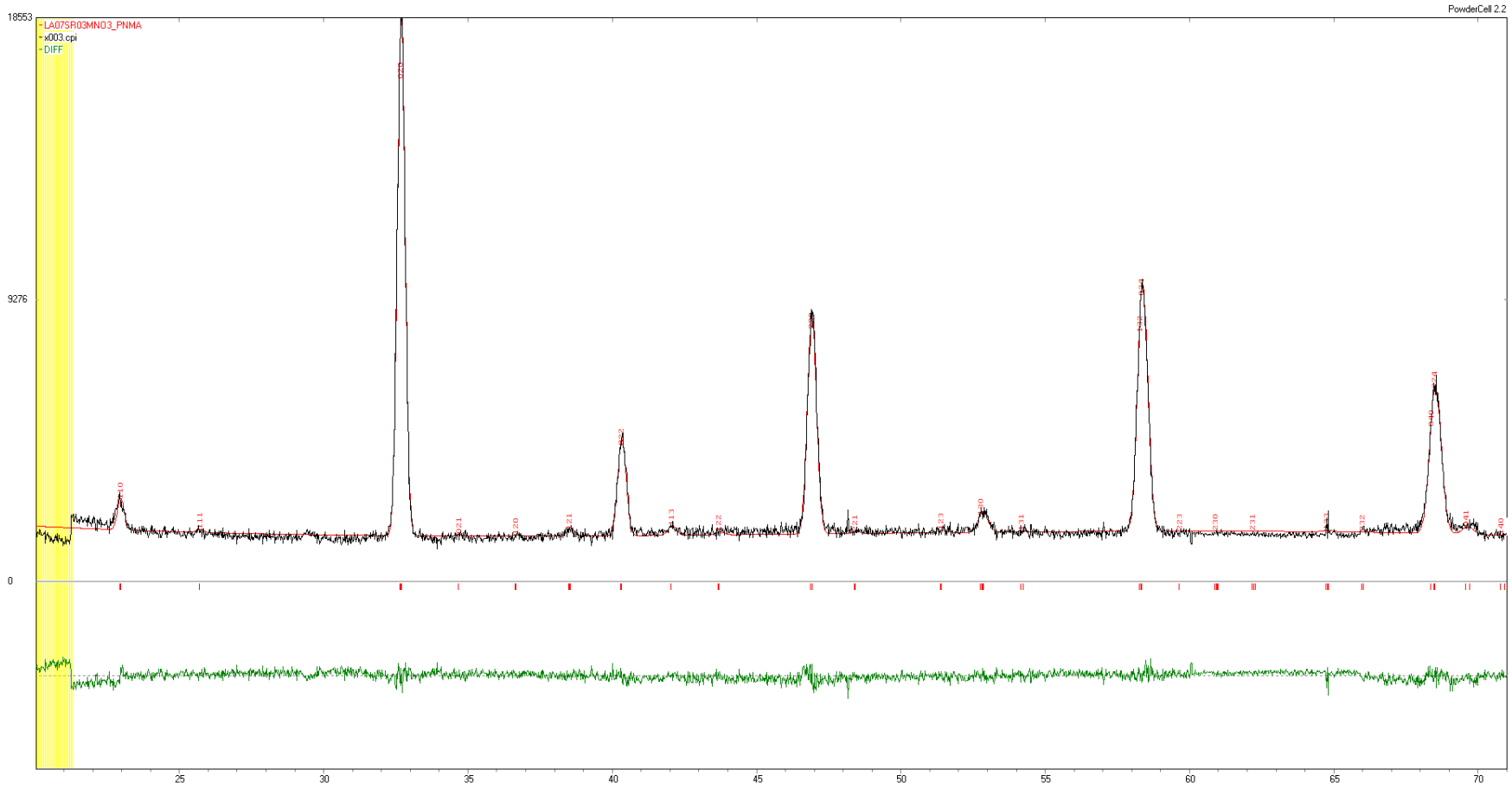
→ Structure Refinement

- ✓ MolCal

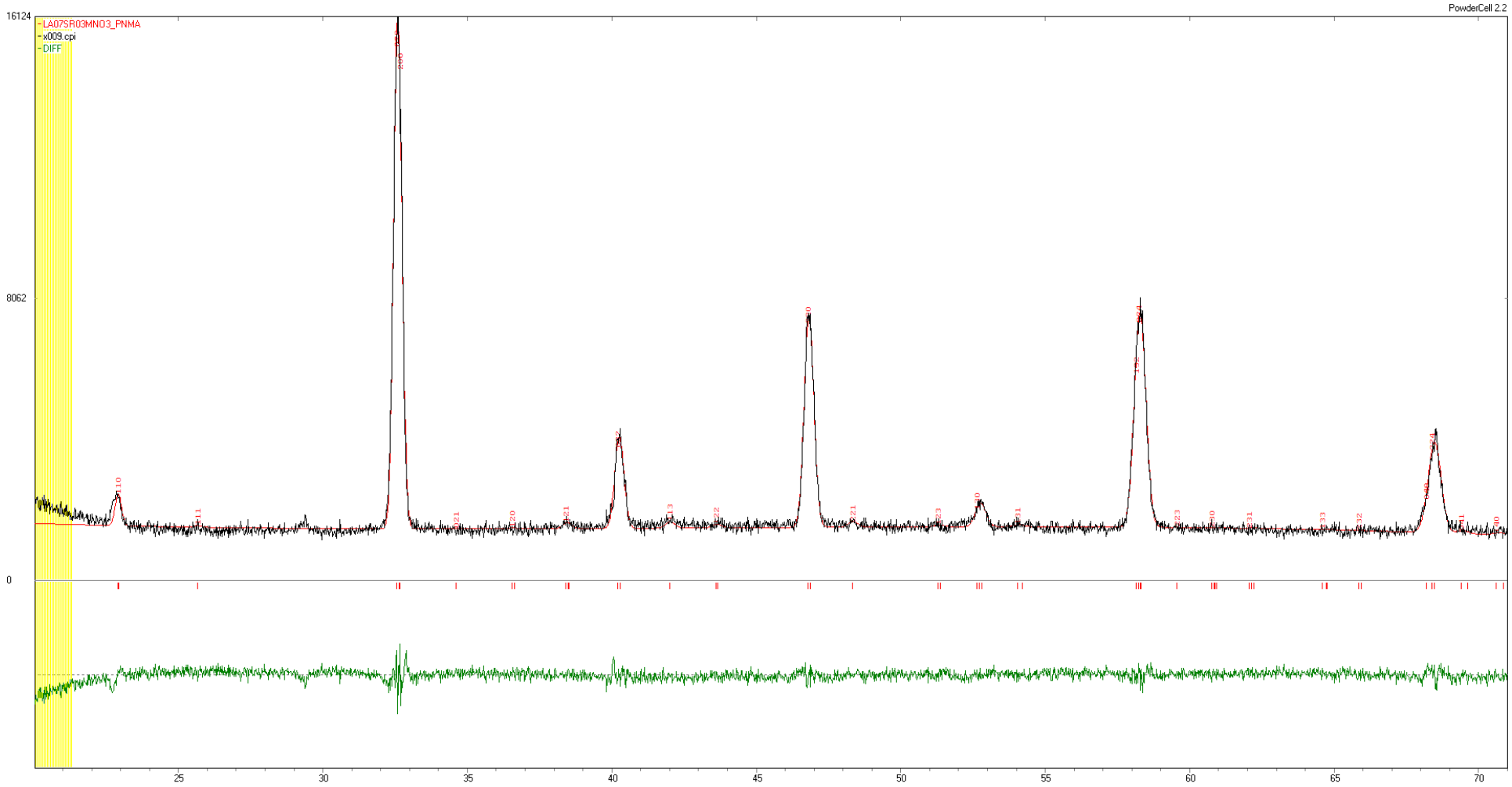
→ Molecular weight Calculation

The variation of the lattice parameters (a, b, c), average size of mosaic blocks (D) and of microstrains (ε) with Sr concentration (x) in $La_{0.7}Ca_{0.3-x}Sr_xMnO3$

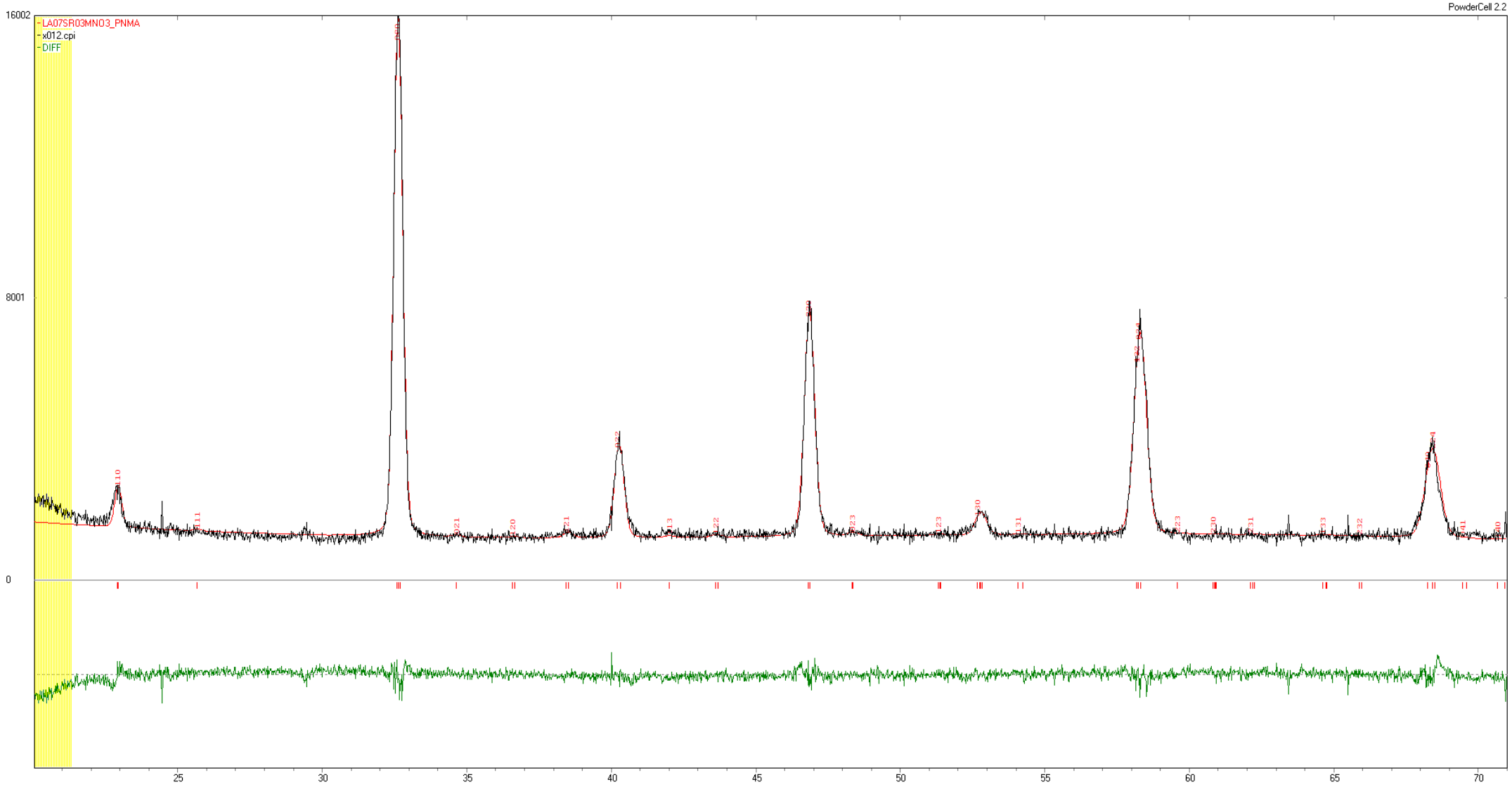
x	a(Å)	b(Å)	c(Å)	v(A3)	D(Å)	ε	GS (Space group)
0.03	5.4745	5.4844	7.7394	232.3704	447	0.0014	Pbnm
0.06	5.4722	5.4890	7.7397	232.4766	430	0.0015	Pbnm
0.09	5.4774	5.4974	7.7452	233.21903	516	0.0019	Pbnm
0.12	5.4748	5.4926	7.7482	232.9952	491	0.0023	Pbnm
0.24	5.5018	5.5018	13.3495	349.9497	311	0.0010	R3C



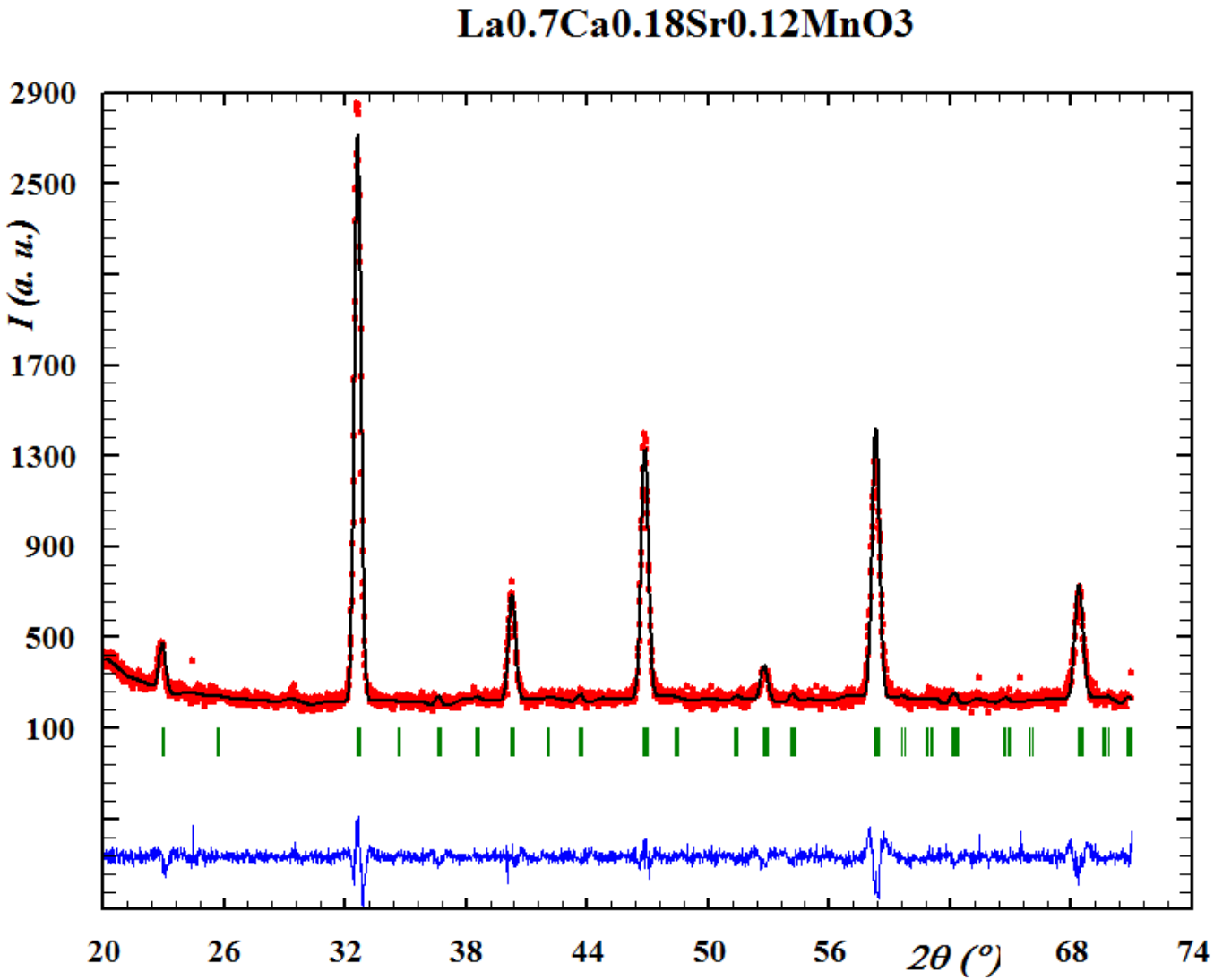
The observed (black), calculated (red) and the difference between the observed and calculated difractogram for x=0.03 (PowderCell)



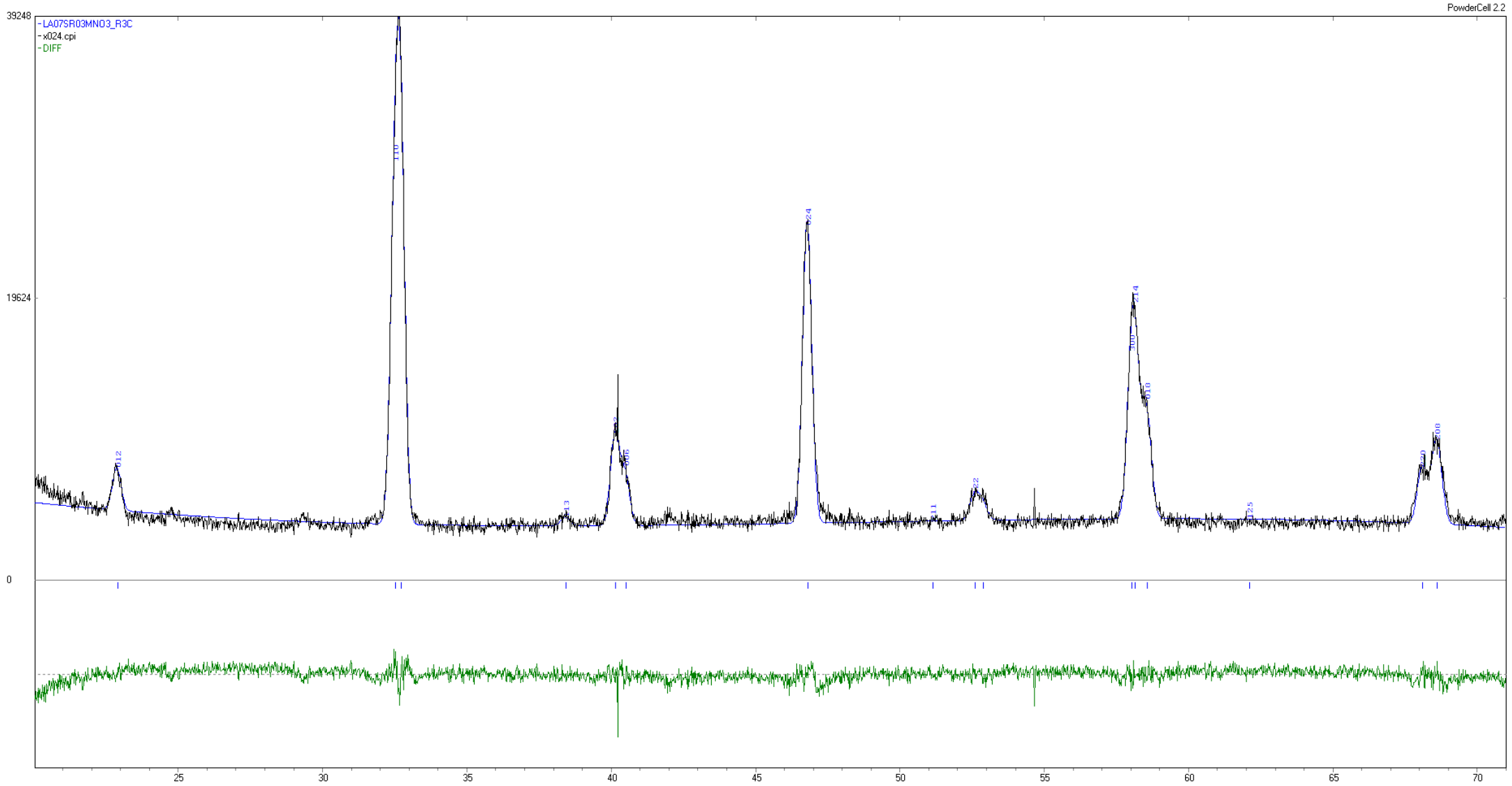
The observed (black), calculated (red) and the difference between the observed and calculated difractogram for x=0.09 (PowderCell)



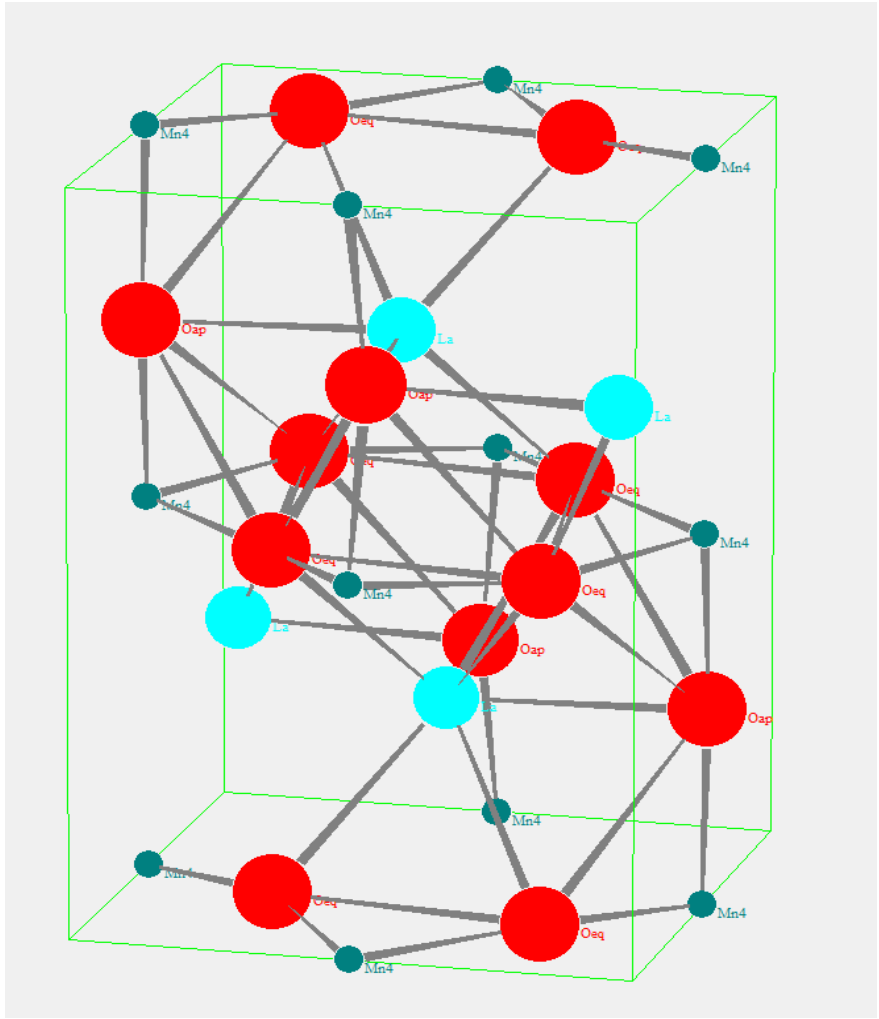
The observed (black), calculated (red) and the difference between the observed and calculated difractogram for x=0.12 (PowderCell)



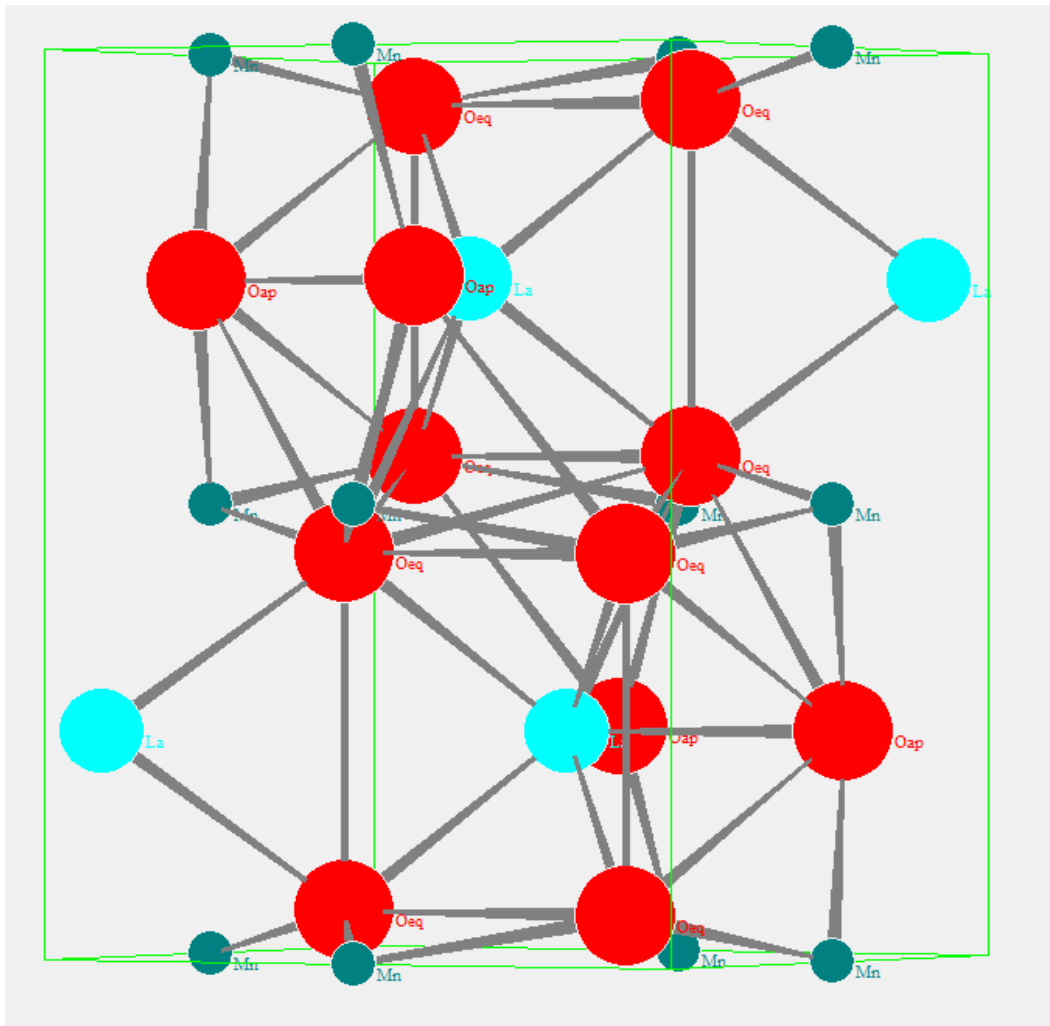
The observed (red), calculated (black) and the difference between the observed and calculated difractogram (blue) for x=0.12 (FullProf)



The observed (black), calculated (red) and the difference between the observed and calculated difractogram for x=0.24 (PowderCell)

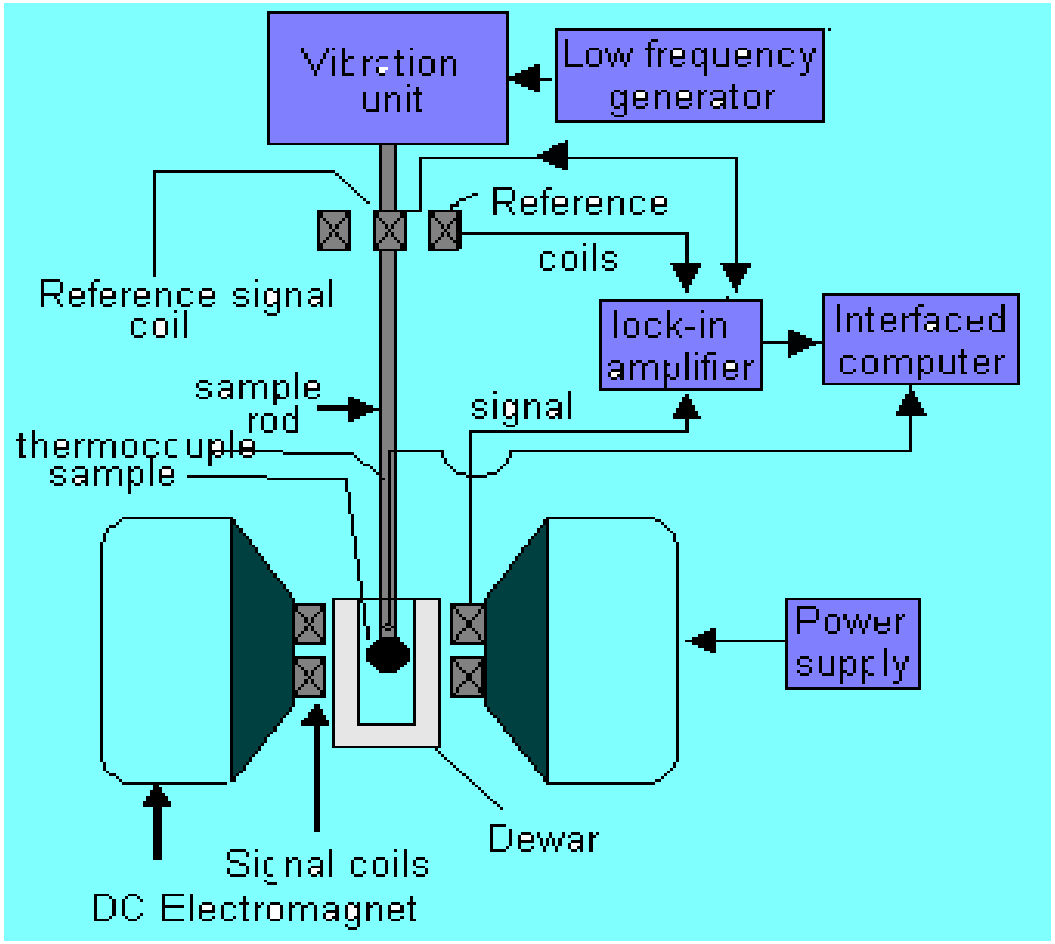


Unit cell for orthorhombic crystal system Pnma



Unit cell for orthorhombic crystal system Pbnm

Magnetic measurements using (VSM)



$$\sigma = k\frac{U}{m}$$

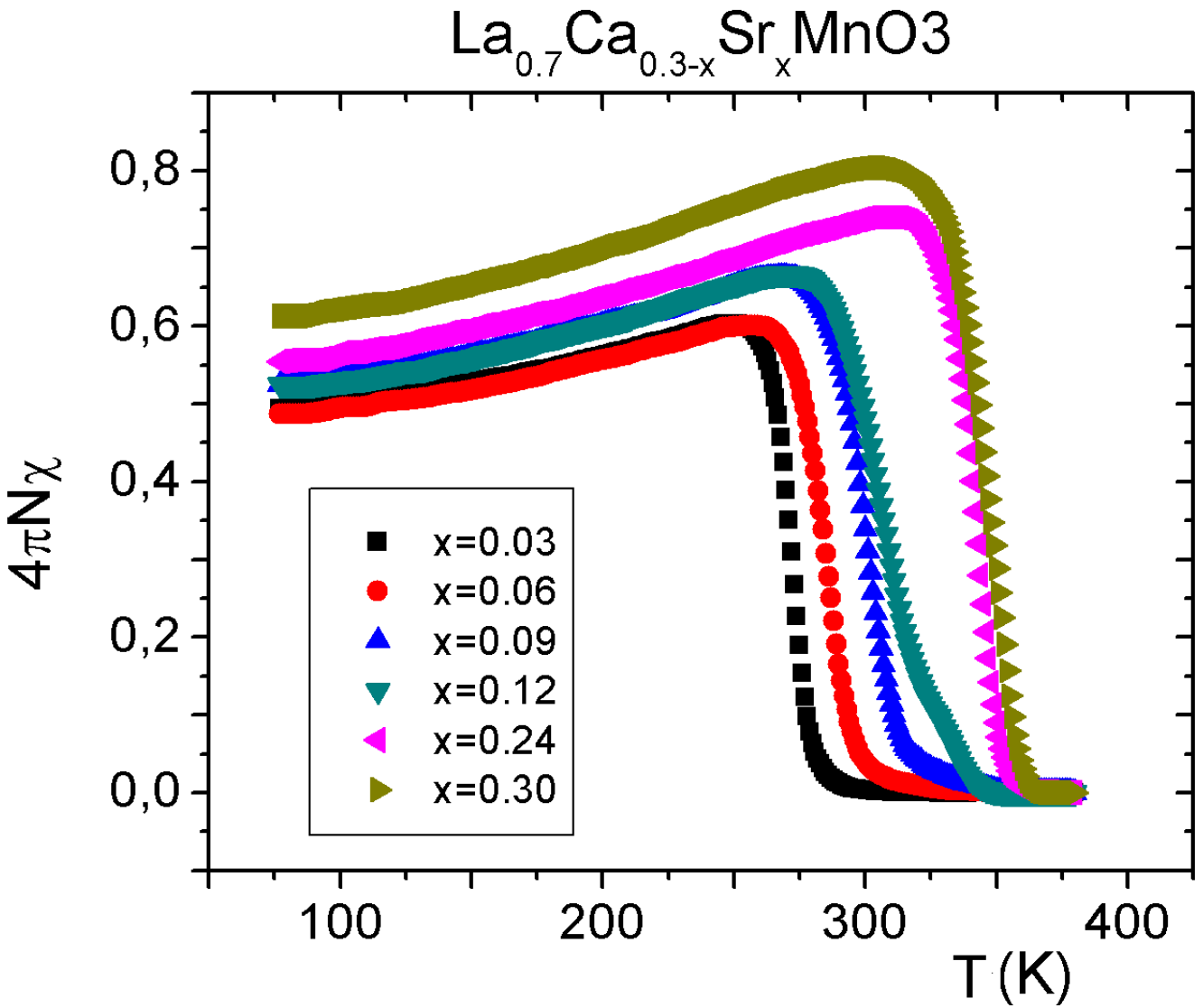
(σ) specific magnetization

(U) voltage drop across the coils

(m) sample weight

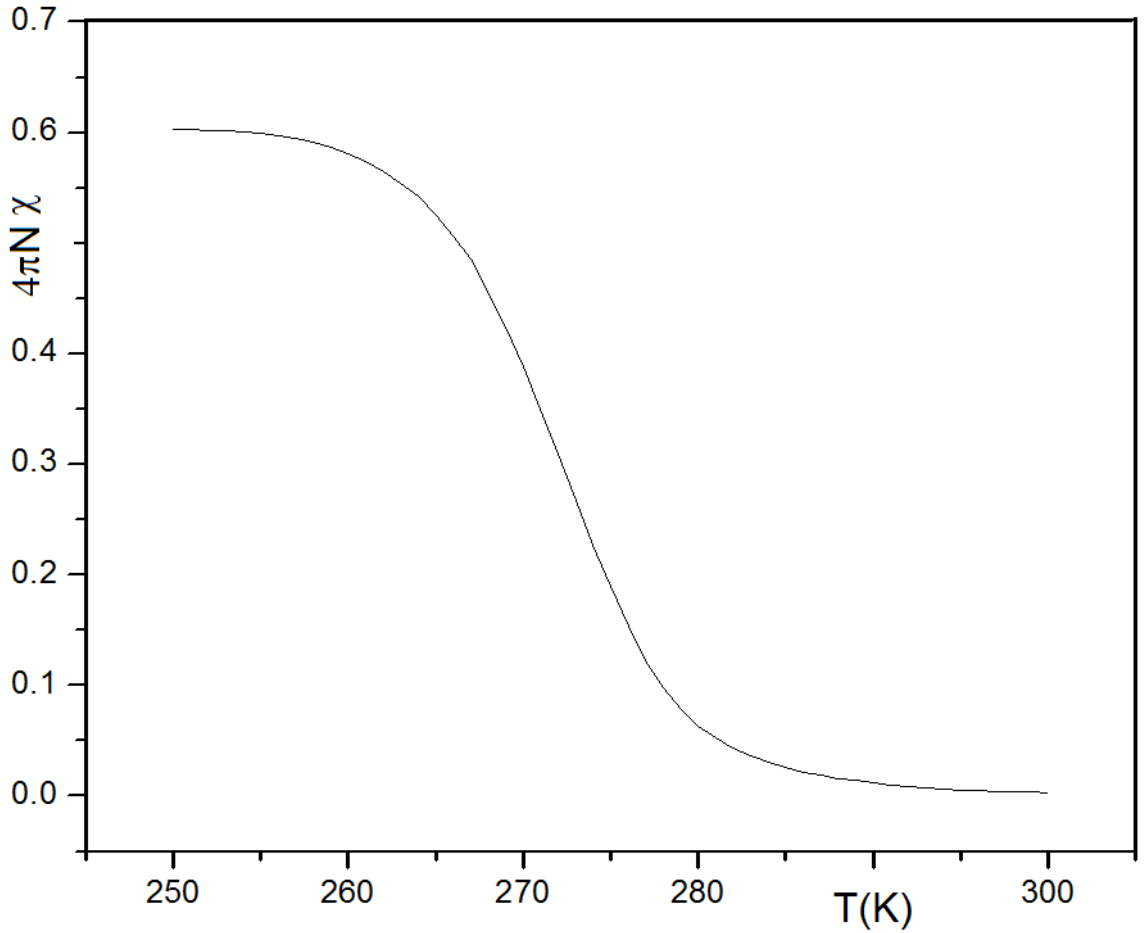
(k) constant of the instrument

Magnetization vs temperature

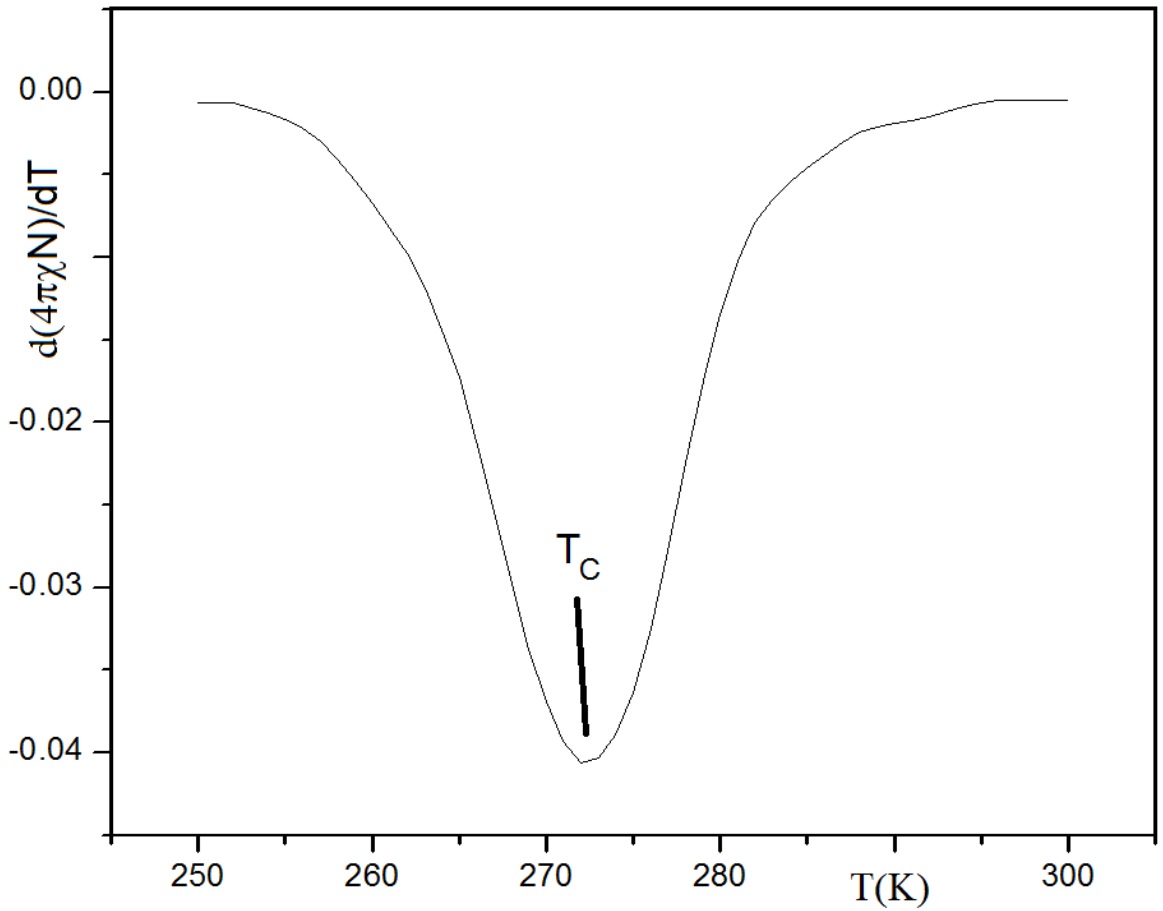


The variation of the magnetization with temperature (T) and Sr concentration (x).

The method to obtain the Curie temperature for $La_{0.7}Ca_{0.3-x}Sr_xMnO_3$ manganites

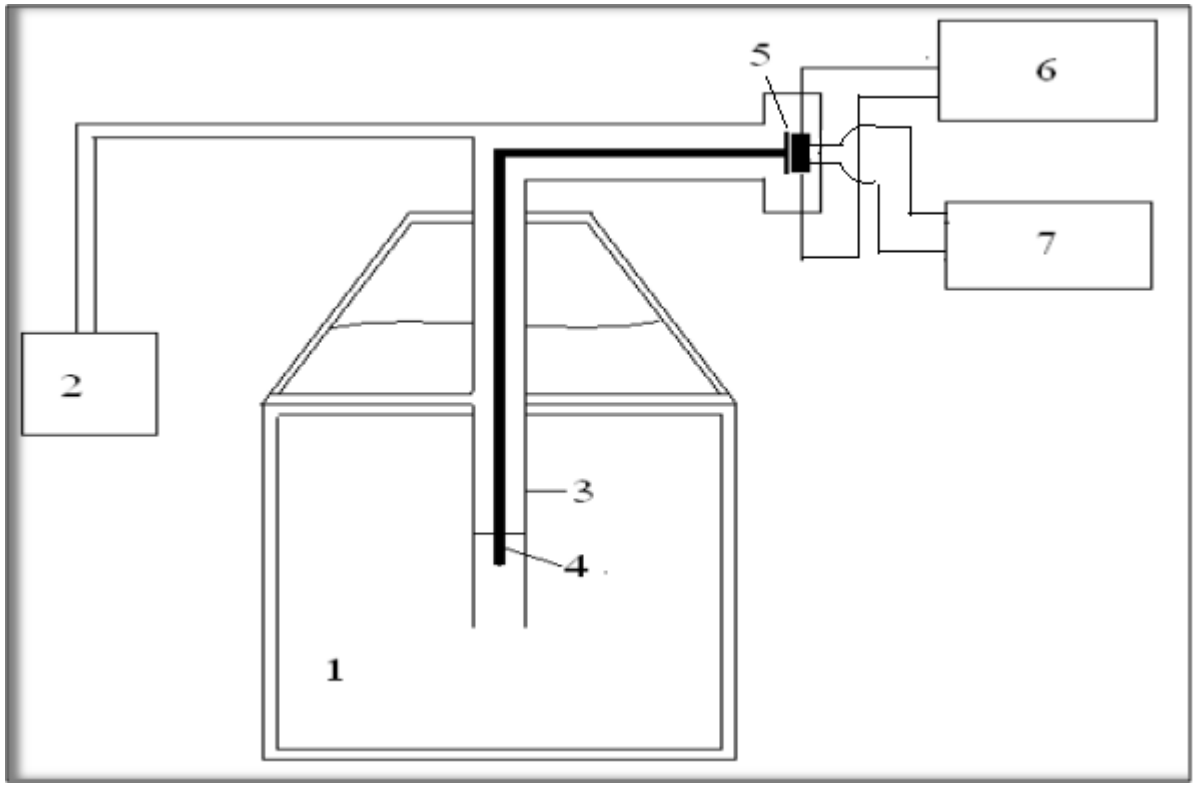


The variation of the magnetization with the temperature near Curie temperature



The variation of the first derivative of magnetization with temperature

Transport measurements by four sonde method



(1)Crygenerator

(2)Vacuum pump

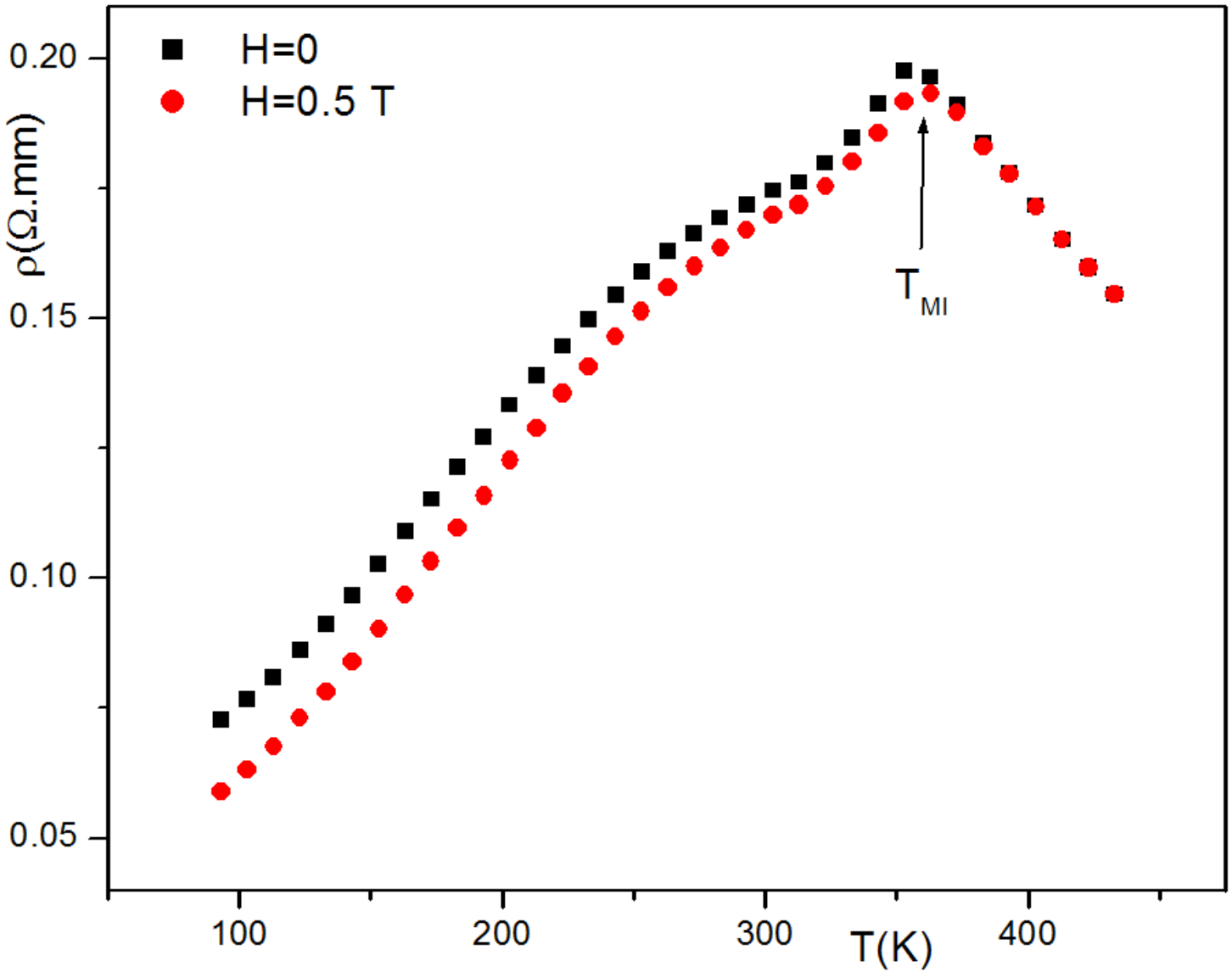
(3)Evacuated tube

(4)Cu rod

(5)Sample

(6)Current source

(7)Voltmeter



The variation of resistivity with temperature and the magnetic field intensity for the sample corresponding to x=0.24

Magnetic and electrical parameters

X	T_c [K]	$T_{IM,extrinsic}$(K)	E_a[eV]
0.03	272	282	0.09738
0.06	287	295	0.07865
0.09	300	313	0.07241
0.12	308	321	0.06617
0.24	353	356	0.04282

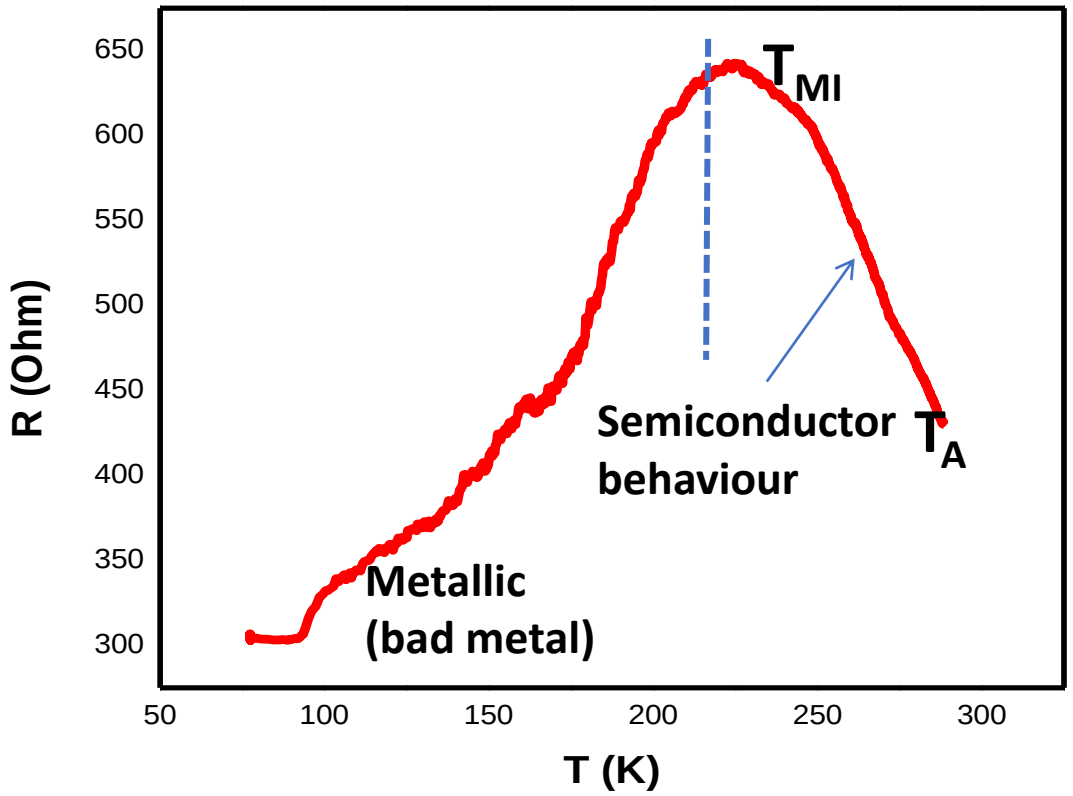
Conductivity models

1) Thermal Activation model (TA)

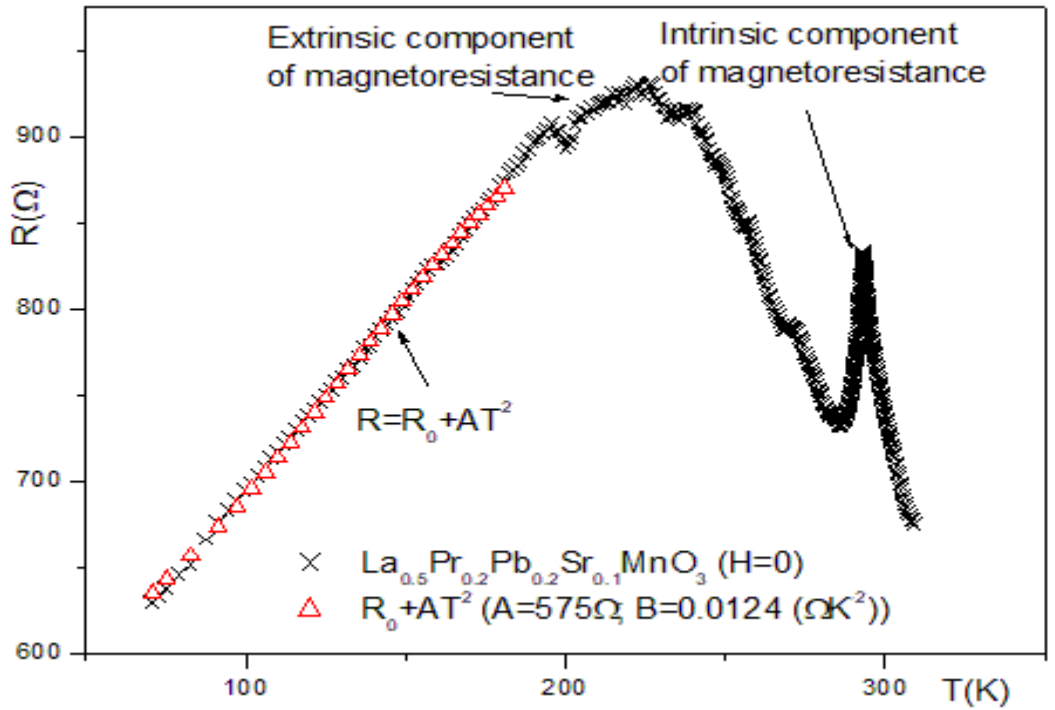
$R=R_0 \exp(-E_a/kT)$

2) Single magnon process (SM)

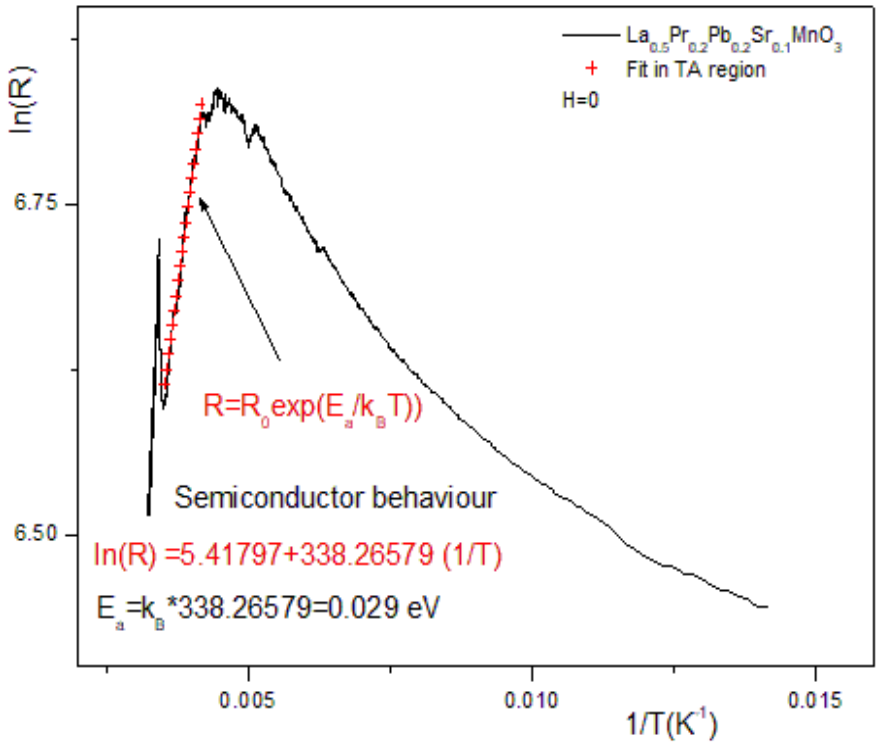
$R=R_0 + AT^2$



Resistance measurements at (H=0)

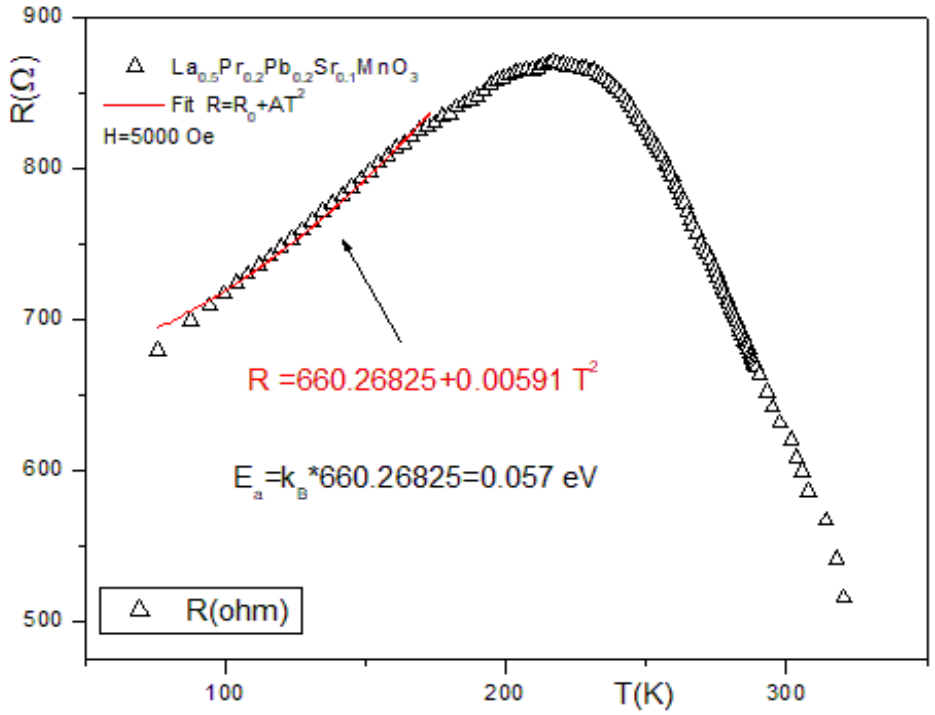


Transport model at low T and (H=0)

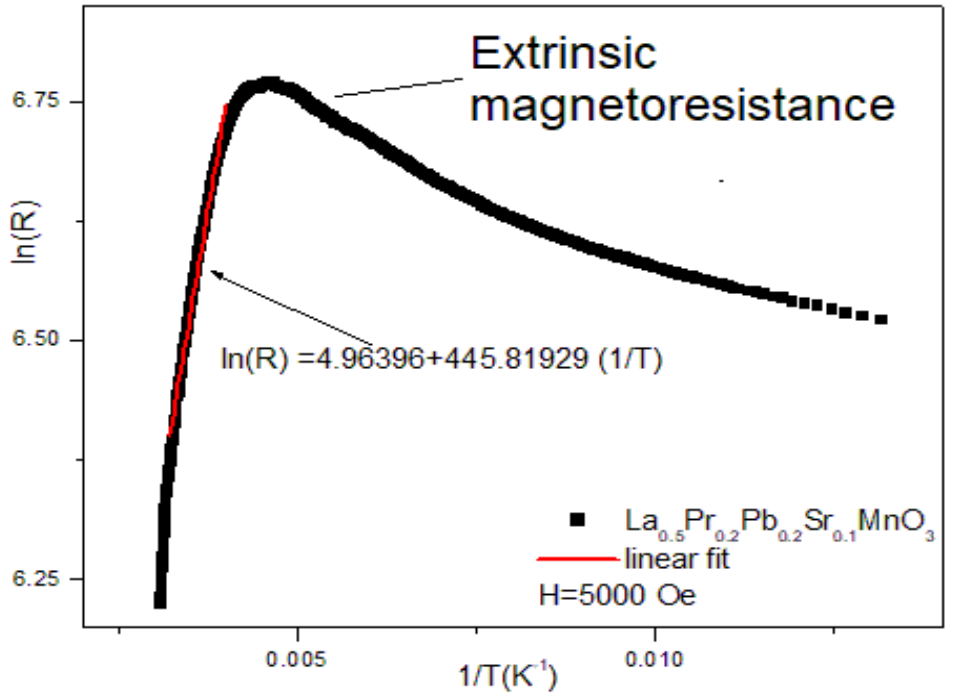


Transport model at higher T and (H=0)

Resistance measurements at (H=5000 Oe)



Transport model at low T (H=5000 Oe)



Transport model at higher T (H=5000 Oe)

Conclusion

- ✓ $La_{0.7}Ca_{0.3-x}Sr_xMnO3$ have synthesized by ceramic method and the structure was confirmed by XRD for all x values
- ✓ Orthorhombic structure (SG Pbnm) was observed for x=0.03 to x=0.12
- ✓ Rhombohedral structure (SG R-3C) for x=0.24
- ✓ Unit cell volume, corresponding to Pbnm phase, have a maximum for x=0.09
- ✓ Average size of the crystalline blocks remains practically constant until x=0.12, a sudden decrease being observed at x=0.24

- ✓ Manganite sample behave as metals for temperature lower than T_{MI} and semiconductor for temperature higher than T_{MI}
- ✓ The Curie and transition temperatures increase with the Sr concentration in the samples
- ✓ Activation energy of thermal activation process decreases with Sr concentration

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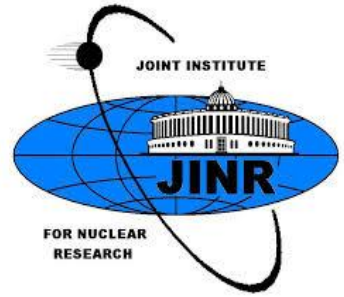

Thanks