

## **Abstract**

The study of the critical behavior of magnetic systems in the vicinity of magnetic phase transitions continues to be a topic of great interest in condensed matter physics. The knowledge of critical behavior and critical exponents provides information into the nature of interactions causing the phase transition and characterize the universality class of the phase change. In this work, we first study the critical behavior in the vicinity of paramagnetic to ferromagnetic phase transition on some double perovskites  $A_2NiMnO_6$  (where  $A = Sm, Pr, \text{ and } Nd$ ) materials. The obtained critical exponents suggest that the magnetic ions contributing to the ferromagnetic phase transition in  $Sm_2NiMnO_6$  follow 3d-Heisenberg Model while long-range mean-field like interactions are responsible for the ferromagnetic phase transition in  $Pr_2NiMnO_6$  and  $Nd_2NiMnO_6$ . The second theme of the work was to understand how to control and tune the MCE, which is a useful technology in magnetic refrigeration. We have studied specific materials like the Rare-earth double perovskites and 3d-metal Chromites, both of which contain more than one magnetic sub-lattice. By our study on these particular material families, we have been able to give general recipes to control the MCE by tuning the magnetic moment size and the nature of the magnetic exchange interactions between the two sub lattices. In the final project, we have sought to marry topological properties with MCE functionalities. We have studied the "rotating MCE" in a ferromagnetic Weyl semi-metal  $Co_3Sn_2S_2$  and demonstrated that materials with anisotropic band-structures (such a Topological material) and anisotropic magnetic properties could be more effective in magnetic refrigeration technologies since a large magnetic entropy change can be achieved just by rotating the magnetic material in a fixed magnetic field. This is more effective compared to conventional MCE, where one needs to change the magnetic field continues to drive a magnetic entropy change.