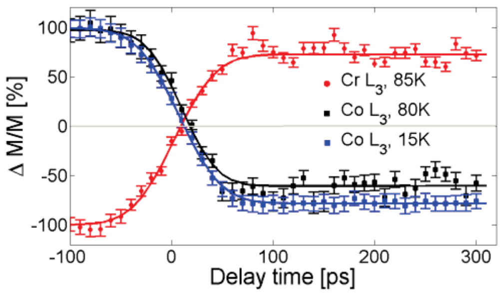
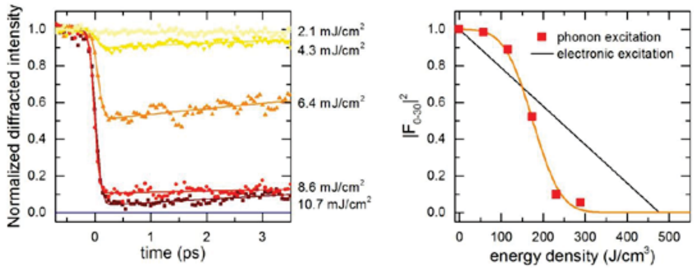




SLS Symposium on

Dynamics and Kinetics

Tuesday, March 22nd, 2016

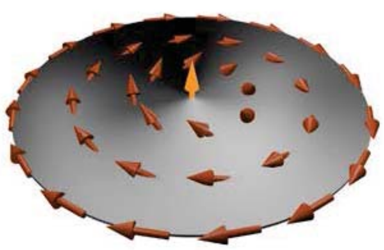
10:00 to 11:45, WBGB/019

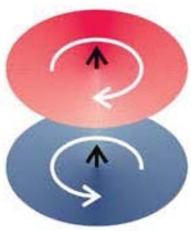
10:00 Ultrafast magnetisation switching in multiferroic $CoCr_2O_4$
E. M. Bothschafter, M.Savoini, M. Porer, M. Buzzi, Y. W. Windsor, C. Dornes, L. Rettig, M. Ramakrishnan, A. Alberca, S.R.V. Avula, D. Schick, N. Pontius, C. Schuessler-Langeheine, J. A. Heuver, S. Mazten, B. Noheda, C. Piamonteze, S. L. Johnson and U. Staub

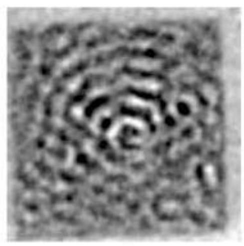
10:30 Ultrafast insulator-to-metal transition induced by coherent lattice excitation in a manganite
V. Esposito, R. Mankowsky, H. Lemke, M. Chollet, J.M. Glownia, M. Nakamura, U. Staub, P. Beaud and M. Först

11:00 Coffee

11:15 Spin Wave Emission From Topological Spin Textures
S. Wintz, V. Sluka, M. Weigand, A. Kakay, K. Schultheiss, T. Warnatz, A. Erbe, V. Tyberkevych, A. Slavin, A. Deac, J. Lindner, J. Fassbender, and J. Raabe







Ultrafast magnetisation switching in multiferroic $CoCr_2O_4$

E. M. Bothschafter[1], M.Savoini[2], M. Porer[1], M. Buzzi[1], Y. W. Windsor[1], C. Dornes[2], L. Rettig[1,3], M. Ramakrishnan[1], A. Alberca[1], S.R.V. Avula[1], D. Schick[4], N. Pontius[4], C. Schuessler-Langeheine[4], J. A. Heuver[5], S. Mazten[6], B. Noheda[5], C. Piamonteze[1], S. L. Johnson[2], U. Staub[1]

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Understanding and controlling the magnetoelectric properties of multiferroic materials of type-II is of high interest, as these materials offer a unique direct coupling between magnetic order and ferroelectric polarization.

Here we report on the observation of all-optical magnetization switching [1] of the ferrimagnetic multiferroic $CoCr_2O_4$ using above band gap excitation with femtosecond laser pulses. By probing the element-specific time-resolved x-ray magnetic dichroic contrast we find that the magnetization in both the Co and the Cr sublattice is reversed up to 90% within tens of picoseconds. However, the magnetization reversal only occurs in the presence of sufficient x-ray exposure. As the material is an insulator and x-ray exposure cannot act directly on the magnetization but enhance the conductivity of the material, this effect indicates that polarized spin currents and/or spin flip scattering play a significant role for the transfer of magnetic moment in the all-optical switching process. Even more important is the observation of magnetic switching in the multiferroic phase of $CoCr_2O_4$. The magnetization reversal is expected to simultaneously reverse the ferroelectric polarization as a result of strong magnetoelectric coupling [2]. Our findings therefore provide a new route towards light-based control of ultrafast magnetization and polarization switching.

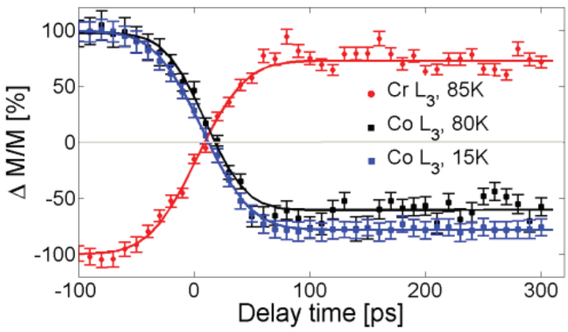

Figure 1 Time-resolved relative change in magnetization of the Co and Cr sublattices in $CoCr_2O_4$ above and below the multiferroic phase transition temperature of ~27 K.

References

1. C. D. Stanciu, A. Tsukamoto, A. V. Kimel, F. Hansteen, A. Kirilyuk, A. Itoh, and T. Rasing, Phys. Rev. Lett. 99, 217204 (2007).
2. Y. Yamasaki, H. Sagayama, T. Goto, M. Matsuura, K. Hirota, T. Arima, and Y. Tokura, Phys. Rev. Lett. 98, 147204 (2007).

Ultrafast insulator-to-metal transition induced by coherent lattice excitation in a manganite

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Due to the strong interplay between their electronic, lattice and spin degrees of freedom, strongly correlated systems exhibit complex phase diagram and external stimulation of their equilibrium state can lead to colossal changes of their properties. In the ultrafast regime, a variety of excitation can be achieved by selecting the appropriate wavelength for the pump pulse. In the present work, we investigate and compare the dynamics of different excitation mechanism on the charge and orbitally ordered manganites $Pr_{0.5}Ca_{0.5}MnO_3$ (PCMO).

The insulator-to-metal transition in PCMO, following excitation of an electronic transition, has been studied in details in [1] and has been found to be well described with a single time-dependent order parameter.

Based on theoretical predictions by Subedi et al. [2] and experimental evidences of ultrafast phonon-driven insulator-to-metal transition [3], we performed a time-resolved study of the dynamics following resonant excitation of a lattice mode with mid-IR pulses.

We observed that the insulator-to-metal transition is launched within the 200fs time resolution of the experiment. Interestingly, the dynamic response is very similar to that upon photoexcitation of an electronic transition, showing that a fast melting of charge order triggers the rearrangement of the unit cell. The main difference, however, lies in the behavior as a function of the absorbed energy density, exhibiting a pronounced threshold behavior.

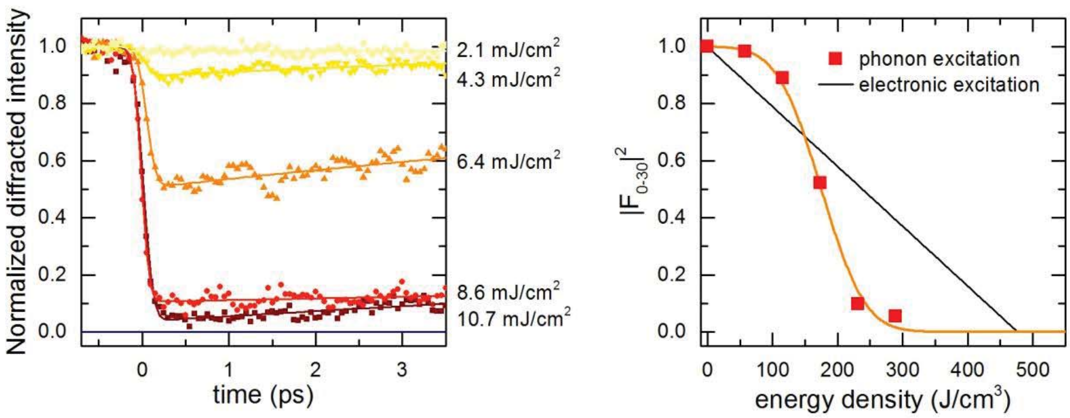

Figure 1: Left: phonon induced dynamics on the (0-30) charge order reflection in PCMO for a set of different fluences. Right: comparison of different excitation mechanisms. The averaged diffracted intensity between 0.5 and 1ps after excitation is displayed as a function of the absorbed energy density.

[1] Beaud et al., Nat. Mat., 2015
[2] Subedi et al., Phys. Rev. B, 2014, 89
[3] Rini et al., Nature, 2007, 449

Spin Wave Emission From Topological Spin Textures

S. Wintz[1,2], V. Sluka[2], M. Weigand[3], A. Kakay[2], K. Schultheiss[2], T. Warnatz[2], A. Erbe[2], V. Tyberkevych[4], A. Slavin[4], A. Deac[2], J. Lindner[2], J. Fassbender[2], and J. Raabe[1]

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Today, spin waves are seen as high potential information carrier for next-generation information and communication devices [1]. This view is based on the substantially reduced energy dissipation and much smaller wavelengths of spin waves compared to traditional charge current signals. For the implementation of spin wave technology into applicable devices, however, novel concepts for the generation, manipulation, and detection of spin waves are yet to be found. With respect to spin wave generation, it was typically necessary to either use patterned transducers with sizes on the order of the desired wavelengths (striplines or point-contacts) or to generate those spin waves parametrically by a double-frequency spatially uniform microwave signal [2]. In the present contribution, we report on a newly discovered concept for the generation of spin waves, which overcomes the bandwidth limitations in terms of minimum wavelength limit given by the patterning size. Our method utilizes the translation of natural topological defects, namely the gyration of magnetic vortex cores to generate isotropically propagating, non-reciprocal spin waves [3]. We directly observed these spin waves by means of time-resolved x-ray microscopy and we will further address directional and one-dimensional spin wave emission in anistropic magnetic systems.

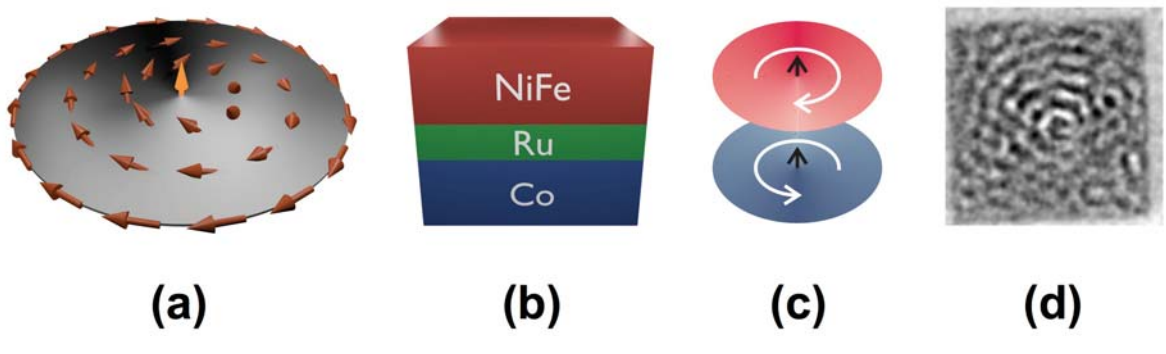

Figure 1: Spin wave emission from vortex cores [3]. (a) Vortex, (b) trilayer, (c) vortex pair, (d) Spin waves in a square of 4 μm (STXM).

[1] D. Rosso, "International Technology Roadmap for Semiconductors Explores Next 15 Years of Chip Technology", *www.semiconductors.org*, (2014).
[2] A. G. Gurevich and G. A. Melkov, Magnetization Oscillations and Waves. New York: CRC, 1996.
[3] S. Wintz et al., submitted (2015).