Pulsed Field Magnetization Measurements of $CaFe_4As_3$

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Introduction

In certain frustrated magnets, competing interactions can create long-wavelength incommensurate modulations, as well as many magnetic states with different modulation vectors close in energy that result in devil's staircases in the magnetization vs magnetic field. The Anisotropic Next Nearest Neighbor Ising (ANNNI) model is a well-studied example of such frustrated "microphases" in the limit of Ising systems [1]. Moving towards isotropic spins, similar phenomenology can be observed marked by incommensurate spirals rather than incommensurate modulations. $CaFe_4As_3$ is a new compound that shows an incommensurate spiral below 90 K for magnetic field H along the crystallographic b axis, and a first-order transition at 25 K where a transverse moment forms with a wave vector of 0.375(2)b∗ and the ordered moment increases [2]. The crystal structure of $CaFe_4As_3$ consists of interwoven segments of $CaFe_2As_2$ (one of the new Fe-based superconductors), with 4 unique Fe sites. This allows for significant competition between different magnetic interactions [3]. The observed behavior has also been attributed to a Fermi surface nesting instability [2]. Here we explore the field-induced phase diagram of $CaFe_4As_3$ and search for possible signs of devil's staircases of field-induced phase transitions in or out of equilibrium in applied magnetic fields.

Results and Discussion

The magnetization isotherms, $M(H)$, of $CaFe_4As_3$ samples for **H || b** were measured in capacitor-driven millisecond pulsed magnets up to 65 T and down to 1.7 K. The $M(H)$ curves taken in pulsed fields at selected temperatures are shown in the left figure and the obtained H-T phase diagram is plotted in the right figure. The observed $M(H)$ at 100 K is linear in field, while $M(H)$ for lower temperatures shows a metamagnetic-like transition. At 26 K, close to T_2, $M(H)$ shows two transitions around 13 and 17 T. The $M(H)$ curve is hysteretic below the lower field transition (solid triangle) that extrapolates to the first-order transition at 25 K for H = 0. $M(H)$ does not show any detectable hysteresis at the higher-field transition that likely corresponds to the 2nd order phase transition at 90 K in H = 0. Close to the phase transition field, we observe no magnetic field sweep rate dependence within available sweep rates of the millisecond pulsed magnets.

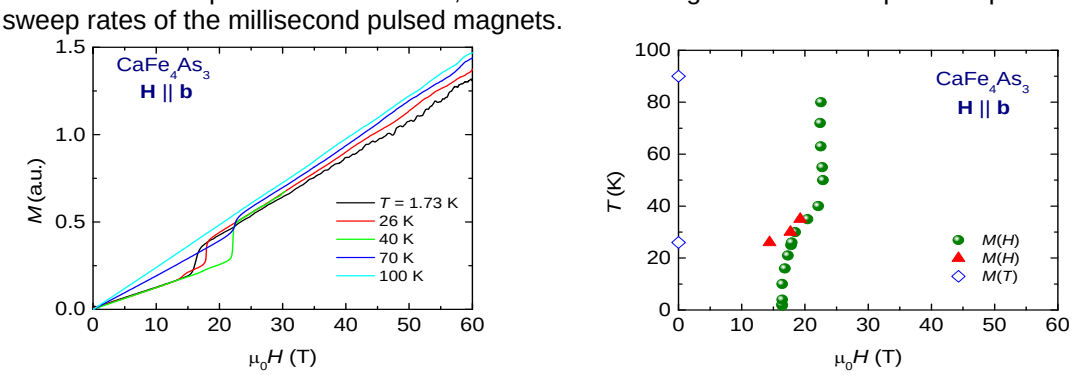

Fig. (Left) $M(H)$ at selected temperatures. (Right) H-T phase diagram obtained from $M(H)$.

Conclusions

Our magnetization measurements reveal no devil's stairacases of field-induced phase transitions and no out-of-equilibrium behavior in the millisecond 65 T pulsed magnets – rather we observe two field-induced transitions that could correspond to the two phase transitions observed as a function of temperature. With further theoretical work, the field-induced phase diagram could select between competing magnetic models for this system.

Acknowledgements

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References

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