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P11530-E005-PF: Magnetization measurements on single crystals β -TeVO₄

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Introduction

β -TeVO₄ 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 VO₅ pyramids [1]. Microscopic analysis identifies frustrated J1-J2 spin chains with sizable coupling in the bc plane and no frustrations. 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 $H \parallel b$ and $H \parallel a, c$, 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].

Experiment

Magnetization measurements with an extraction magnetometer were carried out at the NHMFL pulse field facility at LANL in Los Alamos. We concentrated in the temperature range between 10K and 0.4K and in magnetic fields up to 35T. This investigation is an extension of a previous study carried out on a polycrystalline powder sample to investigations on a high quality single crystal. We applied the magnetic field along all three $H \parallel a$, $H \parallel b$, and $H \parallel c$ direction in this single crystal with monoclinic crystal structure.

Results and Discussion

Fig. A and B show the magnetization as a function of field at temperatures $T \leq 4$ K for $H \parallel c$ and $T \leq 10$ K for $H \parallel a$, respectively. Measurements for $H \parallel b$ (not shown) are almost identical to data taken for $H \parallel a$. The magnetization

in both directions shows distinct anomalies at the phase transitions in form of vertical steps connected by areas of smooth non-linear increase of the magnetization. We do not observe any regions between the anomalies with constant magnetization (plateaux) for neither $H \parallel a$, b nor c . The extremely sharp anomalies in dM/dH (data not shown) broaden quickly with increasing temperature.

Conclusion

Our new results on single crystals do not resemble the behavior of a previously measured polycrystalline powder sample [2]. The kind of anomaly at the phase transitions is different and the anomalies occur at different critical fields. As described above, all phase transitions in the single crystal are marked by steps whereas the powdered sample shows several kinks of varying sharpness. The critical fields obtained by single crystal magnetization experiment are in excellent agreement with the phase diagram estimated with magnetostriction measurements in pulsed magnetic fields[2]. Since the sharp steps at low temperatures broaden very quickly with higher temperature, we are not able to track the phase diagram above 4K with high precision. Hysteresis loops of magnetization data taken during increasing and decreasing magnetic field experiments furthermore evidence a significant change in entropy at the phase transitions.

References

- [1] Savina, Yu. *et al.*, Phys. Rev. B **84**, 1044471, (2011).
- [2] Weickert, F. *et al.*, Phys Phys. Rev. B **84**, 1044471, (2016).

Figure: Magnetization measurements versus magnetic field up to 30T in A) for $H \parallel c$ between 0.4K and 4K and in B) for $H \parallel a$ between 0.5K and 10K. Curves are shifted by a constant offset -0.1 T with decreasing temperature for better visibility. The sharp steps at the phase transitions show fast broadening with temperature.