Experimental report

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Proposal: DIR-254 **Council:** 4/2021

Title: Magnetoelastic coupling of crystalfield transitions and lattice excitations in CePdAl3

Research area: Physics

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Samples: CePdAl3

Instrument	Requested days	Allocated days	From	To
PANTHER	5	5	08/10/2021	11/10/2021

Abstract:

A new kind of magnetoelastic coupling was observed in the tetragonal compounds of the CeTAl3 family of compounds. The coupling involves the localised transition between the crystal electric field split levels of the magnetic Ce ion and the phonons, collective vibrations of the lattice atoms. On the other hand we have observed that in CeTAl3 compounds the magnetic ordering is strongly influenced by the lattice symmetry. This motivated us to investigate the interaction between the crystal field transitions and phonons in the orthorhombic CePdAl3. We want to determine the crystal field energy levels and look for hints for phonon-crystal field coupling in broad Q-range.

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Magnetoelastic coupling of crystalfield transitions and lattice excitations in CePdAl3

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The goal of the beamtime was to investigate the magnetoelastic coupling between the phonons and electron transition in the crystal-electric field of CePdAl3. We performed a series of measurements at various temperatures mapping the momentum-energy transfer space. We did not observe clear evidence of magnetoelastic coupling, such as anti-crossing of CEF bands or unusual phonon dispersions. However, further investigation is ongoing.

On the other hand, we took advantage of performing a single-crystal measurements at PANTHER in order to characterize the CEF scheme. The advantage of using a single-crystal over a polycrystalline sample is that additional information on the J matrix elements can be decoded from the Q-dependence of the CEF level intensity. The illustration of that phenomenon is shown in Figure 1. We detected two transitions at 2 meV and 7 meV energy transfer and reconstructed the measured intensity on the (HKH) scattering plane.

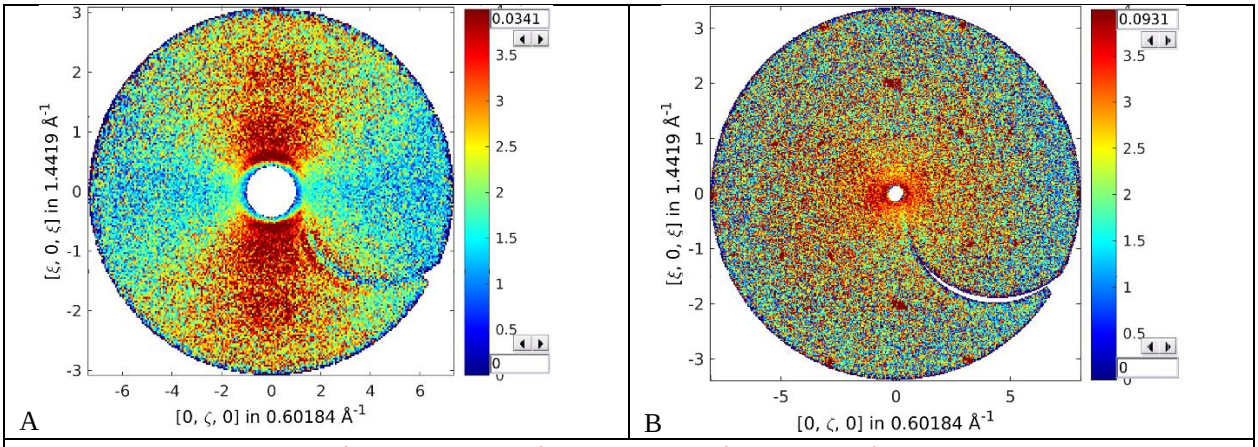

Figure 1. Momentum transfer dependence of the intensity of the crystal-field transitions in CePdAl3. (A) Intensity of the 7 meV transition reconstructed by integrating over the 6<E<9 meV energy transfer and projected on the (HKH) scattering plane. (B) Intensity of the meV transition integrated over 1.5<E<3 meV.

We observed a strong directional dependence of the 7 meV transition and lack of thereof in the 2 meV transition. Both of these provide a strong constraint for the determination of the crystal field parameters of CePdAl3. Important to say, CePdAl3 is orthorhombic with a Ce3+ ion, which results in a J=5/2 system, with 3 double degenerated levels. That allows for 5 independents CEF parameters. Conventional measurements on polycrystalline sample would provide the transition energies (2 constraints) and a ration of the transition intensities (1 constraint) providing 3 constraints on a 5 parameter problem.

We developed new analysis tools for determining the CEF parameters from single-crystal measurements. With measurements on a single-crystal we are able to provide further constraints for that problem and obtain reliable set of parameters.