

Chapter 7

Summary and Future scope

7.1. Summary

There are huge applications of magnetic materials and have been broadly used in various technology like spintronics device, solid state cooling device, magnetic resonance imaging, electromagnet, transformer, magnetic field screening, sensors, protein folding, memory applications, switching and many more multi-functional applications etc. So, we have added ongoing research on some magnetic materials in this thesis. Thus, in present work, “Magnetic and Electrical Properties of Some Magnetically Frustrated Materials” have been carried out. The conclusions of present work have been drawn below.

Firstly, the study on the double perovskite $\text{Eu}_2\text{CoMnO}_6$ has been carried out where some extraordinary magnetic state has been found. In this system, Co and Mn are in mixed valence states and it is electrically semiconducting. A long-range magnetic ordering emerges below 125 K, which is due to dominant ferromagnetic phase transition. Other than, this system shows the existence of Griffith like phase. Further, strong metamagnetic transition has been observed at low temperature. From the AC magnetic study, presence of Hopkinson effect and spin-glass-like behavior have been observed. Additionally, this material also shows a spin-phonon coupling. The existence of MMT along with spin-phonon coupling clearly indicates that the system is very important for potential application.

Besides this, $\text{Eu}_2\text{CoMnO}_6$ have a very high dielectric constant (ϵ') at lower frequency near room temperature and show strong frequency dispersion. On decreasing temperature, the ϵ' decreases sharply to a lower value showing step like behavior, which is attributed to extrinsic to intrinsic transition. The loss spectrum exhibits a frequency-dependent peak showing a thermally activated phenomenon. Moreover, we have doped 50% Tb on Eu site. It was found

that the magnetic ordering temperature has been decreased to 113 K on 50% Tb doping. However, there is large increase in dielectric constant due to Tb doping (almost doubled). There is also a shift in the steps of the dielectric spectrum for a given frequency with Tb replacement, which is motivational to use these systems for technological applications. The study of critical exponents shows that critical parameters are close to the parameters which are obtained by the mean-field theory. Low-temperature MH curve exhibits a very weak MMT on 50% Tb doping owing to emergence of interaction of Tb^{3+} ions. More interestingly, these materials also show magnetocaloric effect, which is of great importance for cooling devices.

Next, detailed study of magnetic and electrical properties of $EuPrCoMnO_6$ have been carried out. It shows multiple successive magnetic transition below 160 K owing to the different Co/Mn magnetic ordering. Further magnetization curve shows a magnetic anomaly around 40 K, which was probed to be due a re-entrant glassy dynamic. Also, a weak glassy transition near magnetic ordering temperature also was observed in the AC susceptibility spectrum. $EuPrCoMnO_6$ also shows Griffiths-like phase in paramagnetic region. More interestingly, it exhibits a purely field induced metamagnetic transition and spontaneous exchange bias at low temperature. There was an increase in resistivity of $EuPrCoMnO_6$ under application of DC magnetic field, showing the presence of positive magnetoresistance. The dielectric spectrum exhibits large dielectric constant near room temperature.

Moreover, the electrical properties of the pyrochlore oxide $Eu_2Ti_2O_7$ have been investigated. It has been that $Eu_2Ti_2O_7$ exhibits a local symmetry breaking 200 K which is attributed to the TiO_6 octahedra. It also the signature of crystal field driven spin-phonon coupling as a prominent anomalous softening in Raman modes and short-range magnetic ordering exist in $Eu_2Ti_2O_7$ below ~ 150 K. More interestingly, a glassy diffused dielectric

relaxor transition in $\text{Eu}_2\text{Ti}_2\text{O}_7$ around 150 K have also been observed; implying that the crystal field, phonon and electric dipoles are correlated to each other. Additionally, analysis of dielectric relaxation spectrum shows the existence of super-paraelectric state in the system rather than dipolar glass. Most importantly, a dielectric transition at lower temperature (below 40 K) has been observed and also there is strong spin freezing below 40 K. This suggest the possibility that the low temperature dielectric transition is related to spin-spin correlation.

7.2 Future scope

As mentioned earlier, the $\text{Eu}_2\text{CoMnO}_6$ possesses strong metamagnetic state along with magnetocaloric effect. Thus, there is possibility of making solid state cooling device using such material in future. The EuTbCoMnO_6 exhibits giant dielectric constant, thus can be used as a good dielectric material. The study on EuPrCoMnO_6 also shows giant dielectric constant along with spontaneous exchange bias and large magnetoresistance, thus can be used for spintronic devices and for high dielectric applications.

The $\text{Eu}_2\text{Ti}_2\text{O}_7$ showed a diffused dielectric relaxor behavior and possibility of coupling of the crystal field, phonon and electric dipoles and a low temperature dielectric transition related to spin-spin correlation. Furthermore, detail structural and magnetic study using other experiments like Mossbauer spectroscopy, neutron diffraction and theoretical DFT calculations can also be performed to clarify the exact origin of the observed spin dynamics and electrical polarization.

It is well-known that the epitaxial growth of the thin films by different techniques produces highly B-site ordered double perovskites. Hence, epitaxial growth of the thin films

of disordered double perovskites can be done to study the effect of largely reduced B-site disorder on its magnetic properties. It will also allow us to fabricate magnetic devices based on their multi-functional properties so that it can finally be applicable to the real life.