

# Title: XMCD study on the magnetic field induced ferroelectric state of $\text{PrMn}_2\text{O}_5$

Proposal Number: HC-3783

**Objectives of the experiment performed:**  $\text{PrMn}_2\text{O}_5$  is an exceptional member in the  $\text{RMn}_2\text{O}_5$  ( $R = \text{rare earth}$ ) type multiferroic family showing no ferroelectricity in ambient condition unlike the other members. Our recent electric polarization measurement on  $\text{PrMn}_2\text{O}_5$  under pulsed magnetic field shows emergence of field-induced ferroelectricity below the magnetic ordering temperature along the b-axis above  $\sim 15$  T for a field applied along the same direction. Such a feature is undoubtedly related to the evolution of non-collinear magnetic structure stabilized at zero field and required to be addressed in a proper way. As a consequence, we planned to perform transmission XMCD at the Mn K and Pr  $L_{2,3}$  edges with magnetic field up to 30 T along crystallographic b-axis. The goal of the experiment was to get track of the evolved spin components along the polarization axis and to unveil the role of Mn and Pr magnetic sub-lattices on the emergence of such field induced ferroelectric state.

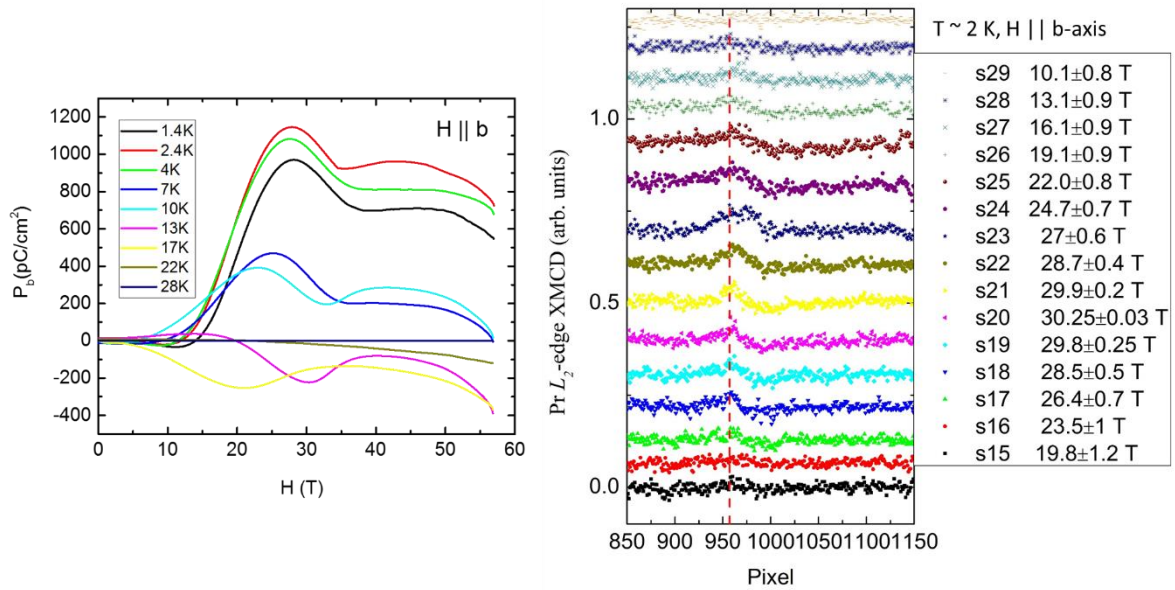


FIGURE: Left panel shows the field induced electric polarization effect. The right panel shows the XMCD signal measured at the Pr- $L_2$  absorption edge at 2 K.

**Outcome of the experiment:** The experiment was performed in the ID24 beamline of ESRF. We used a single crystal of  $\text{PrMn}_2\text{O}_5$  polished down to the thickness of  $\sim 10$  micro meter. After the completion of some initial standard XAS measurements at room temperature performed to ensure the good quality of the sample preparation, we successfully mounted the sample in the specially designed sample holder and managed to cool down to 2 K. We started the XMCD measurement at the Pr- $L_3$  edge with a field pulse up to 30 T along the b-axis of the sample. We did not observe any XMCD signal at this edge. After that we moved to the Pr- $L_2$  edge and started measuring XMCD at 2 K. At this absorption edge, we managed to make only 16 magnetic field pulses. After that, the magnetic power supply stopped working and we had to stop our measurement. We used only 10 shifts out of 18 shifts allotted for this experiment.

However, at the Pr-L<sub>2</sub> edge we had started to see the emergence of XMCD signal before the magnet power supply stopped working. The XMCD result by combining the signal of 16 pulses is depicted in the figure. As can be seen, the XMCD signal at the Pr-L<sub>2</sub> emerges in a magnetic field regime where the field induced electric polarization is the strongest. This very interesting result confirms the fact that indeed a detail XMCD experiment will play a major role in understanding the microscopic origin of the field induced ferroelectricity.

**Remarks:** The present experiment shows that it is possible to measure XMCD signal quite successfully in this composition. Before the occurrence of the unfortunate technical problem, we managed to observe XMCD at the Pr-L<sub>3</sub> absorption edge which is extremely interesting and pretty much new in this family of compound. However, to make it publishable, we need to collect more data to improve the statistics. It is also important to study the Mn-K edge as well. We would highly appreciate if the experiment is rescheduled and we get the opportunity to complete the investigation.