Experimental report

01/07/2022

Proposal: **4-05-846** **Council:** 4/2021

Title: Spin dynamics in hafnium-doped holmium titanate pyrochlore.

Research area: Physics

This proposal is a resubmission of 4-05-831

Main proposer: **Romain SIBILLE**

Experimental team: Victor POREE
Elsa LHOTEL
Edward RIORDAN

Local contacts: Peter FALUS

Samples: $Ho_2(Ti_{0.9}Hf_{0.1})_2O_7$

Instrument	Requested days	Allocated days	From	To
WASP	6	5	07/10/2021	12/10/2021

Abstract:

Following a theoretical study, we propose to investigate possible disorder-induced Quantum Spin Liquids. A possible route to tune such disorder is to control the density of Frenkel pair defects in an initially classical pyrochlore spin ice. This can be achieved by admixing quadrivalent cations at the pyrochlore B site. In this spirit, a series of non-Kramers rare-earth pyrochlore was synthesized and characterized using XRD, NPD and magnetic susceptibility. Experimental observations corroborate the persistence of spin ice correlations along with strengthened fluctuations due to disorder-induced transverse fields. A change in the spin dynamics is thus expected, compared to the classical spin ice. This experiment aims at using neutron spin echo spectroscopy on $Ho_2(Ti_{0.9}Hf_{0.1})_2O_7$ and compare its dynamics with that of the classical system $Ho_2Ti_2O_7$.

Experiment # 4-05-846 : Spin dynamics in hafnium-doped holmium titanate pyrochlore.

A large powder sample of $Ho_2Ti_{1.8}Hf_{0.2}O_7$, placed in a copper can, was mounted on a dilution fridge. The can was filled with few bars of He in order to have as efficient cooling as possible. After some cryogenics issues, a base temperature of the dilution fridge of about 80 mK was reached. This step took a few hours due to the powder nature of the sample. Some data were also collected at 0.1 K, which looked identical to the previous one, indicating no big change in the dynamics of the sample between these two temperatures. The same measurements (~6h) were then performed at various temperature so as to obtain a detailed evolution of the signal as a function of temperature (0.5 K, 1 K, 2 K, 1.5 K, 3K, 5K, 10 K, 20K, 30 K, 40 K, 50 K, 65 K, 80 K, 100 K, 150 K and 200 K). The collected data were individually reduced and fitted using a stretched exponential, as typically done for such spin ice systems. Data and associated fits can be seen in Fig. 1.

The temperature dependence of the fitting parameters is showed in Fig. 2. The best fits were eventually obtained by fixing the stretching parameter to 0.6 for reasons that are still to clarify. From the plot of the relaxation time, we observe a behavior similar to that of the pure $Ho_2Ti_2O_7$ sample, with an increase of the relaxation time when cooling from room temperature, indicating that thermal relaxation is primarily involved, followed by a plateau region where quantum fluctuations seem to stabilize the relaxation time. Eventually, further cooling leads to a divergence of the relaxation time indicating a somewhat strong freezing of the spins.

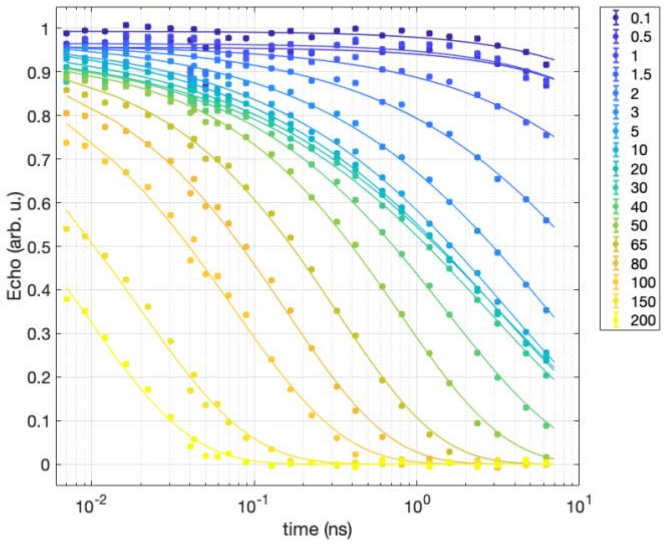

Figure 1: Temperature dependence of the spin echo signal as a function of time. The experimental data are showed by the dots whereas the lines present the associated fits using a stretched exponential.

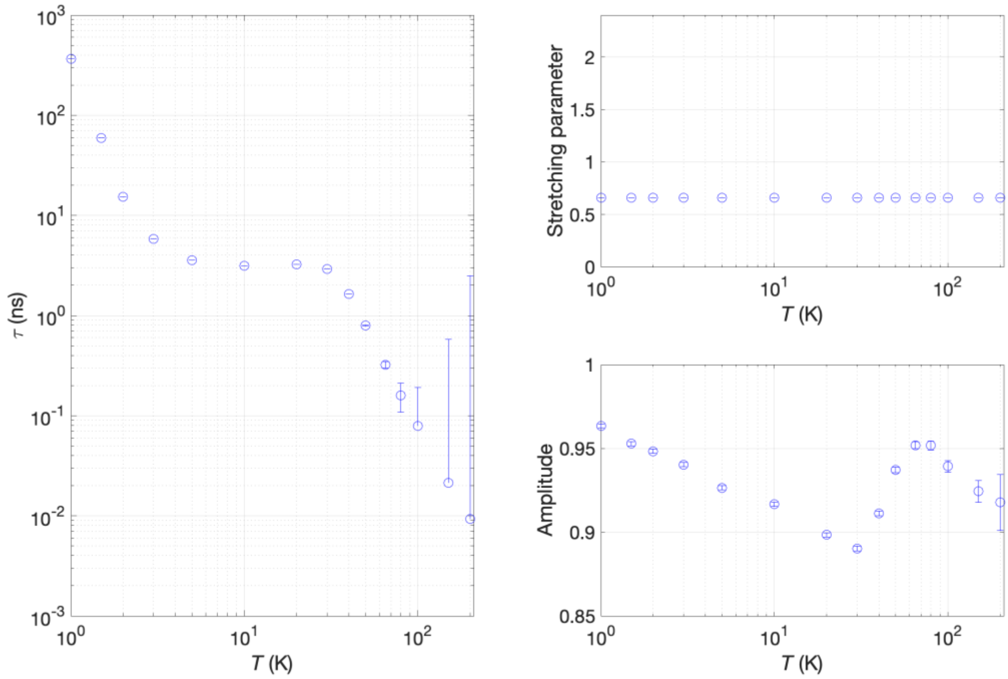

Figure 2: On the left: Temperature dependence of the relaxation times extracted from the stretched exponential fits. The best fits were obtained fixing the stretching parameter to 0.6 as evidenced by the top-right panel. The amplitude of the signal as a function of temperature is plotted in the bottom-right panel.