Thermodynamic signatures of a nearby quantum critical endpoint in UTe_2 under intense magnetic field

We have performed a magnetization study of the unconventional superconductor UTe_2 under pulsed magnetic fields up to 55 T. The magnetic field was tilted by an angle θ from the direction **b** towards the direction **c** of the sample. Our measurements show that the enhancement with θ of the metamagnetic field is accompanied by a reduction of the first-order step in the magnetization, indicating the proximity of a quantum critical endpoint. In the light of our results, a next challenge will be to determine the relation between the quantum critical endpoint and the stabilization of field-induced superconductivity beyond 40 T in this system under magnetic fields tilted by a magic angle $\theta = 35°$.

Several field-induced superconducting phases have been discovered in the paramagnetic heavy-fermion compound UTe_2, revealing a new playground to study the relation between magnetism and superconductivity. At zero magnetic field, a superconducting phase SC1 below $T_{sc} \approx 2$ K was identified as a candidate for a triplet mechanism [1,2]. Under a magnetic field applied along the hard magnetic direction **b**, SC1 vanishes near 20 T and a field-induced superconducting phase SC2 is stabilized near a metamagnetic transition at $\mu_0 H_m$ = 34 T, for $H \lesssim H_m$ [3,4,5]. The metamagnetic transition is associated with a first-order step ΔM = 0.55 μ_B/U in the magnetization, which precedes the onset of a polarized paramagnetic (PPM) regime. By tilting the magnetic field by a magic angle $\theta = 35°$ from **b** to **c**, a second field-induced superconducting phase SC-PPM is stabilized for $H \gtrsim H_m$, i.e., in the PPM regime beyond the metamagnetic transition observed then at $\mu_0 H_m$ = 40 − 45 T [5,6].

Figure 1 shows that the amplitude of the step ΔM induced in the magnetization at the metamagnetic field, decreases when the

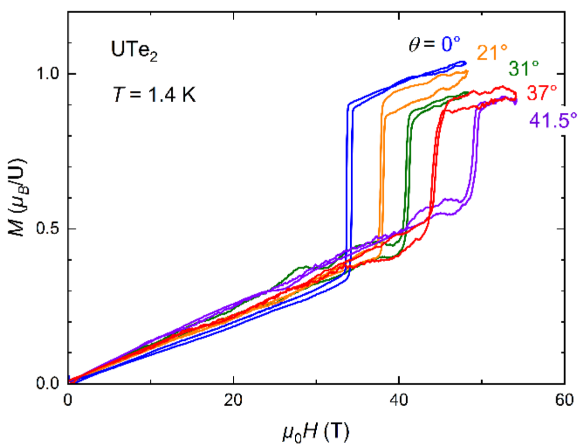

Figure 1: Magnetization versus magnetic field of UTe_2, measured under magnetic-field directions tilted by different angles θ from **b** to **c** at the temperature T = 1.4 K.

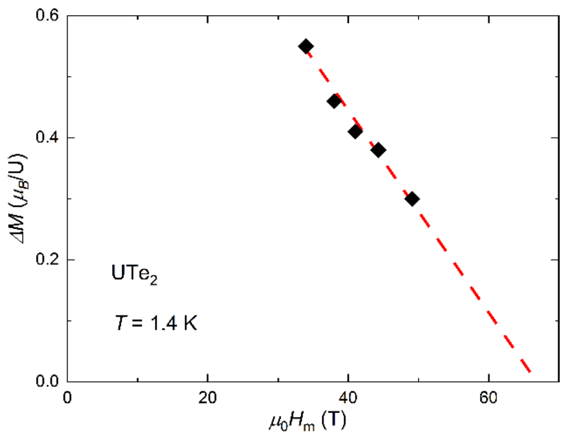

Figure 2: Step ΔM in the magnetization at H_m versus H_m measured in UTe2 under magnetic-field directions tilted by different angles θ from **b** to **c** at the temperature T = 1.4 K.

metamagnetic field is increased by tilting its direction by an angle θ from **b** to **c**. For $\theta = 41°$, ΔM = 0.3 μ_B/U has been reduced by a factor 2 in comparison with its value for $\theta = 0°$. As shown in Figure 2, ΔM is linearly related to H_m. Assuming that this linear relation can be extrapolated at larger angles θ, our ΔM versus H_m data indicate the possible presence of a quantum critical endpoint, at which the first order character of the metamagnetic transition would vanish, for a critical value of the metamagnetic field $\mu_0 H_m^c$ = 65 − 70 T. Our results raise several questions. What is the relation between the field-induced superconducting phases and the possible presence of a quantum critical endpoint of the metamagnetic transition? Can we observe other field-induced superconducting phase (s) at larger magnetic fields and beyond the quantum critical endpoint? To answer these questions, new series of magnetization experiments, under wider ranges of temperatures and magnetic fields will be needed.

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