Multiple Relaxation Channels in Spin Ice Materials $CdEr_2Se_4$ and $CdEr_2S_4$ Under Applied Magnetic Fields

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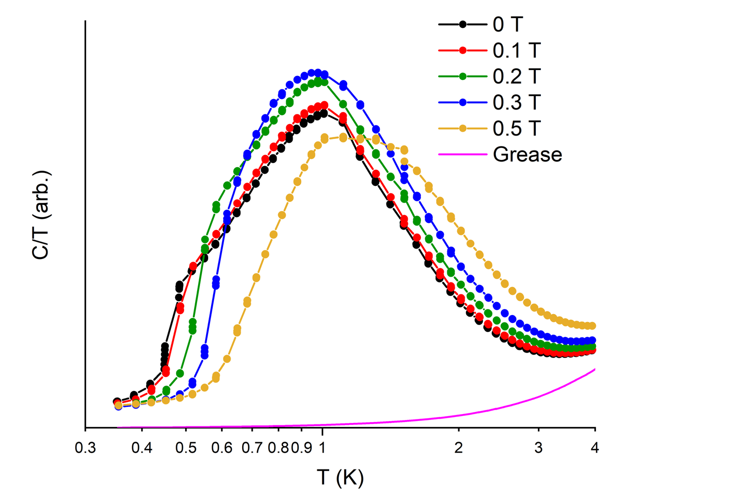
Introduction

The materials $CdEr_2Se_4$ and $CdEr_2S_4$ are dipolar spin ices [1,2,3], a class of frustrated materials exhibiting novel properties such as residual ground state entropy [4] and emergent magnetic monopoles [5]. Typically realised in pyrochlores these spinels can still support spin ice physics on the erbium site which has a tetrahedral arrangement of ions. As part of a series of measurements on these materials for ref. [3], the ac susceptibility was measured in applied magnetic fields revealing unexpected behaviour in the form of a field induced relaxation channel. These measurements are shown alongside further measurements characterising the observed relaxation channels including measurements on recently available single crystal samples.

The specific heat was measured at UCL using the heat capacity option of a PPMS. The sample was affixed to the calorimeter puck using vacuum grease.

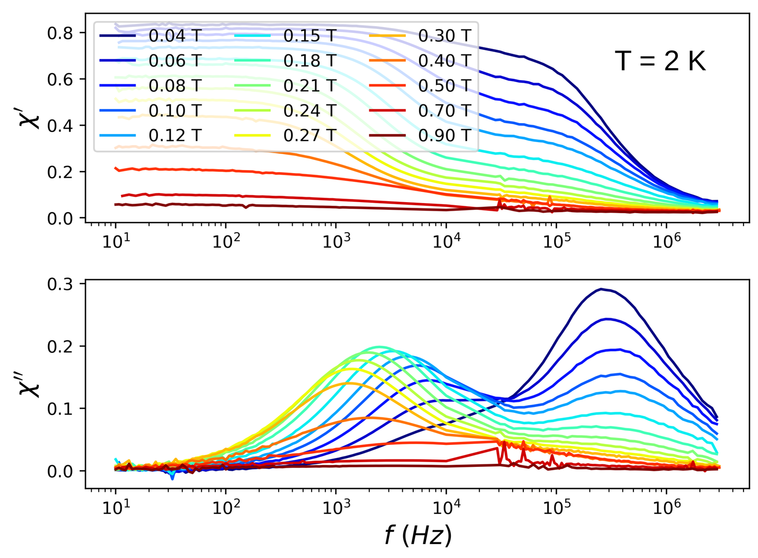
Increasing the magnetic field doesn't produce any significant features in the specific heat.

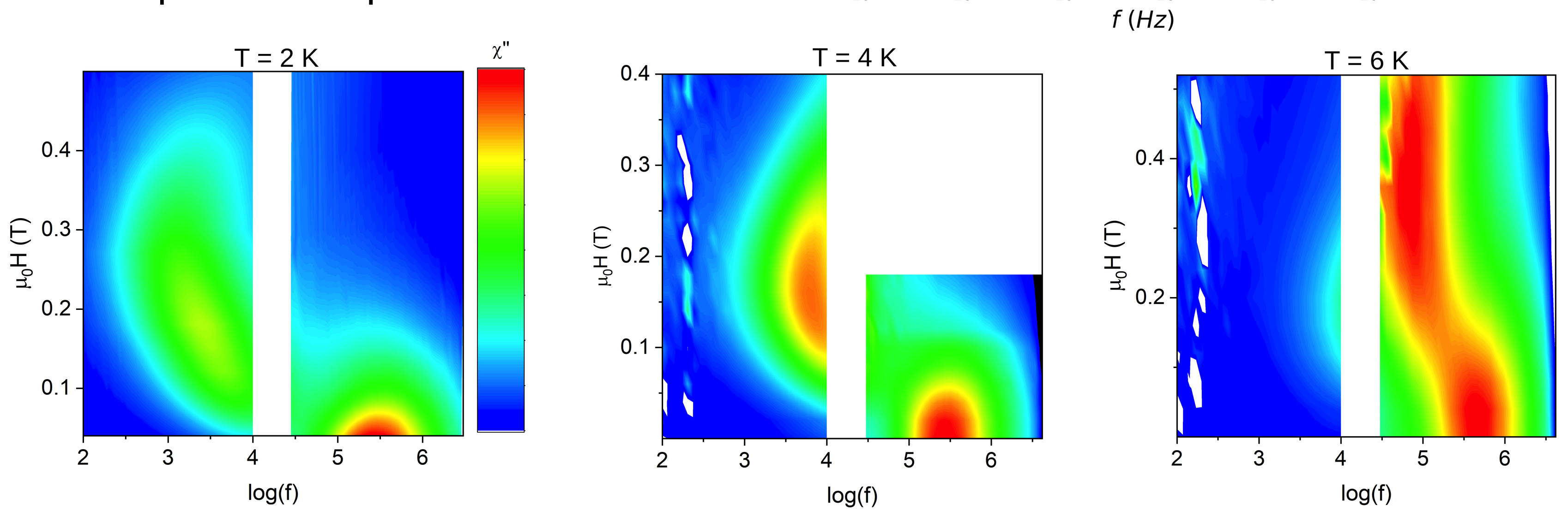


Powder

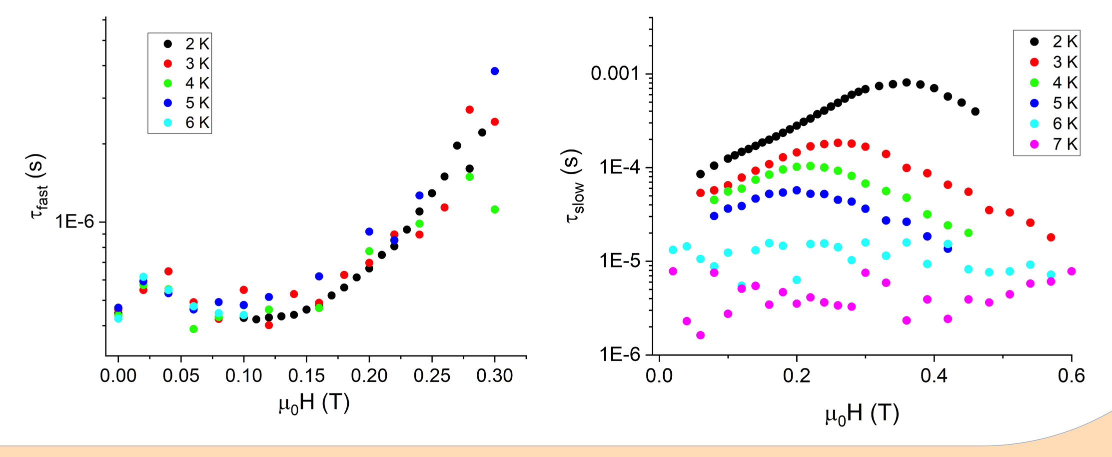
AC susceptibility measurements performed in PPMS cryostat using ACMS option and high frequency susceptometer built in Cardiff.

Application of magnetic fields leads to emergence of a second relaxation channel with different temperature dependence



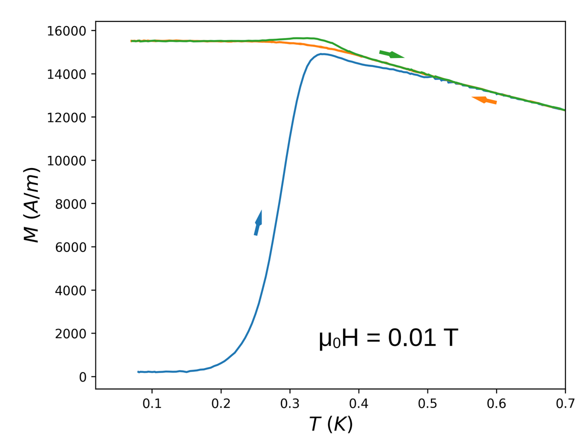


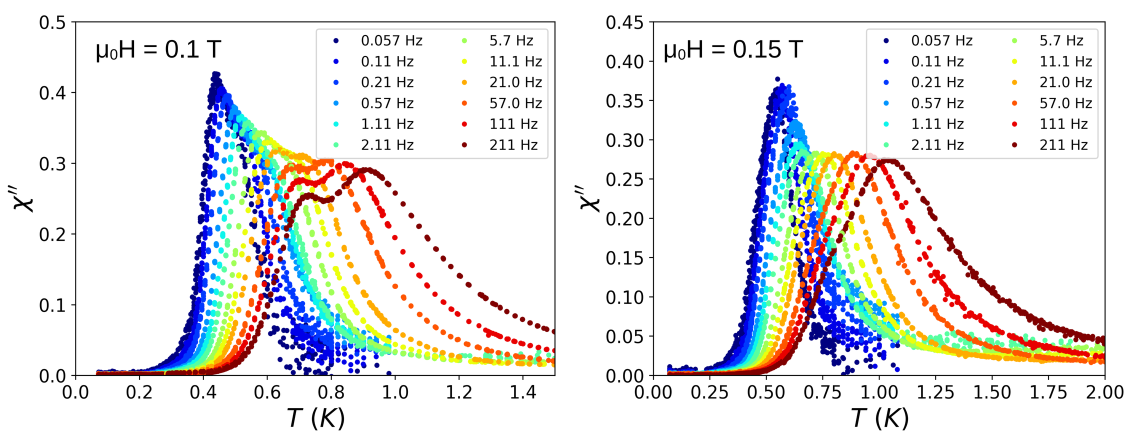
Both peaks in χ'' change with the magnetic field.



DC and AC measurements performed at Institut Néel using a dilution refrigerator to achieve millikelvin temperatures.

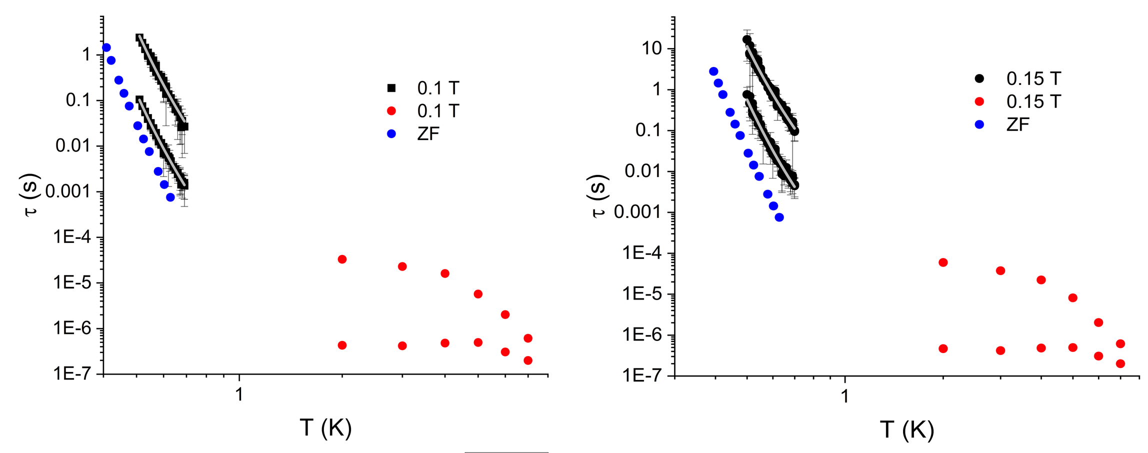
SQUID magnetometers are used to measure the AC susceptibility and DC magnetisation.



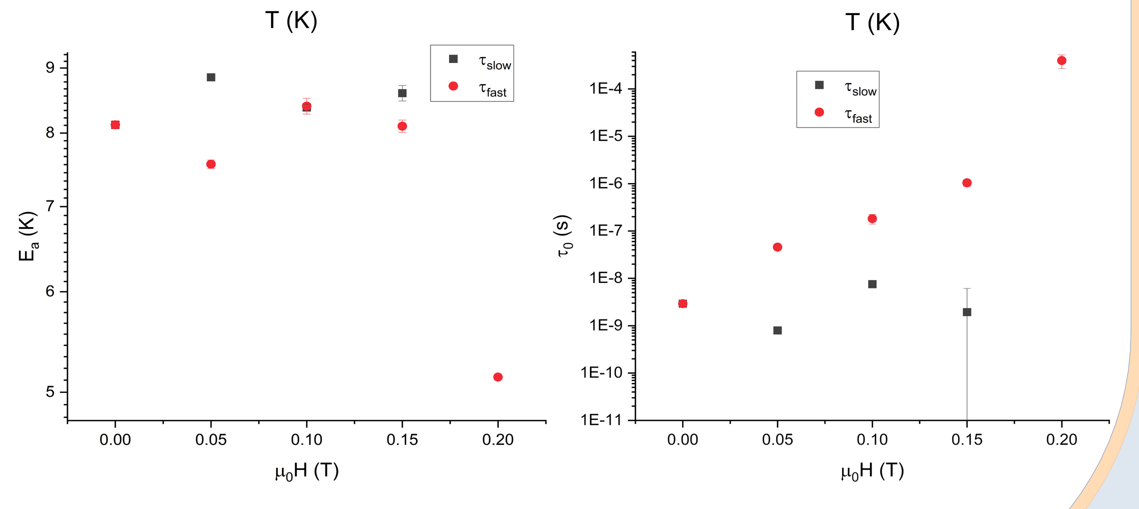


ZFC-FC finds spin freezing temperature of approximately 300 mK.

Both relaxation channels found to persist to millikelvin temperatures.



Energy barrier to spin flipping for both mechanisms shows weak dependence on field.

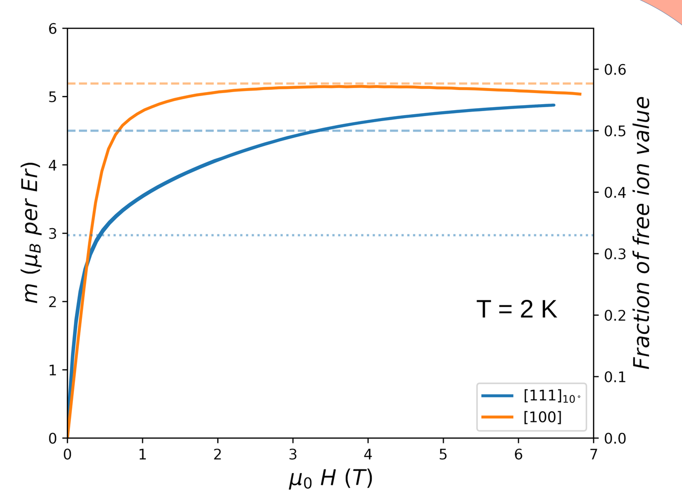


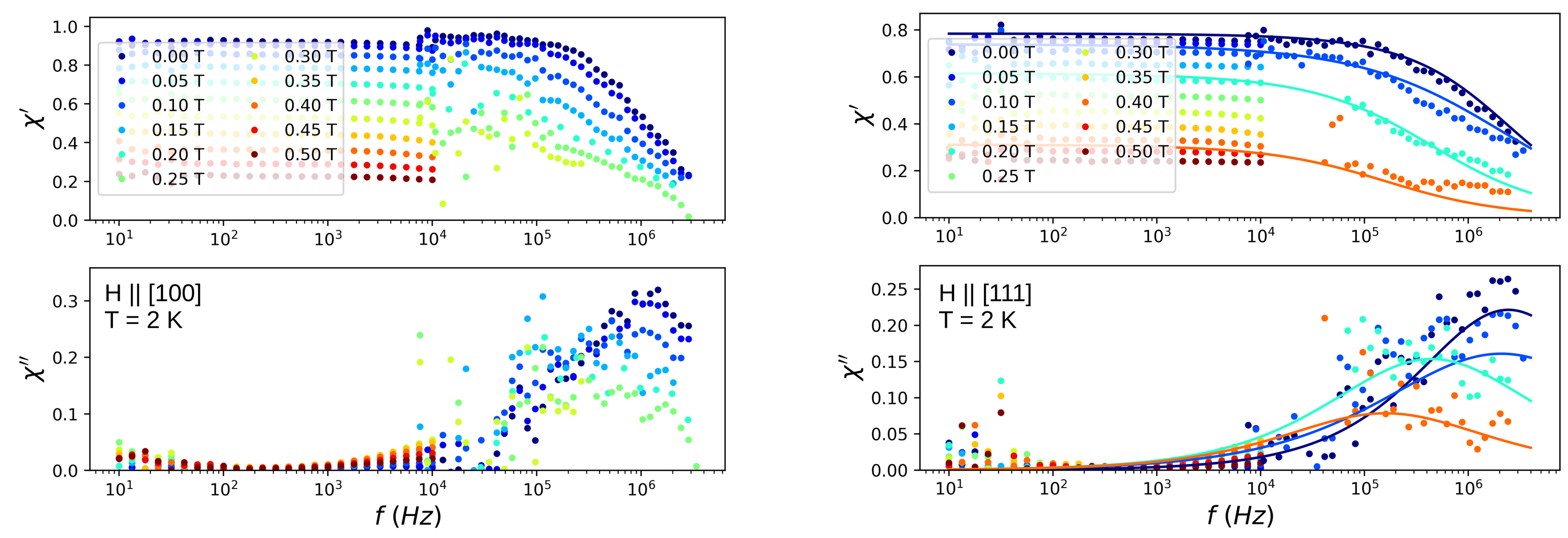
Single Crystal

A single crystal sample was aligned along the [111] and [100] directions. Measured at Cardiff using same apparatus as the powder.

Saturation values approximately consistent with expected for spin ice.

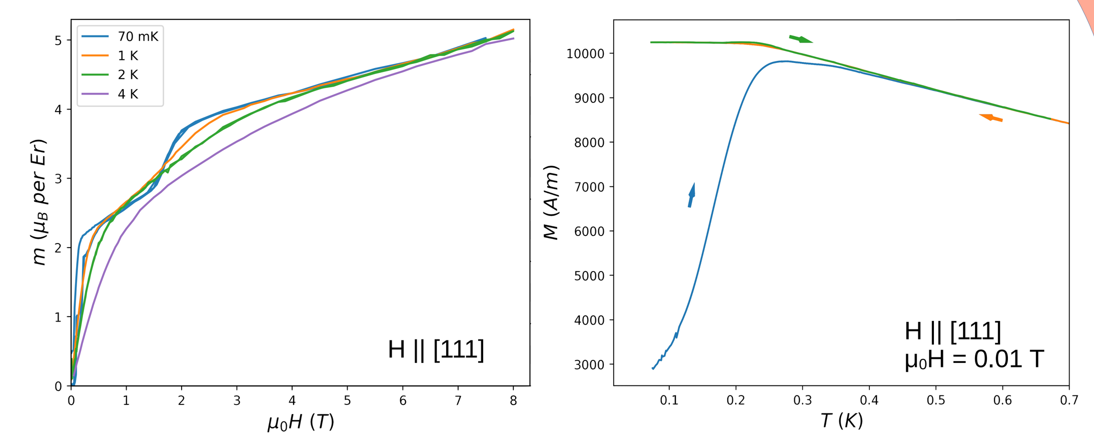
Small sample size means AC susceptibility has weak and noisy signal. No sign of field induced relaxation.





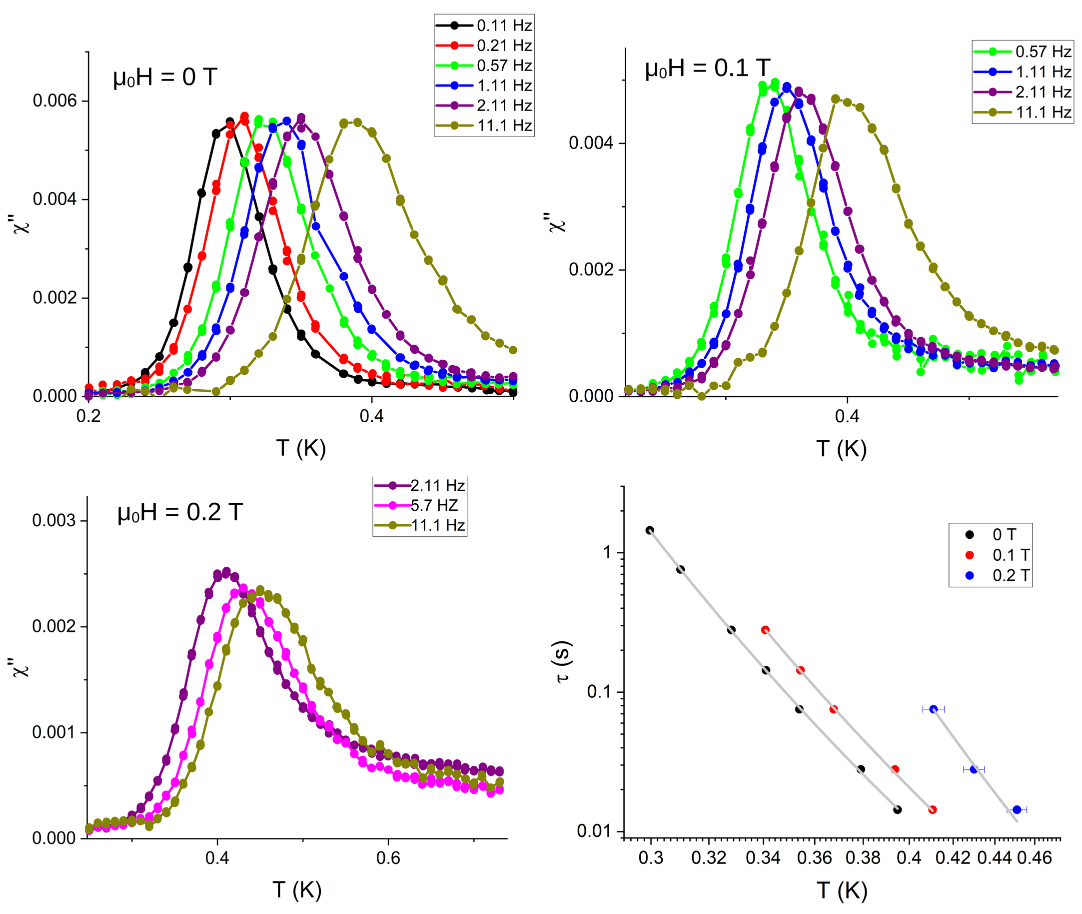
The [111] direction was measured at Institut Néel using the same apparatus as the powder.

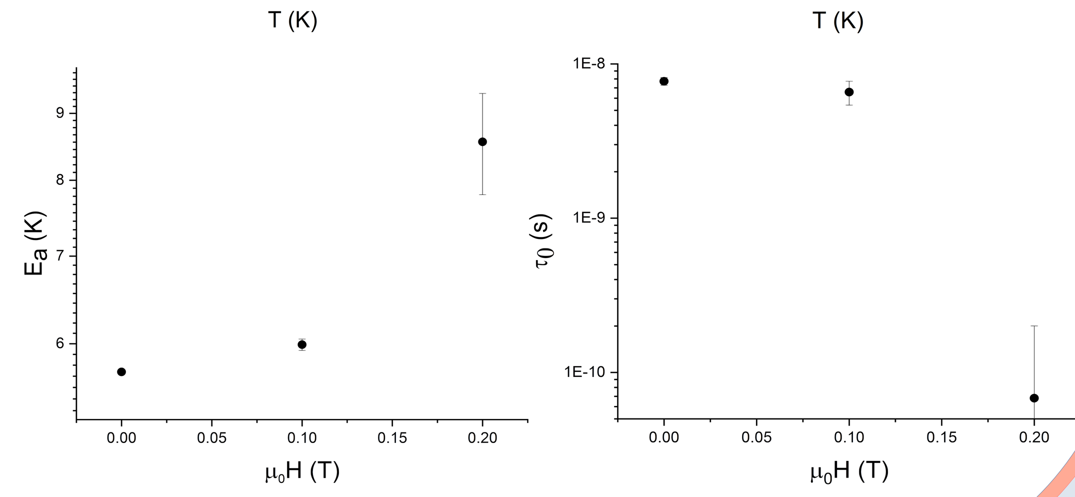
DC magnetisation curves at low temperature show a clear step at around 0.3x the free ion value, consistent with the Kagome ice phase in other spin ice materials.



ZFC-FC finds the spin freezing temperature is lower at approximately 200 mK.

The relaxation time is field dependent but no sign of the field induced channel in the AC susceptibility. As is the energy barrier.





Acknowledgements & References

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