Colossal Magnetoelectric Coupling in Ni_3TeO_6 under High Magnetic Fields

J.-W. Kim, E.-D. Mun, M. Jaime, N. Harrison, (NHMFL-PFF); Y. Oh, J.J. Yang, S.-W. Cheong (Rutgers Center for Emergent Materials, Rutgers University); V. Zapf (NHMFL-PFF)

Introduction

Ni_3TeO_6 was previously shown to exhibit "colossal" magneto-electric coupling at a lower-field phase transition near 9 T, with a very sharp, non-hysteretic jump in physical properties[1]. The material forms a honeycomb structure with three distinct Ni^{2+} sites. Powder neutron diffraction measurements suggest a collinear antiferromagnetic ground state [2], which is unusual for a multiferroic, with the 9 T transition likely being a 2nd order spin flop of part of the Ni^{2+} spins [1]. The non-centrosymmetric crystal structure supports a net electric polarization that is strongly coupled to the magnetization. We seek to understand the magnetic structure and source of colossal magneto-electric coupling.

Experimental

We measured extraction magnetometry, magnetostriction, and electric polarization for H || L || P || c in 65 T capacitor-driven short pulse magnets and in the 100 T multishot magnet to 92 T. Results are calibrated against measurements in a 14 T Physical Properties Measurement System (PPMS) by Quantum Design.

Results

Fig. 1 shows the magnetization M, magnetostriction ΔL/L and electric polarization change P to 92 T for H || c. Besides the 9 T transition, we find a second phase transition at 52 T accompanied by a change in the electric polarization that is even 7 times larger than the 9 T transition. No saturation of any quantity is observed by 92 T. For H perp c, we observe a single phase transition in the electric polarization at 70 T.

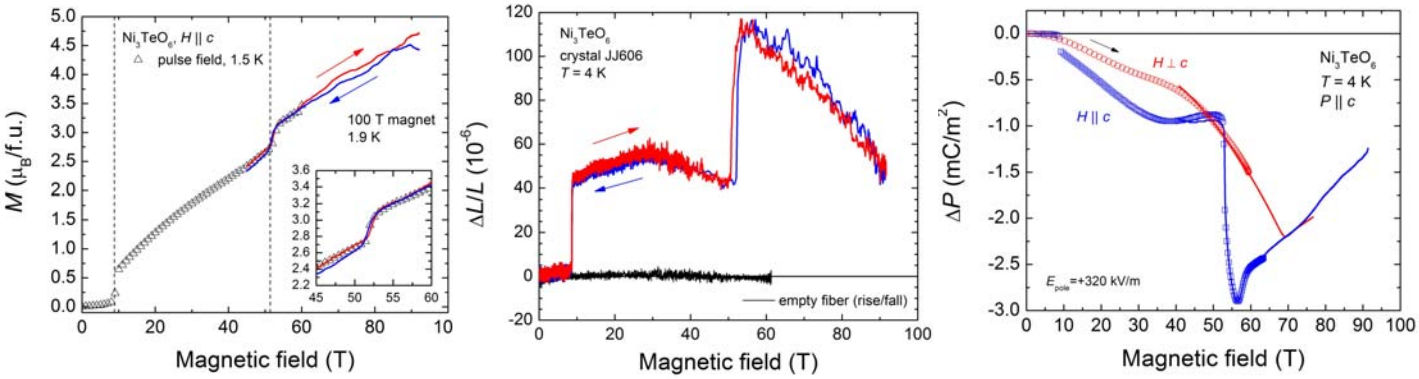

Fig. 1 Magnetization M, magnetostriction DL/L and electric polarization ΔP measured in 65 T short-pulse and the 100 T multi-shot magnet.

Conclusions

These results require at least two, and probably three Ni^{2+} spins to be in the S = 1 state. Monte Carlo simulations in progress by Sergei Artyukhin and David Vanderbilt at Rutgers University suggest that the two closest-neighbor Ni spins flop together, and a third Ni spin flops separately. Further calculations are in progress to determine what magnetic exchange and anisotropy terms in the Hamiltonian can reproduce the data.

Acknowledgements

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References

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[2] I. Zivkovic *et al*, J. Phys.: Condens. Matter 22, 056002 (2010)