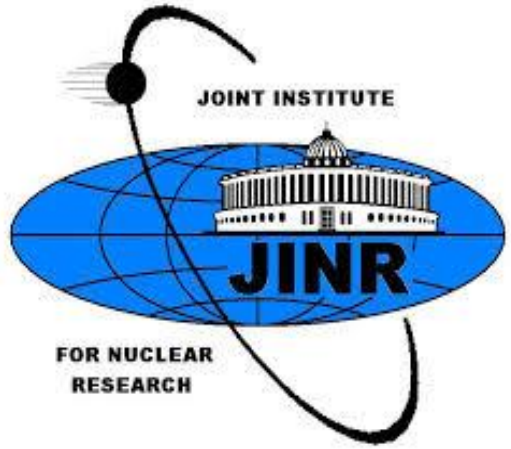
# Transport phenomena and magnetic crystalline structure of manganites

**Project Coordinator**

**Prof. Dr. Mihail Liviu CRAUS**

# Team Work

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# Outline

1 Introduction

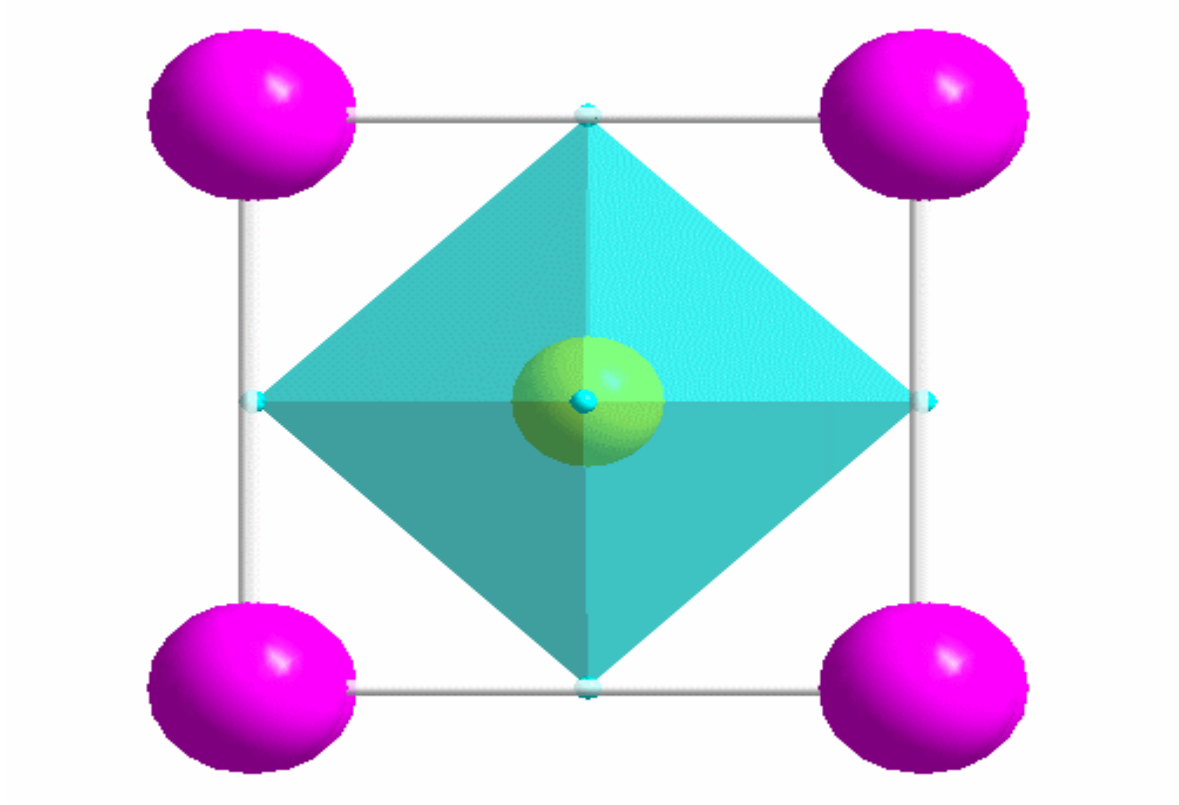
2 Objectives

3 Equipment Description

4 Results

5 Conclusion

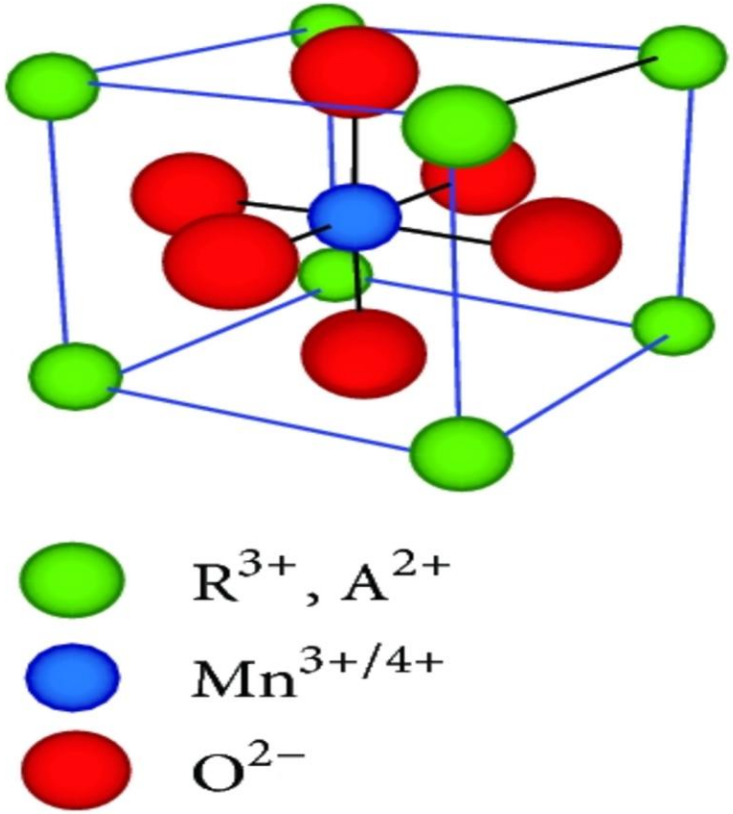
# Perovskite Structure



$ABO_3$

- ✓ **A cations (such as, La, Sr, Ca, Pb, etc.) rare earth and alkaline earth**
- ✓ **B cations (such as, Ti, Cr, Ni, Fe, Co, Zr, Mn, etc.) transition metals**

# Manganites




$R_{1-x}A_xMnO_3$

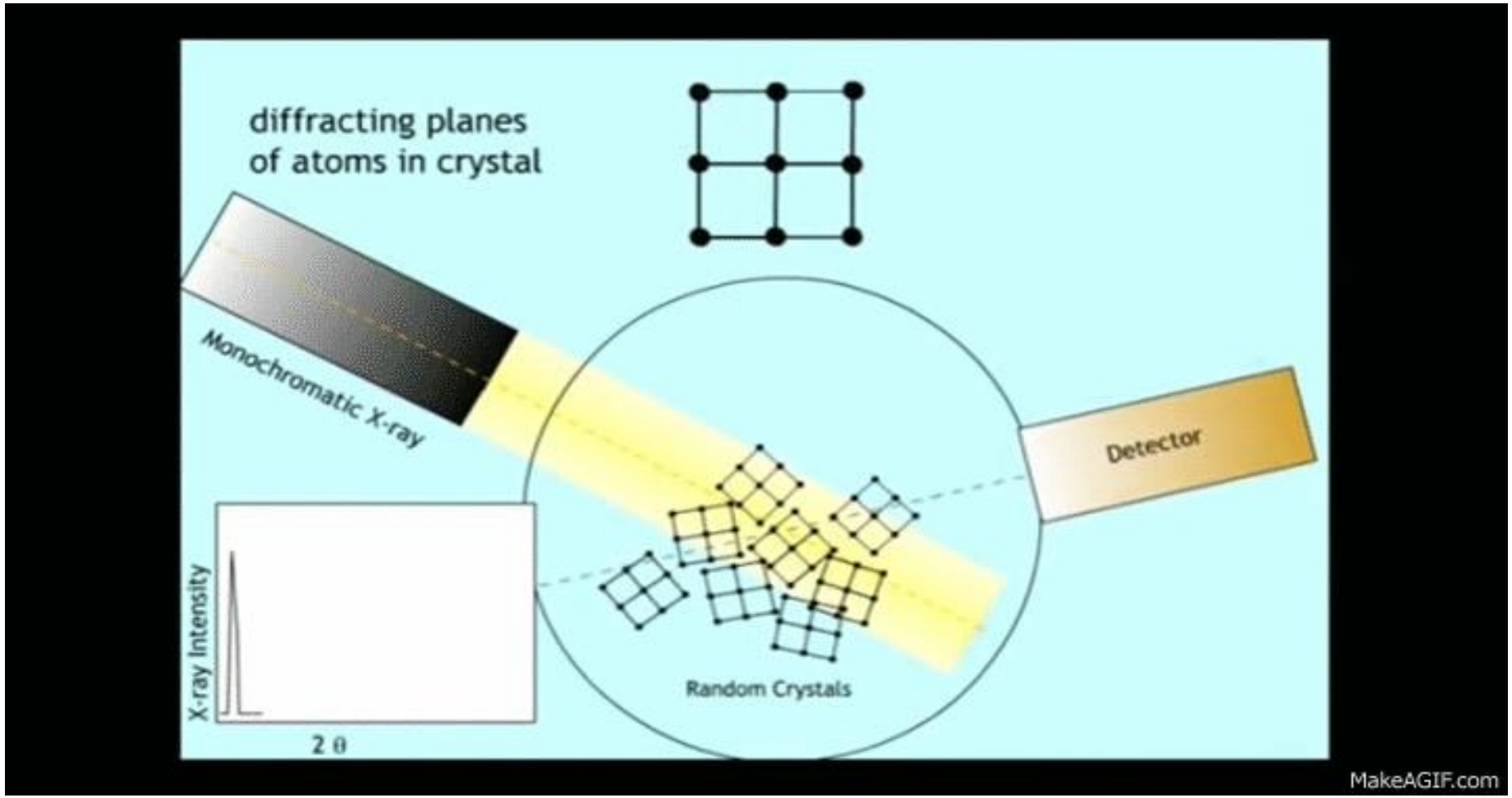
**R** rare-earth cation

**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

# X-Ray diffraction



# $La_{0.5}Pr_{0.2}Pb_{0.3-x}Sr_xMnO3$ Preparation

1. Weighting of the sample

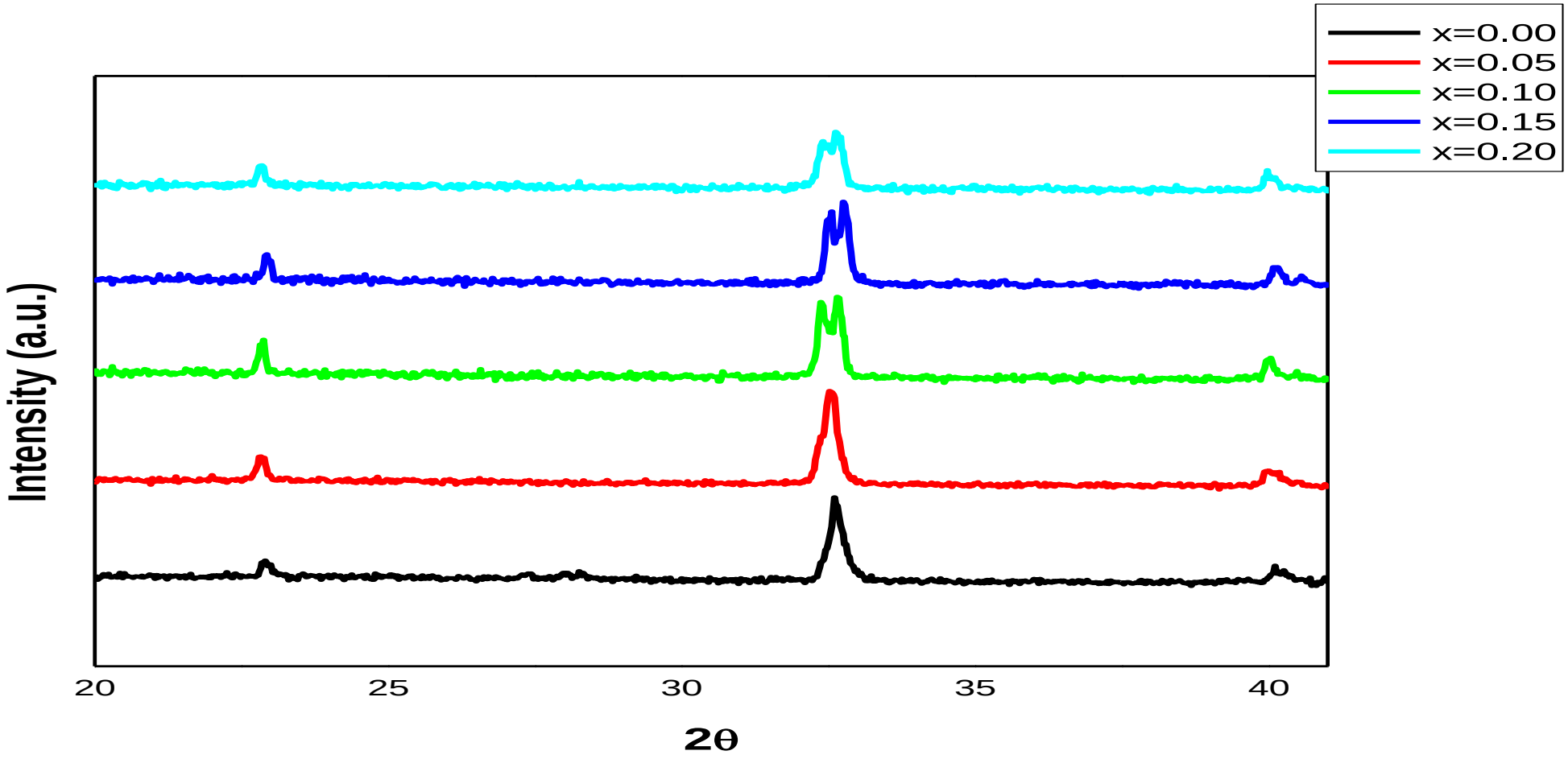
2. Milling and Grinding

3. Temperature treatment (800 °C)

4. Preliminary investigation by XRD

5. Higher temperature sintering (1200 °C)

# XRD of $La_{0.5}Pr_{0.2}Pb_{0.3-x}Sr_xMnO3$



# Software Programs

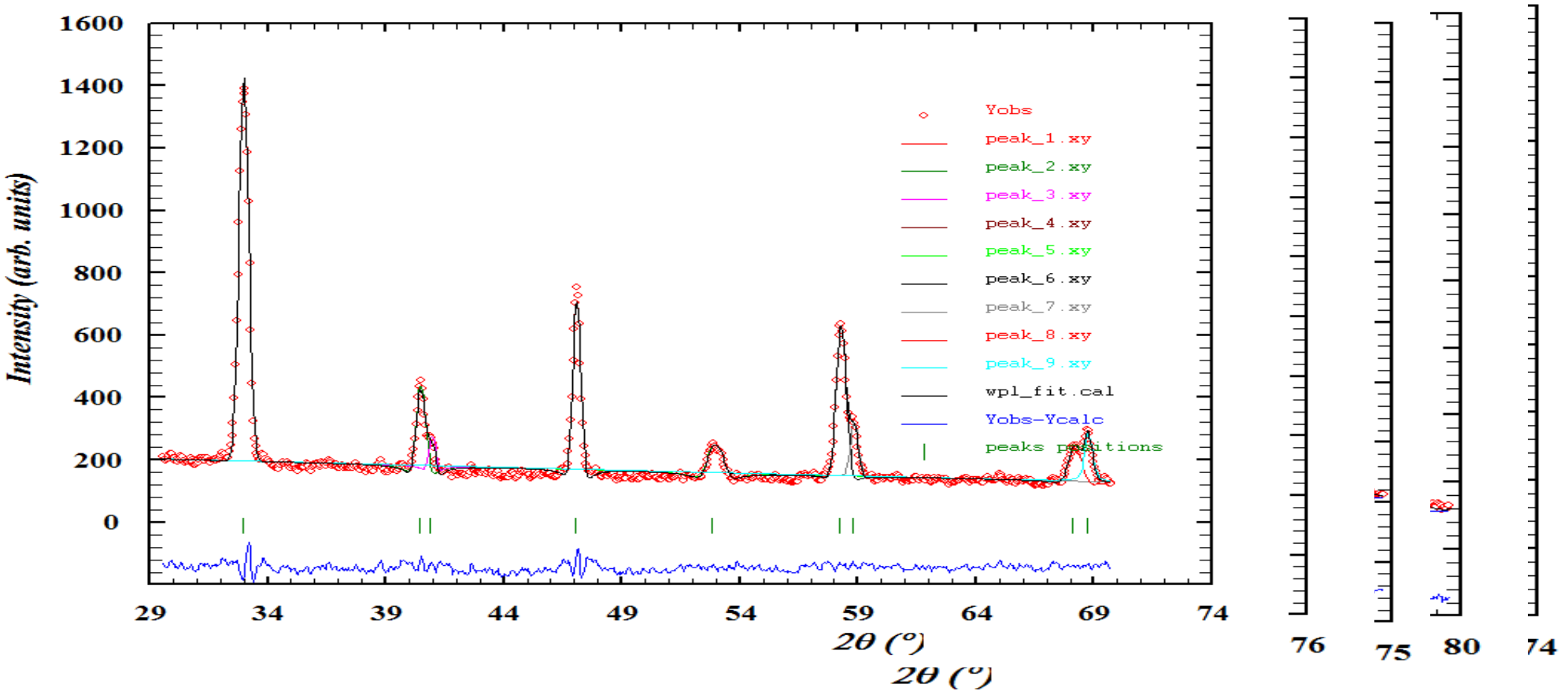
- ✓ Full prof suite code
- ✓ Cristalographica
- ✓ Celerf3
- ✓ Powder cell

→ Structure Refinement

- ✓ MolCal

→ Molecular weight Calculation

# $La_{0.5}Pr_{0.2}Pb_{0.1}Sr_{0.2}MnO3$



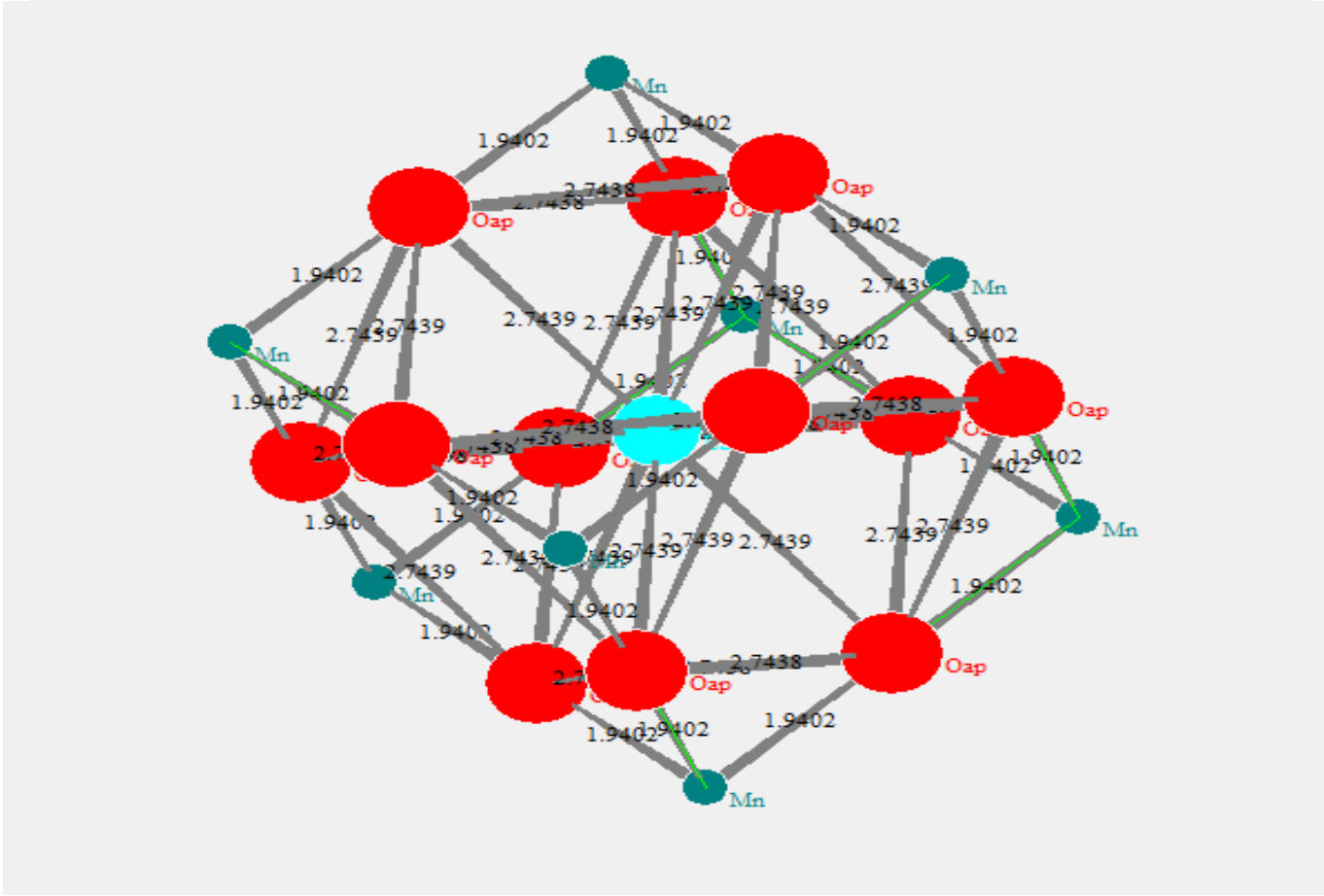
# XRD parameters for $La_{0.5}Pr_{0.2}Pb_{0.3-x}Sr_xMnO3$

| X | SG | a=b (A°) | c (A°) | V ($A^3$) | D (A°) | $\epsilon$ |
|---|---|---|---|---|---|---|
| **0.00** | **Pm-3m** | 3.887 | 3.887 | 58.759 | 323 | 0.0018 |
| **0.05** | **Pm-3m** | 3.889 | 3.889 | 58.818 | 327 | 0.0004 |
| **0.10** | **R-3c** | 5.522 | 13.371 | 349.645 | 518 | 0.0006 |
| **0.15** | **R-3c** | 5.514 | 13.355 | 353.338 | 534 | 0.0005 |
| **0.20** | **R-3c** | 5.524 | 13.384 | 355.701 | 469 | 0.0007 |

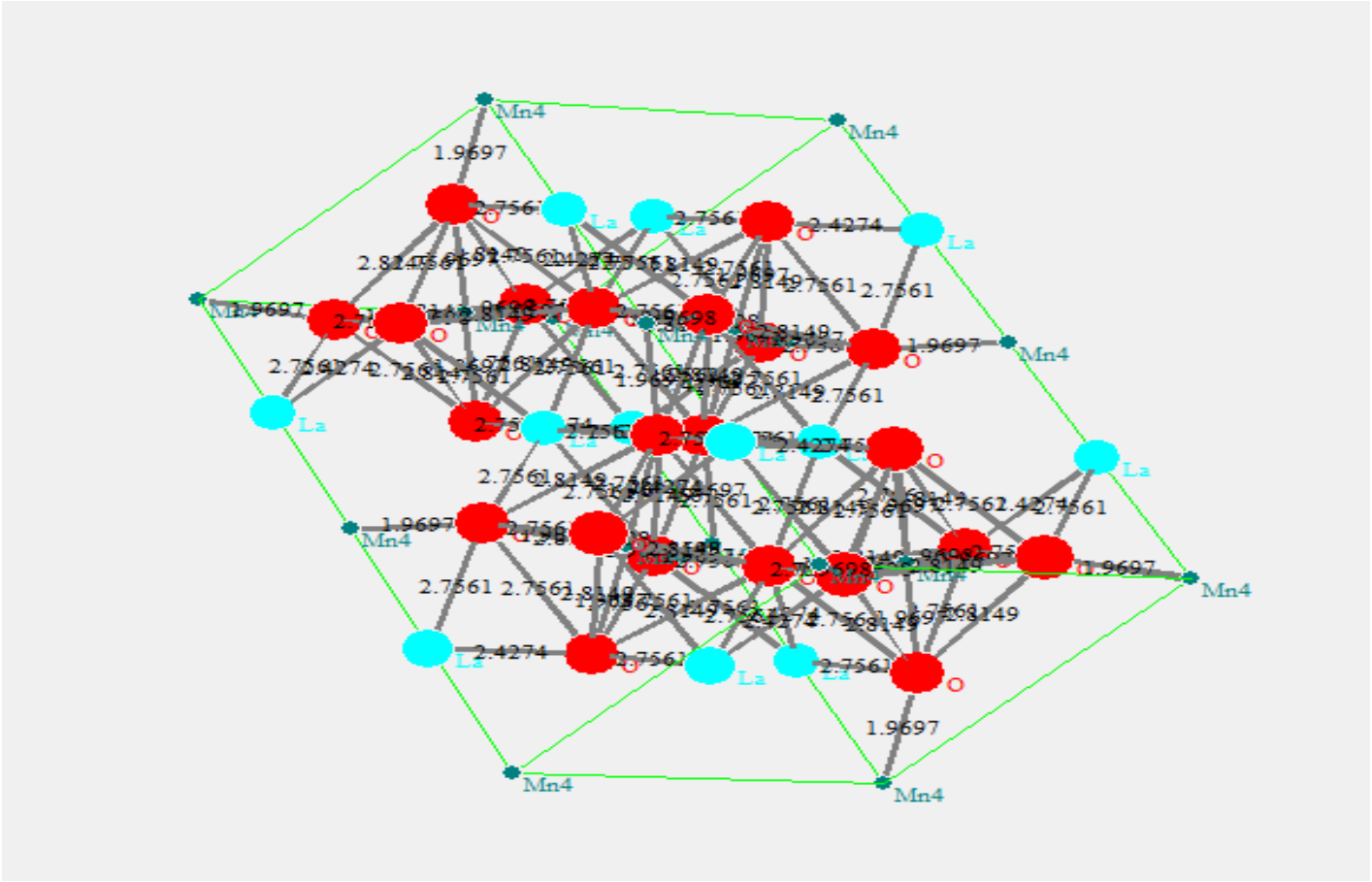
X=0.00, 0.05 Cubic crystal system

X=0.1, 0.15, 0.20 Rhombohedral crystal system

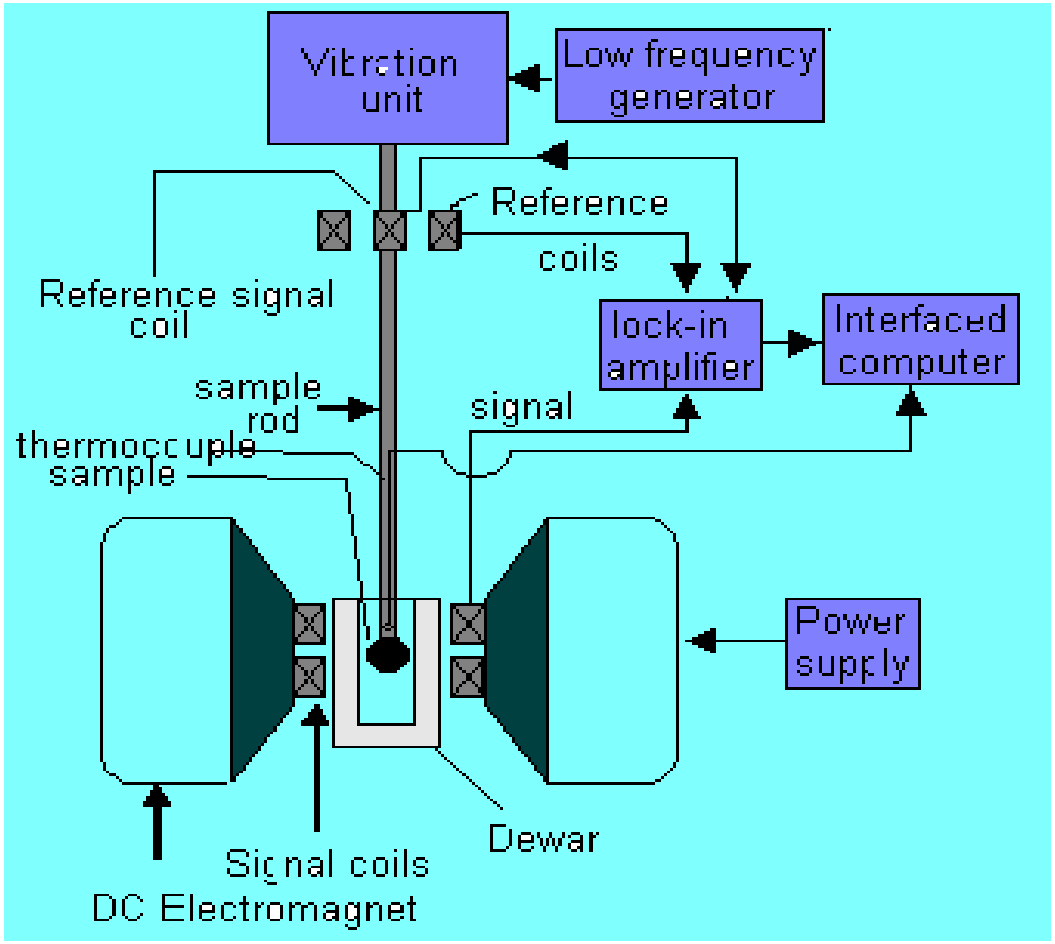
# Unit cell for cubic crystal system (Pm-3m)



# Unit cell for Rhombohedral crystal system (R-3c)



# Magnetic measurements using (VSM)




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

(σ ) specific magnetization

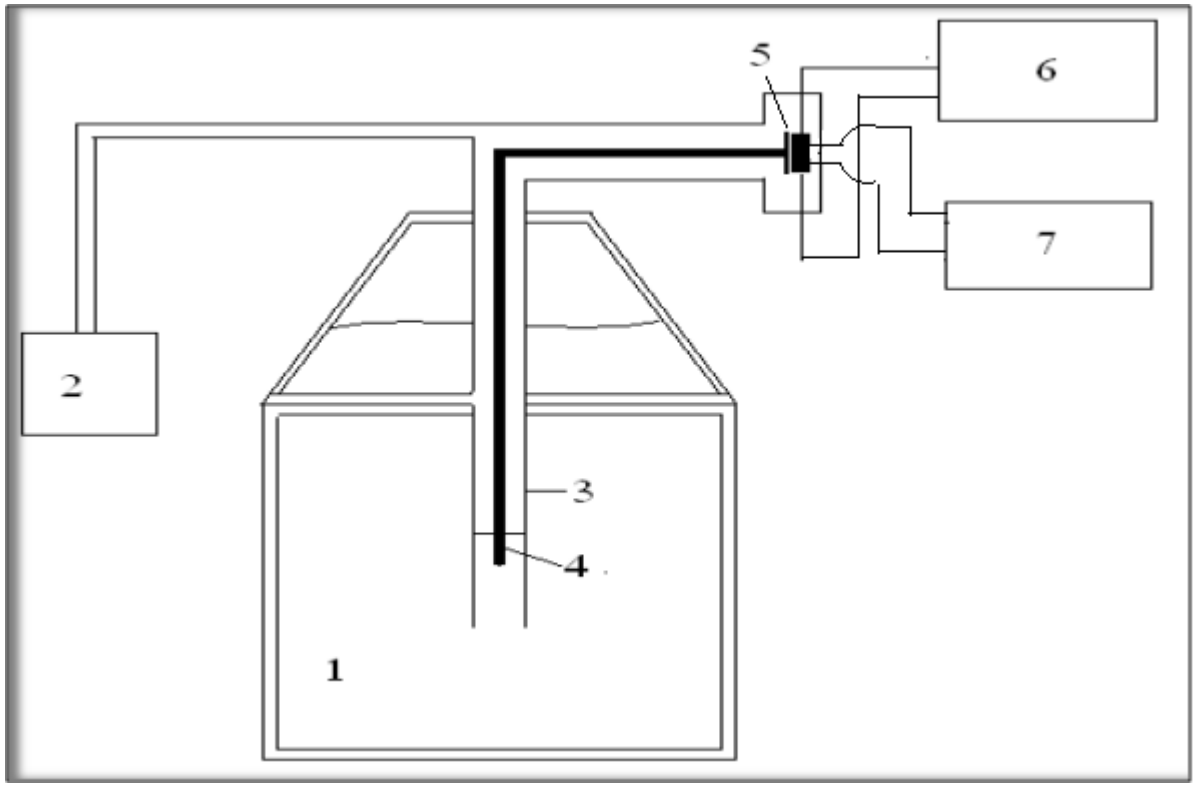
(U) voltage drop across the coils

(m) sample weight

(k) constant

# Electrical measurements

## (four sonde method)




(1)Dewar with liquid $N_2$

(2)Vacuum pump

(3)Evacuated tube

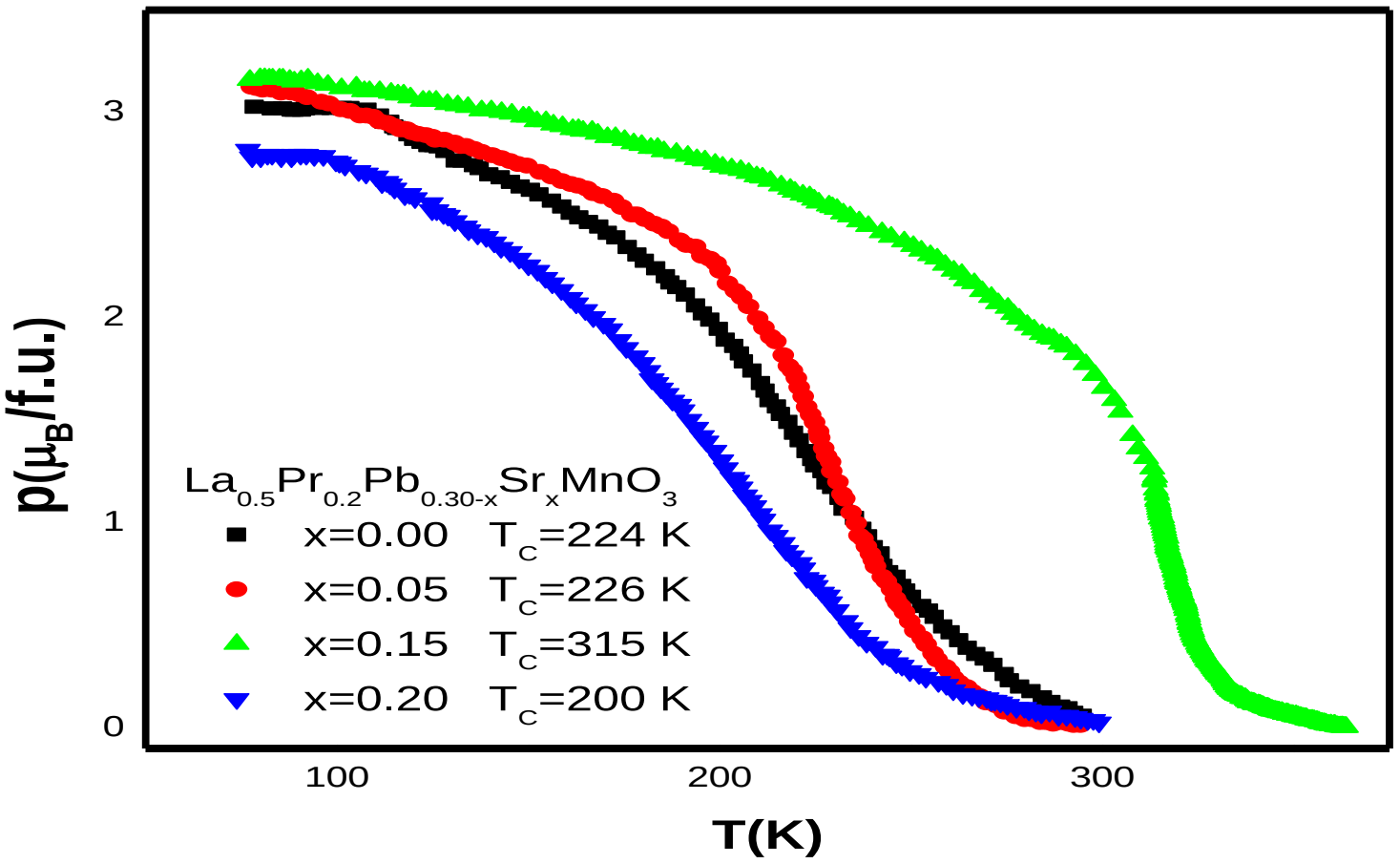
(4)Cu rod

(5)Sample

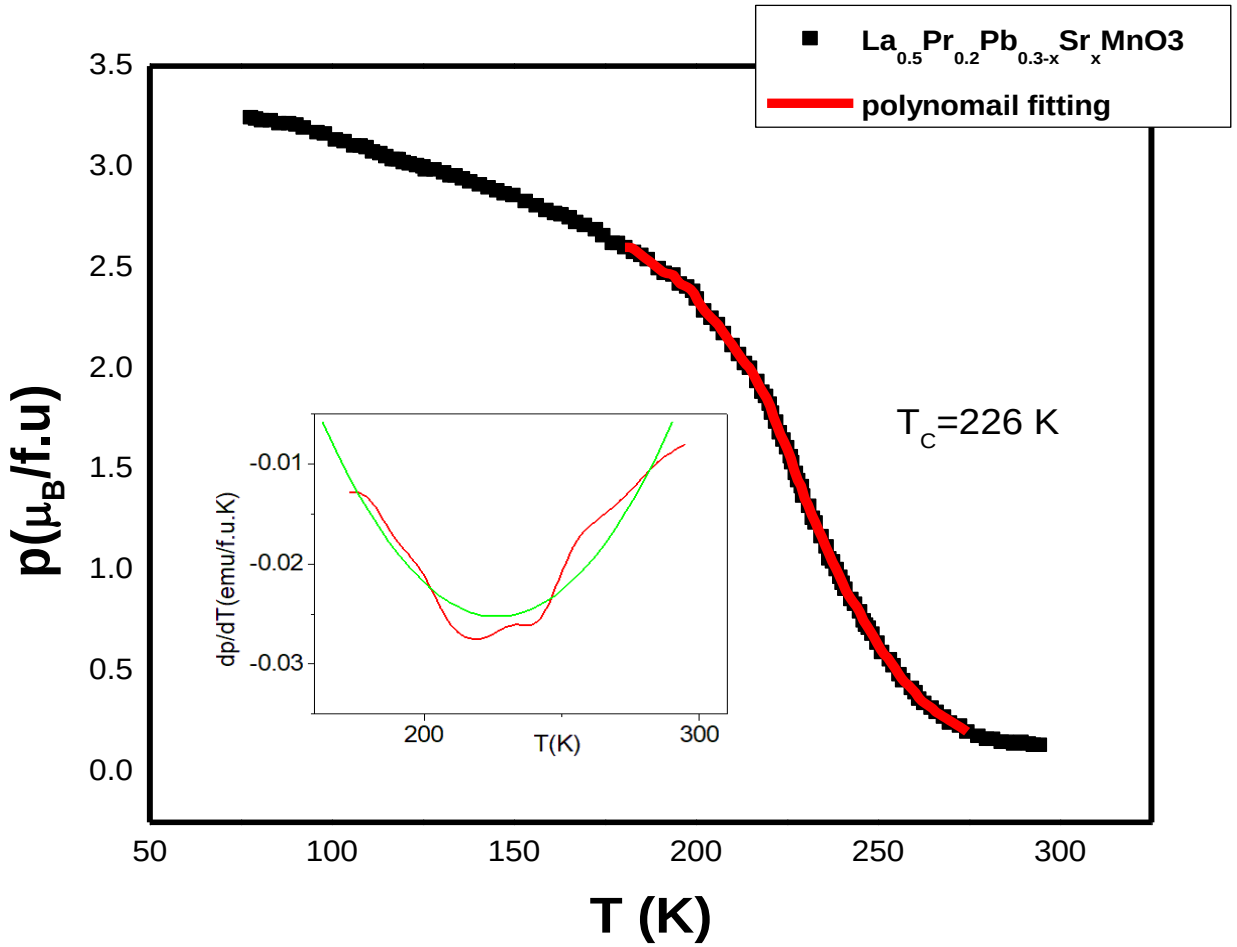
(6)Current source

(7)Voltmeter

# Molar magnetization vs temperature



# Curie temperature (Tc)



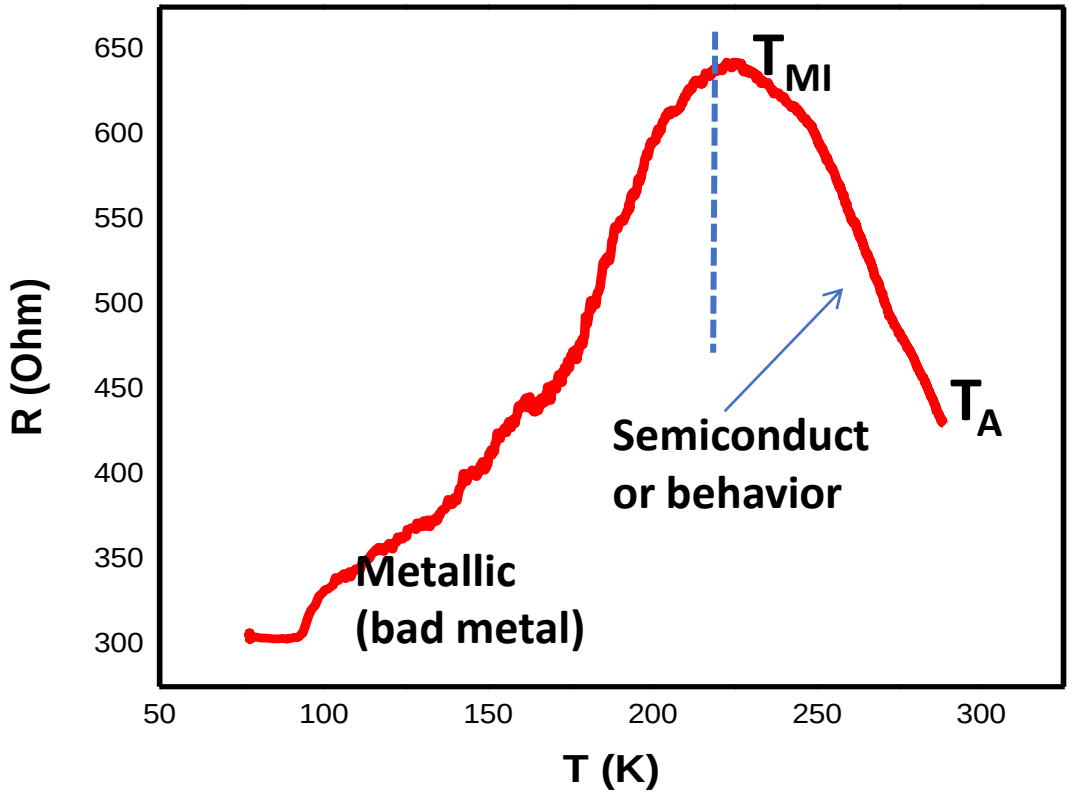
# Conductivity models

- ✓ Thermal Activation model ($T_A$)

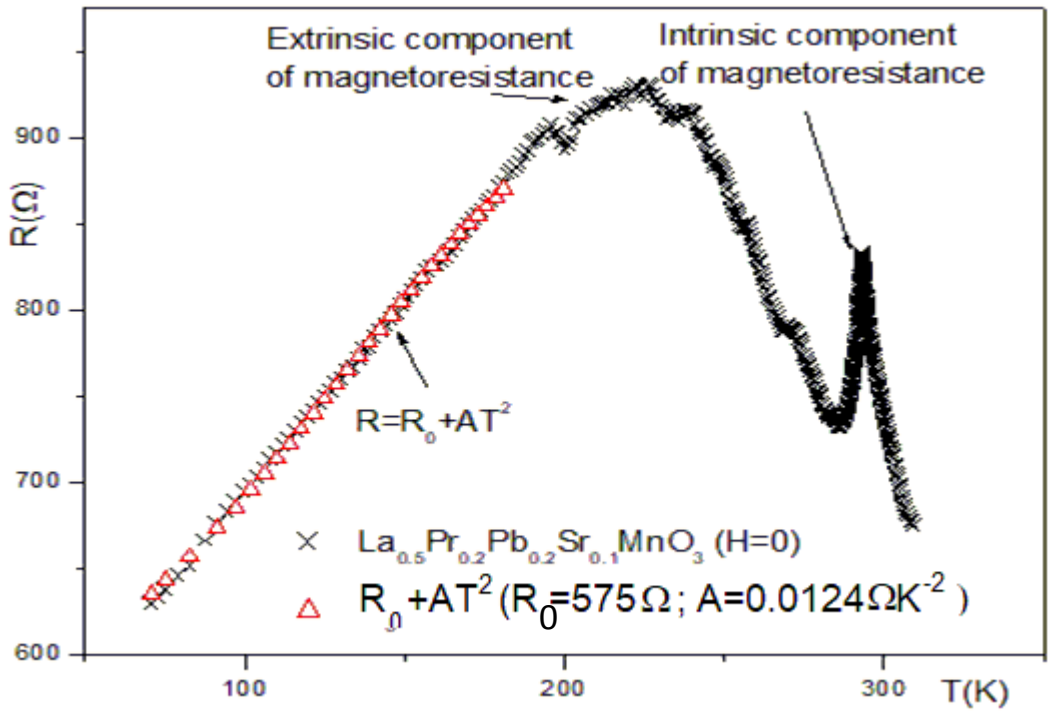
$$R = R_0 e^{\left(\frac{E_a}{KT}\right)}$$ (Viret et al.)

- ✓ Single magnon process

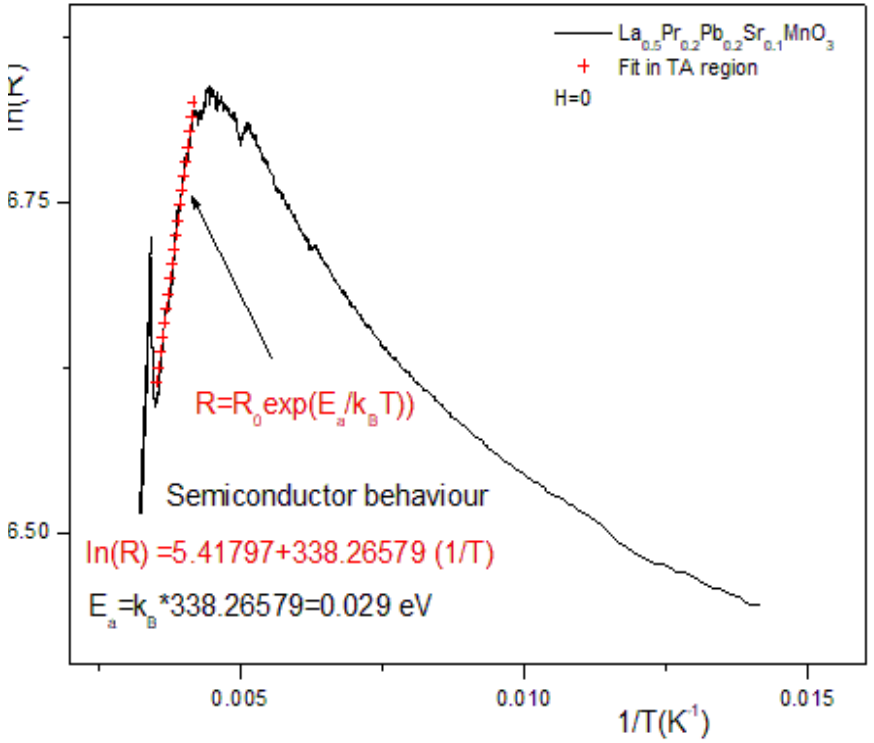
$$R = R_0 + AT^2$$



# Resistance measurements (H=0)



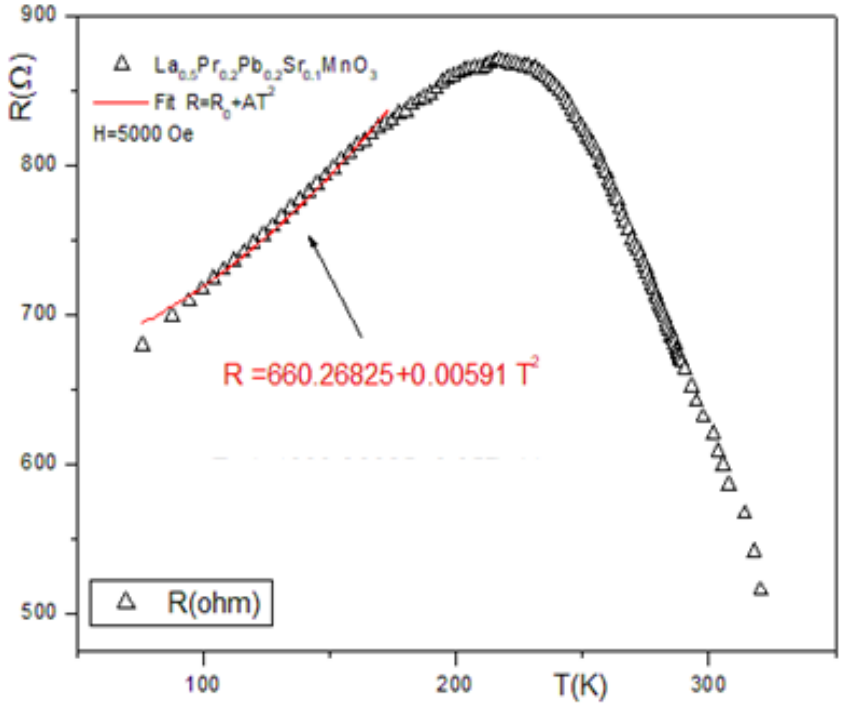

Transport model at low T and (H=0)

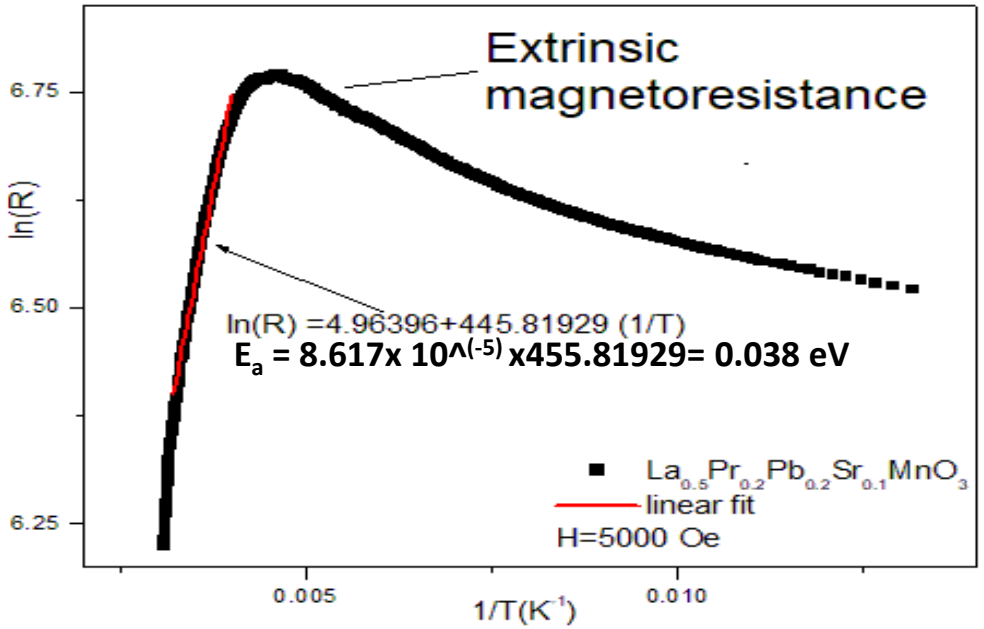



Transport model at higher T and (H=0)

$$E_a = 0.029 \text{ eV}$$

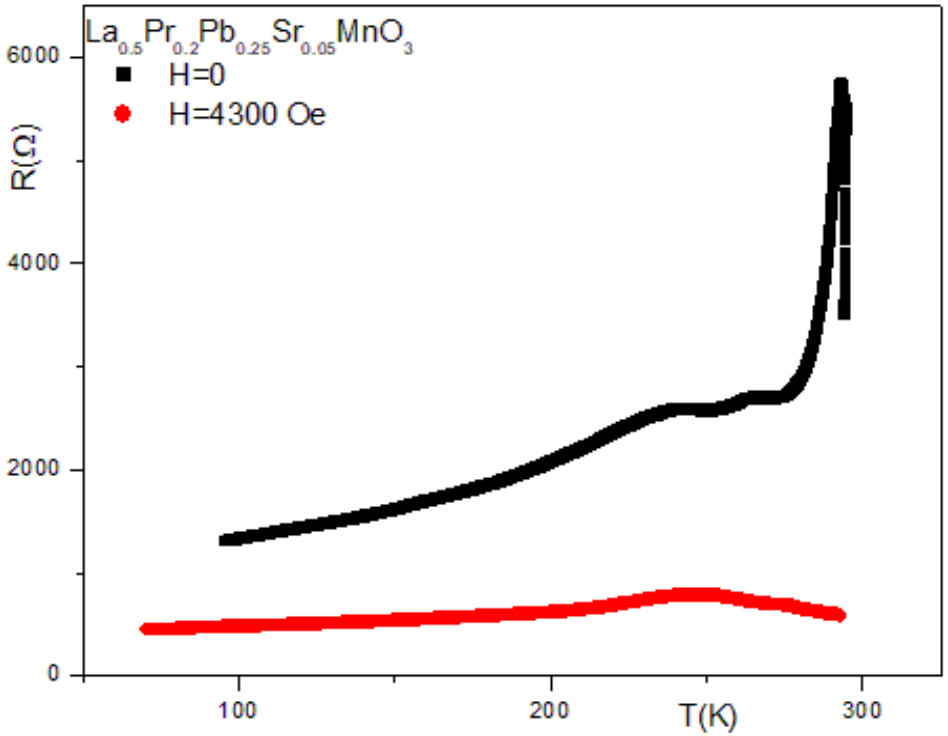
# Resistance measurements (H=5000 Oe)



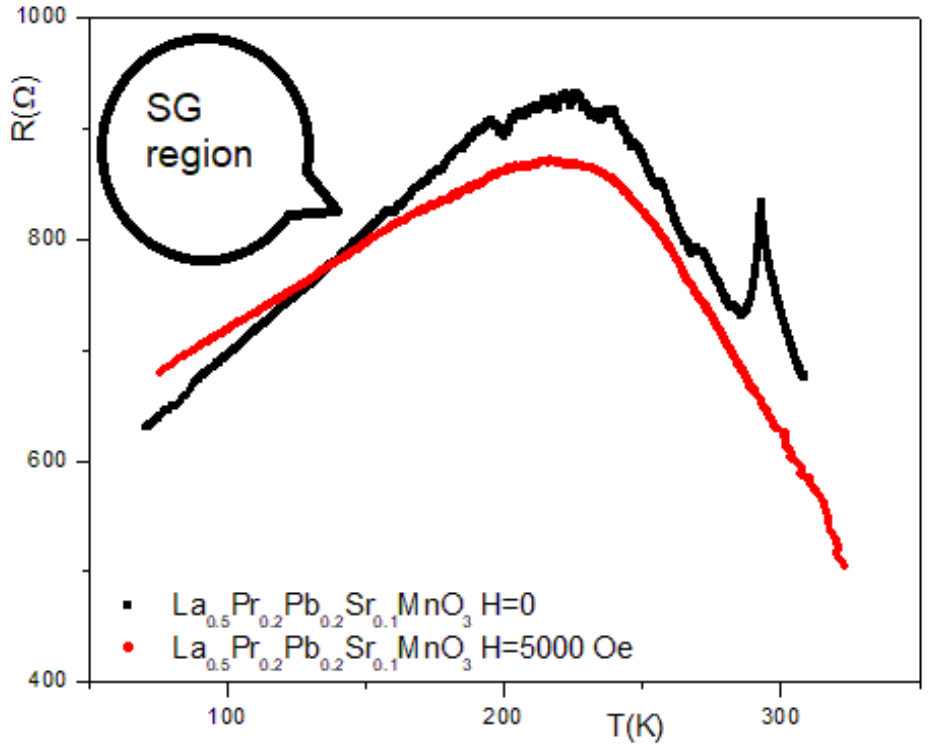




**$E_a$=0.038 eV (H= 5000 Oe)**

# Resistance measurements at different x




X=0.05




X=0.1

# Magnetic and electrical parameters

| X | $T_C$ [k] | $T_{IM,extrinsic}$(K) | $T_{IM,\ intrinsic}$[K] | $E_a$[eV] |
|---|---|---|---|---|
| 0.00 | 224 | 216 | | 0.051 |
| 0.05 | 226 | 239 | 293 | 0.026 |
| 0.15 | 315 | 210 | 303 | 0.029 |
| 0.20 | 200 | 241 | | 0.033 |

# Conclusion

- ✓ $La_{0.5}Pr_{0.2}Pb_{0.3-x}Sr_xMnO3$ have synthesized by ceramic method and the structures were confirmed by XRD for all x values
- ✓ Cubic structure with space group (Pm-3m) was observed for x=0.0 and x=0.05
- ✓ Rhombohedral structure with space group (R-3C) for x>0.05
- ✓ Average size of the crystalline blocks is smaller for cubic structure and larger for hexagonal structure. The microstrains have smaller values for hexagonal structure.

- ✓ Manganite sample behave as metals for temperature lower than $T_{MI}$ and semiconductor for temperature higher than $T_{MI}$

- ✓ At low temperature the samples support a transition from the ferromagnetic to spin-glass state, which influences the transport properties of the samples

- ✓ Activation energy value have a weak dependence on the chemical composition or the structure of the samples. A dependence of the activation energy on the treatment conditions (field magnetic cooling, zero field magnetic cooling, heating in magnetic field, heating without magnetic field) was observed

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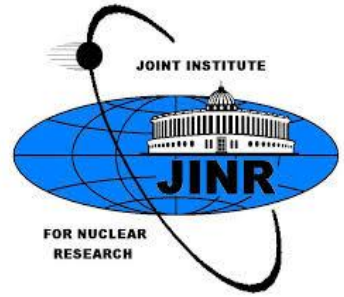


# Thanks