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High Field Magnetization measurements of uranium dioxide single crystals (P08358-E003-PF)

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Introduction

UO_2 is a Mott-Hubbard insulator with well-localized 5*f*-electrons (rare situation among actinide compounds), and its crystal structure is the face-centered-cubic fluorite (CaF_2). It experiences a first order antiferromagnetic phase transition at 30 K to a non-collinear 3-***k*** antiferromagnetic structure, consisting of four sub-lattices having the moments oriented along <111> directions [1]. This transition is accompanied with a simultaneous quadrupolar ordering of the charge density. It is believed that the first order nature of the transition results from the competition between the exchange interaction and the Jahn-Teller distortion of oxygen atoms [2].

Experimental

The magnetization has been measured on several small randomly oriented single crystals of uranium dioxide using a custom-made *ac* experimental setup. The measurements have been performed in pulsed magnetic fields up to 65 T (NHMFL LANL).

Results and Discussion

Figure 1a shows the magnetic field dependence of magnetization of UO_2. The measurements have been performed with increasing and decreasing magnetic field. In paramagnetic state (see for instance 35 K curve in Figure 1a) the magnetization shows a linear M(H) behavior characteristic of Curie law. In antiferromagnetic state the magnetization shows a slight deviation from linearity. Arrows in Figure 1a mark positions where M(H) curves start to deviate from the linearity. Even though the deviation is weak a tentative phase diagram can be constructed (Figure 1b). Previous measurements identified details of the antiferromagnetic structure to be non-collinear 3-**k**. The nature of the high field magnetic state is unclear at the time of writing this report.

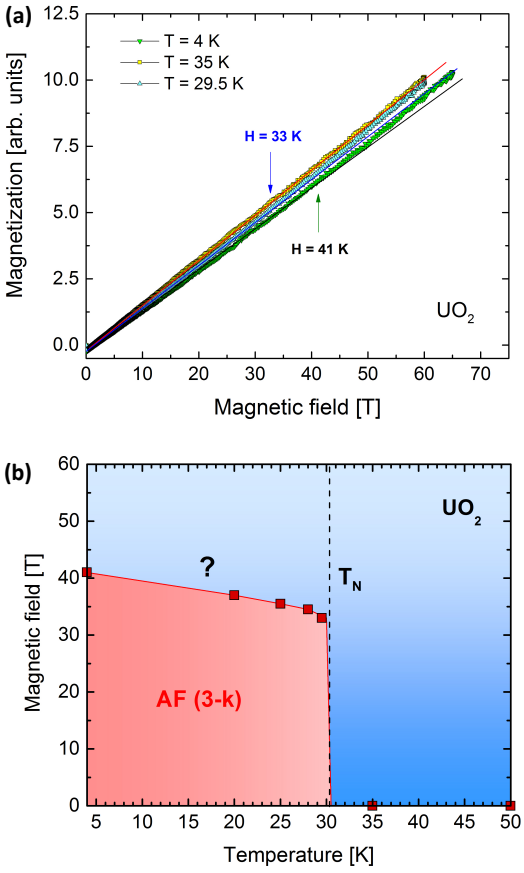

Figure 1 The field dependence of magnetization of UO_2 single crystals performed at 35, 29.5, and 4 K. The arrows mark position where a small deviation from linear behavior is observed. (b) A tentative phase diagram obtained from the magnetization results.

Conclusions

Our preliminary high field magnetic measurements of UO_2 are consistent with a complex nature of the magnetic ordering in this material, compatible with the previously proposed non-collinear 3-***k*** magnetic structure. Further extensive magnetic studies on well-oriented (<100 > and <111>) UO_2 crystals are planned to address the puzzling behavior of UO_2 in both antiferromagnetic and paramagnetic states at high fields.

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