Experimental report

29/05/2024

Proposal:	**4-03-1756**	**Council:**	10/2022

Title: Understanding the quantum criticalfluctuations in the frustrated metal YbAgGe

Research area: Physics

This proposal is a resubmission of 4-03-1753

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Samples: YbAgGe

Instrument	Requested days	Allocated days	From	To
ORIENTEXPRESS	1	1	25/05/2023	26/05/2023
IN5	7	7	25/05/2023	01/06/2023

Abstract:

Metallic magnets with frustrated interactions may host novel quantum spin liquid states, but their experimental determination is very challenging. The phases are predicted close to quantum phase transitions, where the energy scale of the critical fluctuations overlaps with the characteristic spin-liquid excitations. YbAgGe is as a frustrated metal that undergoes a magnetic field-driven bicritical quantum phase transition, excluding the possibility of an interfering quantum spin liquid state. Using the material as a model system to establish detailed knowledge of how magnetic frustration affects quantum critical fluctuations. We plan to study the temperature dependence of the critical fluctuations on either side of the bicritical point, which will allow us to determine the universality class of frustrated quantum phase transitions.

Experimental report

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The experiment was performed from Thursday May 25th to Thursday June 1st 2023 with our two coaligned YbAgGe samples of total mass 4 g. The samples were aligned with the (1, -1, 0)-axis vertical. Due to the proximity of the holder base from the neutron beam, the holder has been covered with a layer of gadolinium-oxyde powder mixed with glue to reduce parasitic scattering. A dilution fridge inside the 10 T vertical magnet was used.

Contrary to the initial plan, where we wanted to measure the critical scaling at a fields above and below the phase transition, we opted for a single measurement exactly at the bi-quantum critical point. This maximizes the signal of the critical scattering and record contributions from both phases in one scan. They can then be disentangled as they lie at different q-vector. We thus decided to measure at a field of 4.5 T and temperatures of 0.05, 0.25, 1, 4, 16 K and 50 K for background. To avoid hysteresis from the first order transition between the two ordered phases, we performed a field cooling from the paramagnetic phase into the ordered phase.

Due to the high background noise stemming from the magnet/dilution and low intensity of the diffuse scattering, our first measurement with an incoming energy of 5.5 meV was unsuccessful. We decided to lower the incoming energy to 3.55 meV to be below the treshold of the aluminium lines at the expense of out-of-plane coverage. With this setup, we finally saw the diffuse scattering signal. We settled for measurement scans of 1 degree steps in a_3 and 5 minutes per points. The diffuse scattering obtained at 4.5 T and base temperature (50 mK) is shown by Figure 1. It follows a similar shape as the one previously taken at zero field at CNCS [1]. At a quantum critical wavevector, the intensity of the magnetic scattering exhibit a so-called E/T scaling. Such scaling is shown by Figure 2 for a given critical exponent $\alpha = 1.5$. For this exponent, the scaling is not perfectly continuous, indicating as expected that the fluctuations are not from a simple antiferromagnetic model.

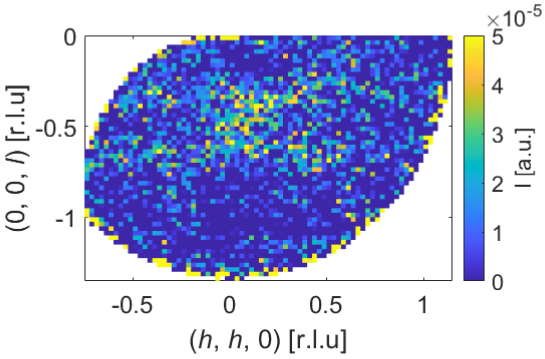

Figure 1: Background substracted signal obtained in the $(h,\, h,\, l)$ plane at 50 mK and 4.5 T.

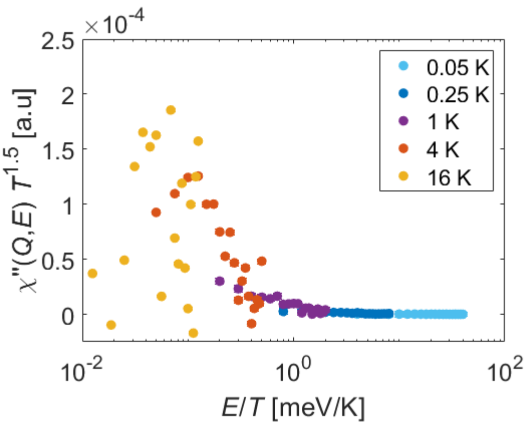

Figure 2: E/T scaling of the magnetic scattering for a given α= 1.5.

At the end of the experiment, we realized that one of the two sample fell off the holder. It is unknown if it fell at the very beginning during cooldown, during the experiment or at the end while getting back up to room temperature. Despite this unfortunate event, the data is workable and we are currently in the process of analyzing them further and more in depth.

[1] L. Poudel *et al.* *npj Quantum Materials*, 4(52), 2019.