# Experimental Report: HC-5133
# Complex 4*f*-5*d* metamagnetism of $Nd_2ZnIrO_6$

1. **Description of experiment**

The coexistence of a localized and itinerant magnetic sublattices in the double perovskite $Nd_2ZnIrO_6$ results in non-collinear magnetic order that reacts anisotropically to external fields. In this pulsed-field single crystal XMCD study, we aimed to measure ion-specific magnetization curves of Nd and Ir to distinguish their roles in a series of metamagnetic transitions. The *L*-edges resonance of Nd and Ir make the material ideally suited for ionic-specific studies in the hard x-ray range.

The experiment was performed using the energy-dispersive XMCD setup at ID24-ED. For this, the samples had to be thinned to approximately the absorption length at the respective *L*-edges (Nd: 6.726 keV, 10 μm, Ir: 11.214 keV, 15 μm). In this session, all measurements were performed at the Ir $L_2$ edge, (the energy was calibrated using a Ta foil). For publishable statistics, we collected ca. 25 pairs of pulses each for CR and CL polarization (4.2 mF capacitor bank at 8.2 kV; 30 T / 22 ms pulse).

2. **Difficulties**

One difficulty of the energy-dispersive geometry is that inhomogeneities in the samples can cause anomalies in the spectra that may obscure the XMCD response. We found that some of our crystals contained an irregular distribution of flux inclusions. Suitability for our measurement could only be judged by mapping the homogeneity of the transmitted beam. Ultimately, this was acceptable, because we had prepared a large number of samples.

3. **Deviations from original proposal**

We originally proposed to investigate two ions (Nd, Ir), for fields applied along two different directions (H||***a***,***b***), and possibly even at two edges ($L_2$, $L_3$). Given the complexity of the setup (ca. 6 shifts preparation of the instrument), and the need to screen several samples, this proved much too ambitious. Instead, we limited our measurements to the Ir $L_2$ edge.

4. **Achievements**

We were able to obtain reproducible Ir $L_2$ 30 T XMCD curves for fields along the ***a*** and ***b*** axes, see Fig. 1. Surprisingly, the curves do not feature the step-like metamagnetic transition around 4~5 T, which we had observed in SQUID magnetometry (see proposal). The most likely explanation is that this transition is dominated by the large Nd magnetic moments. On the other hand, we discovered that the Ir magnetism is highly anisotropic at the broad metamagnetic transition around 20 T.

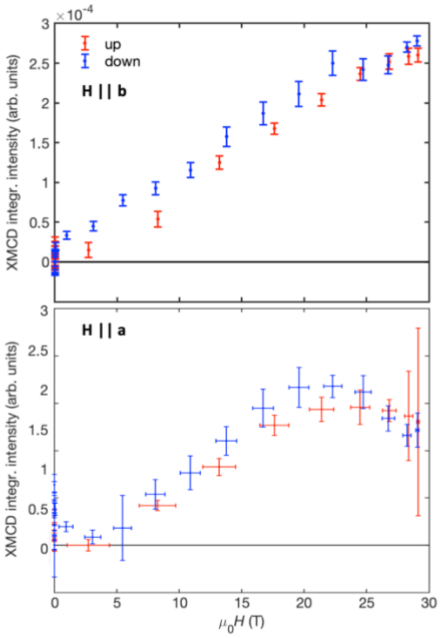


**Fig. 1.** Preliminary analysis of the 30 T XMCD signal for fields along the a and b axes of $Nd_2ZnIrO_6$ (an optimization of the raw data analysis may yet improve statistical uncertainties).

5. **Conclusion and Outlook**

This was our first synchrotron experiment using pulsed-field equipment (in particular, energy-dispersive XMCD). We had highly underestimate the overhead of beamtime spent on preparing the equipment and carrying out a diligent measurement (confirming the sample quality, reproducibility, sample centering etc.). Ultimately, we were able to obtain a conclusive dataset of the Ir magnetism, including new insights on the two metamagnetic transitions. **To bring this data to publication, the XMCD study must provide a consistent explanation of the bulk magnetization. This can only be achieved by measuring the response of the other magnetic sublattice. To this end we will propose a second session in which we will repeat the present experiment at the Nd *L* edge.**