Experimental report

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Proposal: **5-41-807** **Council:** 10/2014

Title: Investigation of the Magnetic Phases of the New Ambient Pressure Heavy Fermion Superconductor Ce3PtIn11.

Research area: Physics

This proposal is a new proposal

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Samples: Ce3PtIn11

Instrument	Requested days	Allocated days	From	To
D10	10	8	02/11/2015	10/11/2015

Abstract:

We recently were able to synthesize a new heavy Fermion compound Ce3PtIn11. This compound belongs to the same type family of Ce-based heavy fermion superconductors as CeRhIn5 (under pressure) and CeCoIn5 (ambient pressure). Experiments on high quality single crystals of Ce3PtIn11 revealed that at ambient pressure the compound exhibits two successive
transitions at T1 = 2.2 K and TN = 2.05 K and below Tc = 0.32K enters into a superconducting state. We propose a neutron experiment on a stack of oriented single crystals in order to determine the magnetic structures of the – likely - incommensurate (T1), commensurate (TN) and superconducting (Tc) state at ambient pressure. By additionally determining the effective moment on the Ce-ion in each phase it can be concluded if magnetism is from local 4f moments which is of importance to the pairing mechanism of the Cooper pairs as well of the nature of the quantum critical point of this compound. In this view, Ce3PtIn11 might be unique, being the first known stoichiometric and full inversion symmetrical Ce-based heavy Fermion compound where superconductivity develops out of a local moment magnetic state at ambient pressure.

EXPERIMENTAL REPORT OF PROPOSAL 5-41-807: "Investigation of the Magnetic Phases of the New Ambient Pressure Heavy Fermion Superconductor Ce_3PtIn_{11}."

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The aim of the experiment was to determine the magnetic structure of the novel heavy fermion superconductor Ce_3PtIn_{11}. The compound crystallizes in the typical tetragonal structure (space group *P4/mmm*) based on the $AuPt_3$-type ($CeIn_3$-block) and $PtHg_2$-type (TIn_2–block with T = transition metal) units alternating along the *c*-axis. The stacking leads to a remarkable peculiarity; the compound possesses two inequivalent crystallographic Ce-sites with the Ce1-site occupying the Wyckoff *2g* position and the Ce2 resides at *1a* and hence each site spans a layer of equivalent Ce-ions (for details, see [1]). The Ce2-site experiences a $CeIn_3$ environment, whereas the Ce1-site's surrounding atoms are identical with those Ce-ions in Ce_2PtIn_8 [2]. At ambient pressure Ce_3PtIn_{11} exhibits two successive transitions at T_1 = 2.2 K and T_N = 2.05 K into a possible incommensurate (iAFM) and commensurate (AFM) local moment AFM state, respectively, before becoming superconducting below T_c =0.32 K [1]. The mechanism behind this apparent duality of magnetism and superconductivity is yet not fully comprehended. The observation of superconductivity emerging in the magnetic phase in Ce_3PtIn_{11} at ambient pressure might be a breakthrough in understanding this heavily discussed phenomenon in heavy fermion community [3, 4]. So far one could only speculate about the magnetism and coexistence of magnetism and superconductivity in this compound. The neutron experiment was performed to answer the most pressing questions: (1) the magnetic structures of iAFM and AFM phase. (2) coexistence/competition of SC and magnetism and (3) is the magnetic moment on Ce1 the same as on Ce2, which otherwise might hint to a spatial separation of magnetism and SC.

For the experiment performed at ambient pressure, one Ce_3PtIn_{11} single crystal of mass 10.4 mg has been selected after being analyzed by EDX, single-crystal x-ray diffraction and specific heat. Prior to the experiment on D10, the sample was measured on CYCLOPS diffractometer in order to find possible magnetic reflections and eventually the propagation vector of the magnetic structure. However, no additional reflections have been found suggesting that the magnetic unit cell may equal to the crystallographic unit cell. The more probable scenario is, however, that the cerium magnetic moment in the compound is too weak to be detected using CYCLOPS.

The allocated measurement time on D10 was 8 days. The dilution four-cycle cryostat was used in order to reach both the magnetic iAFM and AFM and superconducting state in Ce_3PtIn_{11}. The single crystal has been attached to the sample holder with its *c*-axis in the axis of holder. First, the UB matrix was obtained and the nuclear reflections in the paramagnetic region (at 10 K) were collected. After that, the temperature was lowered down to 0.8 K in order to search for magnetic satellites. We scanned the reciprocal space along the most symmetrical directions in fine steps (0.02 - 0.007) employing in turns both 2D camera and tube analyzer. No magnetic reflection was found. In further step, we focused on the weakest available nuclear transitions (225,425,625, 115, 315, 515, etc.) to observe any possible difference in their intensity between the paramagnetic and ordered state. Unfortunately, we were not able to find any traces of magnetic signal. The last approach we performed was the temperature scan (temperature interval 0.1 - 3 K and 5 K) of selected nuclear intensities (201, 00-7,-113, 010 and -2-2-7); however, no evolution of integral intensities was observed. To sum up, we were not able to determine the propagation vector of the magnetic structure of Ce_3PtIn_{11} as we have not observed any magnetic reflection. We assume that the cerium magnetic moment is extremely small to be resolved by D10. Another scenario suggests that the magnetic reflections can be found in the reciprocal space in higher Q, but in such case, their intensity would be probably not strong enough to be detected.

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