

## **CHAPTER 7**

### **Conclusions and Future scopes**



## 7.1 Conclusion of the thesis:

❖ The polycrystalline pyrochlore samples  $(\text{Tb}_{1-x}\text{Eu}_x)_2\text{Ti}_2\text{O}_7$  (TETO) with ( $x= 0, 0.25, 0.50, 0.90, 0.95, 1.0$ ) were prepared through solid state reaction route. An increase of antiferromagnetic interaction has been observed by the DC magnetization study on the samples. Eu rich TETO compounds show the contribution of exchange interaction and dipolar interaction.  $\text{Tb}_2\text{Ti}_2\text{O}_7$  shows a partial spin freezing at high temperature ( $T \sim 33$  K) which is associated to single ion freezing by its nature. A field induced transition solely associated to the Tb substitution is observed at lower temperature which is different from the single ion freezing. The high temperature spin freezing is contributed to both Eu and Tb ions spin relaxation in TETO samples. The field induced transition corresponds to single moment saturation. All the compounds have shown a field induced transition  $T^*$  which shifts towards higher temperature on increasing the concentration of Eu ions.

❖ In chapter 4, there is the thoroughly magnetic investigation of  $\text{Dy}_{2-x}\text{Eu}_x\text{Ti}_2\text{O}_7$  (DETO) ( $0 \leq x \leq 2.0$ ) samples. Behaviour of temperature dependent magnetic data is variable for all DETO samples. Enrich Eu content samples can be fitted with the high temperature series expansion equation, while enrich Dy containing samples can be fitted with the Curie-Weiss law. The contribution of both dipolar field and anisotropy exchange interaction has been existed in rich Eu samples which induce the wasp-waisted hysteresis loop in same compounds. Moreover, two type of single ion spin freezing is identified in Eu rich DETO samples from AC susceptibility measurement. The low temperature spin freezing is corresponds to  $\text{Dy}^{3+}$  ions whereas, high temperature spin freezing is due to  $\text{Eu}^{3+}$  ions. It is also found that the both spin freezing are thermally activated.

❖ Regarding to disorder driven spin frustration, we have prepared  $\text{La}_{1.8}\text{Pr}_{0.2}\text{CoFeO}_6$  (LPCFO) double perovskite with solid state reaction method. XRD data identified the single phase monoclinic crystal structure ( $P2_1/n$  symmetry) for LPCFO. Electronic state of Fe and Co ion is revealed by XAS tool which is confirmed the trivalent oxidation state of Co with low spin state and Fe ion with high spin state. Further, above room temperature magnetic ordering along with low temperature reentrant cluster glass state has been reported for same sample by AC magnetic susceptibility measurement. This system also occupies the high dielectric constant, and low loss tangent. Presence of reentrant cluster glass and spin lattice interaction originates the negative magneto dielectric coupling in LPCFO sample at two different temperature region.

❖ We have also studied the effect of hole ( $\text{Ca}^{2+}$ ) doping on  $\text{La}_2\text{CoFeO}_6$  system. i.e.  $\text{La}_{a1.5}\text{Ca}_{a0.5}\text{CoFeO}_6$  (LCCFO). The hole doping creates the mixed valance states of Co and Fe ions which was identified by XPS technique. The Co ion has mixed +2/+3 oxidation state and Fe ion has mixed +3/+4 oxidation state at room temperature. The ferrimagnetic ground state for LCCFO system has been verified by both DFT analysis and neutron diffraction technique. The magnetic data shows the paramagnetic transition to ferrimagnetic transition at 167 K. M-H curve of LCCFO compound at 5 K exhibit the shifting in curve from origin confirms the presence of large  $H_{\text{SEB}} \sim 0.2106$  T and giant  $H_{\text{CEB}} \sim 1.56$  T. The spontaneous exchange bias is persisted upto 90 K for same compound. Moreover, two low temperature reentrant cluster glass transitions have been observed from AC susceptibility measurement.

## 7.2 Future Plans:

❖ To study the change in multifunctional properties of  $\text{LaPrCoFeO}_6$ , i.e. when Pr ion half replaced La ion in LPCFO.