Experimental report

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Title: Determining the magnetic structures of noncentrosymmetric EuPtAs

Research area: Physics

This proposal is a new proposal

Main proposer: **Michael SMIDMAN**

Experimental team: Wu XIE
Michael SMIDMAN
Devashibhai T. ADROJA

Local contacts: Oscar Ramon FABELO ROSA
Jose Alberto RODRIGUEZ VELAMAZAN

Samples: EuPtAs

Instrument	Requested days	Allocated days	From	To
D9	15	10	31/01/2020	10/02/2020

Abstract:

We propose to probe the magnetic structure of the noncentrosymmetric compound EuPtAs, in the zero-field and field-induced magnetic phases. Noncentrosymmetric intermetallic lanthanide materials have been found to exhibit a range of complex, non-collinear magnetic phases, due to the interplay of the Ruderman-Kittel-Kasuya-Yosida and Dzyaloshinskii-Moriya interactions. We recently synthesized single crystals of EuPtAs, which we found undergoes two antiferromagnetic transitions in zero-field below TN1=15 K and TN2=7.3 K. Upon the application of a magnetic field, the system undergoes multiple transitions, giving rise to a complex field-temperature phase diagram. We propose to determine the magnetic structure across this phase diagram by performing neutron diffraction measurements on the D9 instrument, at temperatures down to 2K and in fields of up to 5T along the c-axis. This will allow us to gain an understanding of the complex magnetism and underlying interactions in the system.

Experimental report: Determining the magnetic structures of noncentrosymmetric EuPtAs

We have performed single crystal neutron diffraction measurements on the antiferromagnetic compound EuPtAs using the D9 instrument. This has a noncentrosymmetric tetragonal crystal structure (space group $I4_1md$). Our physical properties measurements reveal the presence of two magnetic transitions in zero-applied field, and multiple field-induced magnetic phases. In this experiment, due to time limitations and the reduced beam time during the experiment due to a two-day reactor shutdown, we only measured in the two magnetic phases (with transitions at 15 K and 8 K). Due to the large neutron absorption cross section of Eu, we measured on D9 with a neutron wavelength of 0.85 Å.

During the experiment, after measuring a small number of peaks in the paramagnetic state, we cooled down to 2K to probe the magnetic phase. At 2K, magnetic Bragg peaks were found which approximately correspond to propagation vectors (0.5 0 0.5) and (0 0.5 0.5). Upon closer inspection, it was found that these peaks actually exhibited a double peak structure, and the intensity was not maximum at the center of the ω-scan, while no such splitting is seen in the nuclear reflections. This is shown clearly in Fig. 1, which displays the results from integrating the ω-scans of these reflections around the region of interest near the reflection. This suggests that the origin of the splitting is not due to a structural distortion, rather the magnetic propagation vector is incommensurate. From careful measurements of the positions of the maximum peak intensity, the propagation vectors were estimated to be (±0.52 0 0.56) and the symmetry related (0 ±0.52 0.56). A 2D-plot of the centre of the ω-scan of one such peak is displayed in Fig. 2, with a nuclear peak for comparison. Further reciprocal space scans were performed at 2 K, but no other magnetic Bragg peaks were detected. Therefore we measured all the accessible magnetic Bragg peaks with these propagation vectors within a certain Q range.

We also performed measurements at 10 K, where the incommensurate Bragg peaks are still detected, and again the accessible magnetic Bragg peaks within a range of Q were measured. We also warmed the system to 20K, and measured a large number of nuclear peaks, in order to constrain the crystal structure and determine the extinction parameters. In addition, the temperature dependence of two magnetic peaks and two nuclear peaks were measured, to look for the temperature dependence of the order parameter, and for any evidence of a k=0 component.

Work is currently underway to analyze the possible magnetic structures, and fit the data with different models. Due to the unusual field-temperature phase diagram, in particular the presence of a dome-shaped field-induced phase for fields between 4 and 6 T along the c-axis, it would be of particular interest to perform further measurements on D9, with a magnetic field applied along the c-axis.

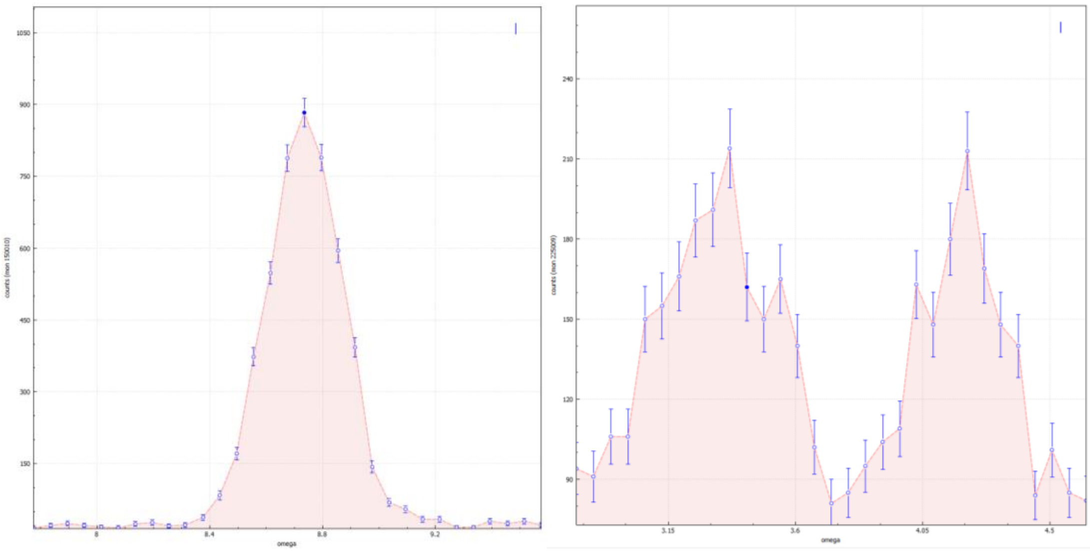

Fig. 1. Integration of the collected ω-scans around the (1 -1 2) nuclear and (0.5 0 1.5) magnetic reflections. In order to reduce the background contribution the integration was done using a region of interest around the observed reflection.

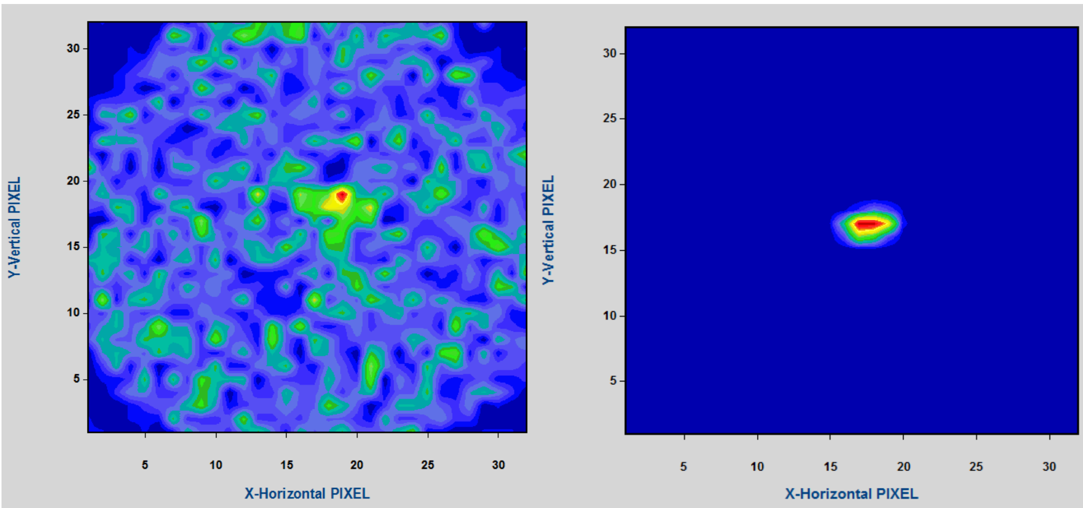

Fig. 2. 2D plots at the center of the ω-scan for the (0.00 -0.48 1.56) magnetic reflection (left), and (1 -1 2) allowed nuclear reflection at 2 K.