Why does magnetic switching occur at such high magnetic fields in Sr_3NiIrO_6?

K.R. O'Neal,[1] A. Paul,[2] A. al-Wahish,[1] K.D. Hughey,[1] A.L. Blockmon,[1] X. Luo,[3,4,5] S.-W. Cheong,[3,4,6] V.S. Zapf,[7] C.V. Topping,[8] J. Singleton,[7] M. Ozerov,[9] T. Birol,[2] and J. L. Musfeldt[1]

1. University of Tennessee; 2. University of Minnesota; 3. Pohang University of Science and Technology; 4. Pohang Accelerator Laboratory; 5. Institute of Solid State Physics; 6. Rutgers University; 7. NHMFL at Los Alamos National Laboratory; 8. University of St Andrews; 9. NHMFL at Florida State University

Funding Grants: J.L. Musfeldt (NSF DMR-1629079, DOE DE-FG02-01ER45885), S.-W. Cheong (NSF DMR-1629059, ICT 2016K1A4A01922028), T. Birol (NSF DMR-1629260), G.S. Boebinger, J Singleton, V.S. Zapf, M. Ozerov (NSF DMR-1157490, NSF DMR-1644779), J. Singleton, V.S. Zapf DOE BES "Science at 100 Tesla"

Sr_3NiIrO_6 displays one of the highest known coercive magnetic fields: up to 55 Tesla is needed to switch the magnetization of this material between different branches of the hysteresis loop in a plot of magnetization versus applied magnetic field.

This material contains magnetic Ni^{2+} and Ir^{4+} in oxygen cages, that alternate along chains. While materials with 3*d* transition metal ions like Ni^{2+} display strong electron correlations, narrow band widths, and robust magnetism, materials with 5*d* magnetic ions like Ir^{4+} are recognized for strong spin-orbit coupling, increased hybridization, and more diffuse orbitals. *Combining these properties leads to novel behavior such as the ultra-high coercive fields. Little is known about the physics behind this incredible coercivity, such as the importance of the lattice, domains, or interchain interactions.* We explore these here with magneto-optical measurements.

Fig.1 (a) displays the infrared spectrum of Sr_3NiIrO_6 at 0 and 35T, with the difference displayed at the top. Three phonons [Fig. 1 (b-d)] show sensitivity to magnetic field and grow as the magnetization squared. *Together, these data reveal which lattice distortions facilitate microscopic spin rearrangements., resulting in the creation of magnetic order, which pushes the magnetic switching to very high magnetic fields as high as 55T.*

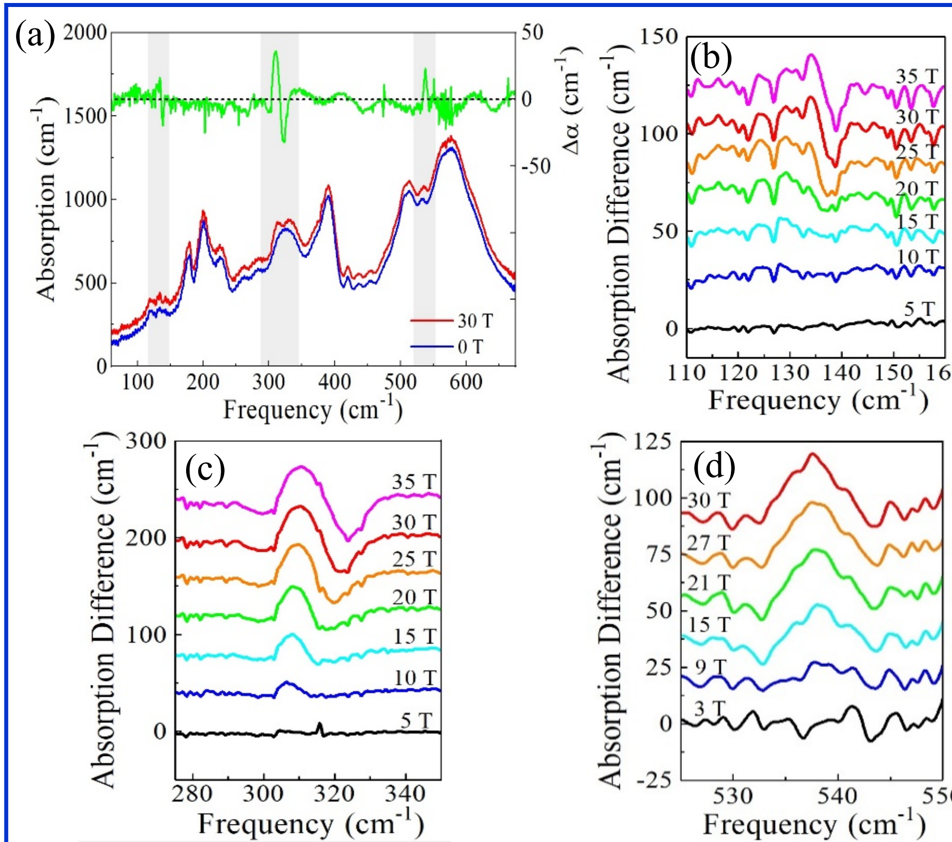

Figure (a) Infrared spectrum at 0 and 35 T, with the difference highlighted above. (b) Integrated absorption differences track magnetization squared. (c-e) Zoomed view of absorption differences

Facilities and instrumentation used: FT-IR spectrometer with 35T resistive magnet in the NHMFL DC Field Facility, and 65T pulsed magnets in the NHMFL Pulsed Field Facility.

Citations: **[1]** J. Singleton, J. Kim, C. Topping, A. Hansen, E. Mun, S. Chikara, I. Lakis, S. Ghannadzadeh, P. Goddard, Y. Oh, S-W. Cheong, and V. Zapf, **Phys. Rev. B**, **94**, 224408 (2016)

[2] K.R. O'Neal, A. Paul, A. al-Wahish, K.D. Hughey, A. Blockmon, X. Luo, S-W. Cheong, V. Zapf, C.V. Topping, J. Singleton, M. Ozerov, T. Birol, J.L. Musfeldt, *Spin-lattice and electron-phonon coupling in 3d/5dhybrid Sr_3NiIrO_6,* **njp Quantum Materials, 4**, 48 (2019) doi.org/10.1038/s41535-019-0184-x