Experimental report

17/05/2024

Proposal: **5-41-1214** **Council:** 4/2023

Title: Magnetic structure of Ce2Bi

Research area: Physics

This proposal is a new proposal

Main proposer: **Nikolai PAVLOVSKII**

Experimental team: Anton KULBAKOV
Nikolai PAVLOVSKII

Local contacts: Eric RESSOUCHE
Ketty BEAUVOIS

Samples: Ce2Bi

Instrument	Requested days	Allocated days	From	To
D10	4	0		
D23	4	5	02/11/2023	07/11/2023
ORIENTEXPRESS	1	1	08/11/2023	09/11/2023

Abstract:

The tetragonal compound Ce2Bi shows the layered structure (space group: I4/mmm) with two inequivalent Ce sites. This material undergoes antiferromagnetic ordering at TN = 10 K. Additionally, in-field measurements have revealed the presence of a metamagnetic transition (occurring at ¿1.75 T) into a phase known as the field-induced magnetic phase (FIMP). The nature of the FIMP state above the metamagnetic transition remains to be determined, in particular whether this corresponds to a field induced spin-polarized state, or a different field-induced magnetic state with a net magnetization less than the saturated value. The main purpose of this experiment is to refine the magnetic structure of this compound in the AFM and FIMP phases.

Experiment Title

Magnetic structure of Ce_2Bi

Proposer

Name: Nikolai Pavlovskii <nikolai.pavlovskii@tu-dresden.de>
Affiliation: Technische Universität Dresden, Germany
Co-proposers: Dmytro Inosov, Anton Kulbakov

Report

Introduction

The compounds Ce_2Bi and Ce_2Sb represent rare examples of the heavy fermion materials that exhibit the coexistence of an antiferromagnetic magnetic (AFM) order and a tricritical point (TCP) in their temperature-magnetic field (T, B) phase diagram [1]. This combination is unusual because the TCP typically occurs in the ferromagnetic (FM) heavy fermion materials. In AFMs, the magnetic order can in many cases be continuously suppressed to zero temperature at a quantum critical point (QCP) by tuning pressure, magnetic fields, or chemical substitution. In the case of FMs, the situation is usually different. There, a QCP is generally avoided by changing the character of the magnetic phase transition from the second order to the first order, which induces a TCP [1].

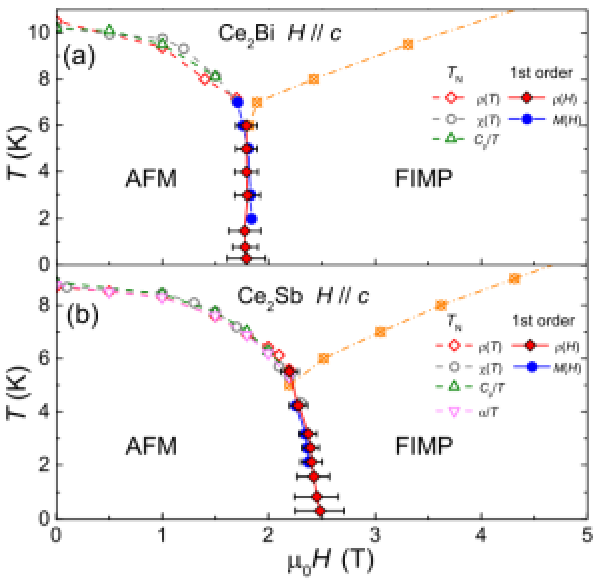

Fig. 1 The magnetic phase diagtam of Ce_2Bi and Ce_2Sb from Ref. [1]

The tetragonal compounds Ce_2Bi and Ce_2Sb undergo the AFM transitions at around 10 and 8 K, respectively [2-4]. Both materials share the same layered structure. Additionally, in-field measurements have revealed the presence of a metamagnetic transition (occurring at ∼1.75 T for Ce_2Bi and at ∼2.5 T for Ce_2Sb) into a phase known as the field-induced magnetic phase (FIMP) [1]. A distinctive feature of this transition is the crossover from the second-order transition to the first-order transition with decreasing of the temperature. These findings suggest the existence of a tricritical point (TCP) in the phase diagram of the material. The nature of the FIMP state above the metamagnetic transition remains to be determined, in particular whether this corresponds to a field induced spin-polarized state, or a different field-induced magnetic state with a net magnetization less than the saturated value.

Experimental configuration and results

The experiment was conducted from November 2 to November 7 using the D23 instrument, thermal neutron lifting-counter two-axis diffractometer at ILL, France. Neutrons with the wavelength λ = 1.282 Å were selected using a PG (002) monochromator. We were allocated one extra day, so we decided to take an additional sample (Ce_2Sb).

Our main purpose of this experiment is to refine the magnetic structure of Ce_2Bi in the AFM and FIMP phases. We mounted the sample in the (H 0 L) scattering plane to reach the magnetic ordering vectors. However, when determining the structural peaks, we noticed a high degree of mosaicity in the single crystal, which resulted in very broad peaks. To accurately identify the problem, we attempted to determine the degree of mosaicity using the OrientExpress instrument (automatic Laue neutron-diffractometer), which confirmed that the sample was unsuitable for this study (Fig. 2). We suspect that the sample degraded in air. Unfortunately, the penetrating capability of our laboratory X-ray Laue instrument was insufficient to detect this and select a different single crystal. After that, we decided to use a second sample, which we also checked with the OrientExpress. Its quality was sufficient to continue the experiment (Fig. 3).

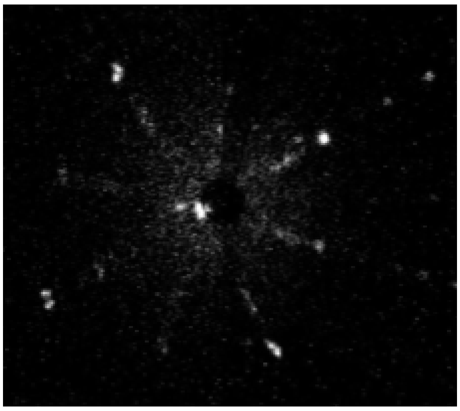

Fig. 2 Laue pattern of Ce_2Bi

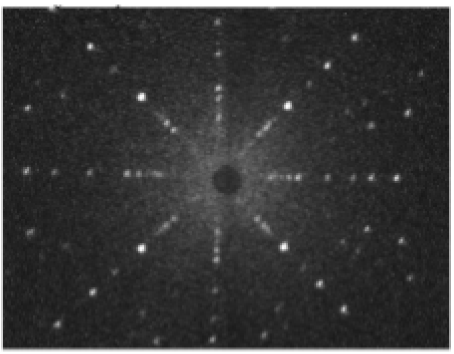

Fig. 3 Laue pattern of Ce_2Sb

Given the similar magnetic phase diagrams (Fig. 1), we assumed that the magnetic structure of these compounds (Ce_2Bi and Ce_2Sb) would also be similar. Therefore, we attempted to locate the magnetic peak (1 0 1/2) we had observed earlier in the compound Ce_2Bi. Despite our efforts, we did not observe any significant magnetic peaks in Ce_2Sb. This suggests that the magnetic ordering in Ce_2Sb differs from that in Ce_2Bi.

In summary, while the experiment did not yield the expected magnetic peaks in Ce_2Sb, it provided valuable information about the differences in magnetic ordering between Ce_2Bi and Ce_2Sb. These findings will inform future research directions and experimental approaches to elucidate the magnetic structures of these compounds.

[1] F. Wu et al., PHYSICAL REVIEW B 99, 064419 (2019)
[2] A. ISOBE et al., Journal of Magnetism and Magnetic Materials 70 (1987) 391-392
[3] K. Ohoyama et al., Journal of Physics and Chemistry of Solids 60 (1999) 1189–1191
[4] A. Oyamada et al., Journal of the Physical Society of Japan Vol. 62 No.5 May 1993