Pulsed Field Magnetization of MgV_2O_4

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Introduction

The interplay between spin and orbital degrees of freedom of highly frustrated magnets becomes particularly relevant when the ground state manifold of the dominant interaction is massively degenerate [1]. This is the ideal scenario for finding rich phase diagrams because small interactions become the primary selection mechanism of spin-orbital ordering. A high susceptibility to small interactions opens the possibility of inducing phase transitions with moderate external pressure or magnetic fields. The vanadium spinels AV_2O_4 (A = Cd, Zn, and Mg) are archetypical realizations of highly frustrated spin-orbital systems [2]. These materials exhibit a cubic to tetragonal transition at a temperature $T = T_S$ and the antiferromagnetic (AFM) ordering below $T_N < T_S$ [3]. The weak nature of the interactions that select the magnetic ordering in highly frustrated magnets suggests that moderate fields could induce a different spin ordering [4]. We previously observed a field-induced phase transition in the magnetization and electric polarization of CdV_2O_4 [5]. Here we seek similar behavior in MgV_2O_4.

Results and Discussion

Single crystals of MgV_2O_4 were grown by the traveling-solvent floating-zone technique. The magnetization isotherms, $M(H)$, were measured in short-pulsed fields up to 62 T and down to 0.5 K. The left figure shows $M(H)$ curves of MgV_2O_4 for **H** || [111]. $M(H)$ is linear up to a field between 30 and 40 T and then shows an upturn or a jump. A magnetization value of ~ 0.2 μ_B/V^{3+} is seen at 60 T, which is much less than the saturation magnetization value. In the right figure, we describe a magnetic hysteresis observed for **H** || [111] at T = 0.5 K between first and subsequent *M(H)* pulses.

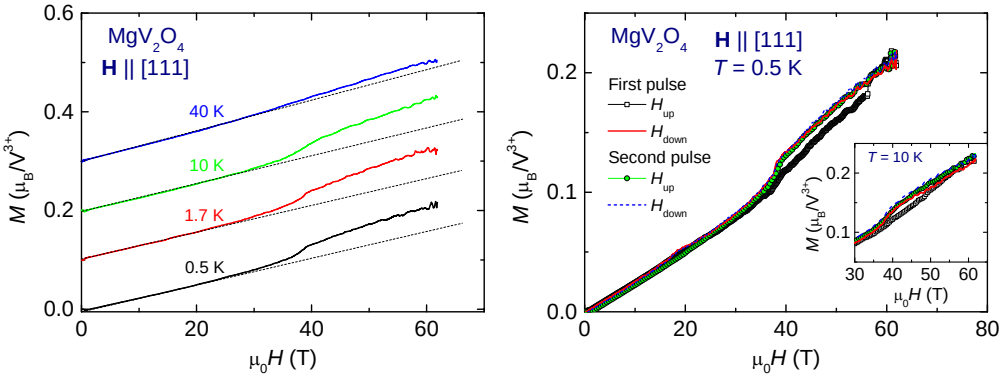

Fig. (Left) M(H) of MgV_2O_4 at select temperatures for **H** || [111]. For clarity, the M(H) curves are successively shifted upward by 0.1 mB/V3+. Dashed-lines are guides to the eye. (Right) M(H) of MgV_2O_4 at T = 0.5 K. The first M(H) pulse is measured by cooling the sample from above TN to T = 0.5 K and then pulsing the field, and the subsequent pulses are measured at T = 0.5 K without first thermal cycling to above TN. Symbols and lines indicate up- and down-sweep of magnetic field, respectively. The inset shows a similar sequence of pulses at T = 10 K.

Conclusions

We observe a field-induced phase transition marked by a magnetization jump at H ~ 40 T in a single crystal of MgV_2O_4. The ~40 T transition corresponds to the experimental evidence of a quantum phase transition induced by relatively small fields in MgV_2O_4, in spite of their large Curie-Weiss temperature θ_p ~300 K [6]. This work is combined with previous observations of a similar phase transition in CdV_2O_4 and theoretical modeling of the interplay between magnetic frustration and spin-orbit coupling, and published in Phys. Rev. Letters [5].

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