Magnetization & Magnetostriction Measurements of the *S* = ½ One-Dimensional Heisenberg Antiferromagnet β-$TeVO_4$

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Introduction

β-$TeVO_4$ crystallizes in the monoclinic space group $P2_1/c$. The spin structure is an arrangement of V zigzag double chains that run parallel to the *c*-axis and are formed by slightly distorted VO_5 pyramids [1]. Fig. 1 Inset illustrates the spin interactions with NN (J_1) and NNN (J_2) interactions. Structural considerations suggest that even higher order interactions ($J_{3/4}$, $J_\perp$) are important. Magnetic susceptibility vs temperature experiments reveal a Curie-Weiss behavior with AFM correlations ($\theta \approx$ -11 K) and a pronounced maximum at 14 K. A small anisotropy is observed between *H* ll *b* and *H* ll *a,c*, with *b* being the magnetic easy axis. Three anomalies are observed at 2.26 K, 3.28 K and 4.65 K in the magnetic susceptibility, however, the magnetic order corresponding to these transitions is currently unknown [1].

Experimental

We measured the magnetization and magnetostriction vs field at the NHMFL-LANL in a capacitor-driven short pulse magnet up to 60 T in the temperature range between 0.38 K and 4 K. The experiments were carried out on high quality polycrystals with the compensated pick-up coil technique χ(H) and the optical Bragg fiber grating technique, respectively.

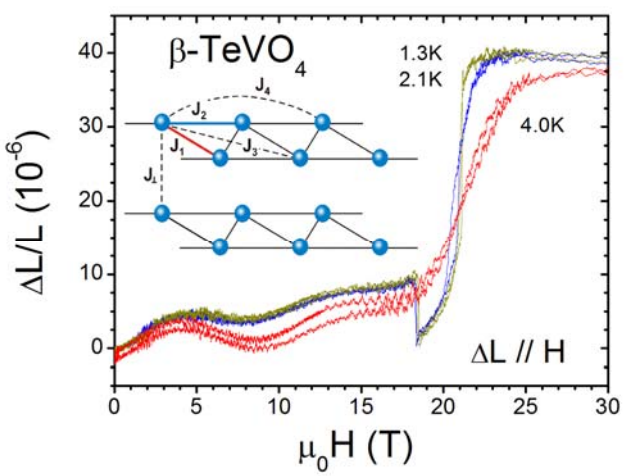

Fig. 1: Magnetostriction ΔL/L vs magnetic field. Low field oscillations are an artifact. Inset: Exchange interactions J_1-J_4

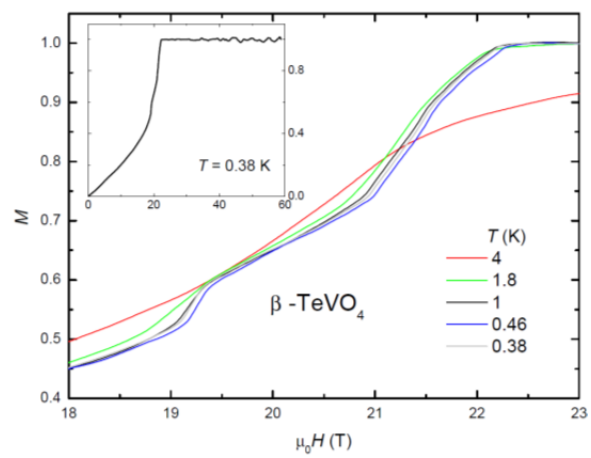

Fig. 2: Magnetization vs field at different temperatures. Inset: Magnetization vs field, full range, at T = 0.38K

Results and Discussion

Fig. 1 shows the magnetostriction obtained when ΔL//H at T = 1.3K, 2.1K an 4K. Sharp transitions are observed at 18.5T, 21T and 21.5T. Fig. 2 inset shows the magnetization at T = 0.38 K in field to 60 T. We observe several features in the magnetization around 20 T and saturation above 22.5 T. The body of Fig. 2 shows the intermediate field range, where the magnetization exhibits clear features at 19.2 T, 21 T, 21.5 T and 21.8 T.

Conclusions

Recent DFT calculations [2] support the picture of a two-leg spin ladder system, whereas the susceptibility results point to a single spin chain with zero inter-rung coupling in β-$TeVO_4$. Neither model can explain the observed plateaus and steps in the magnetization and magnetostriction. We speculate that anisotropy effects, such as Dzyaloshinskii–Moriya terms play a significant role in the physics of β-$TeVO_4$.

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References

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[2] Tsirlin, A. A. *et al*, unpublished results (2013).