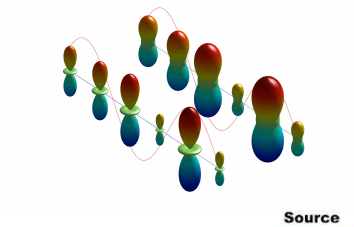

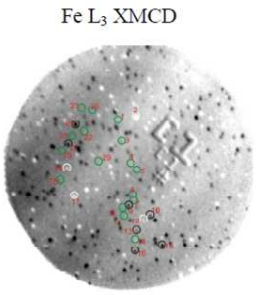

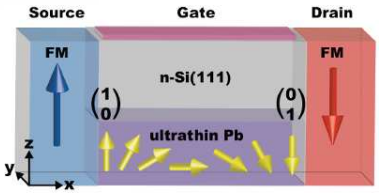

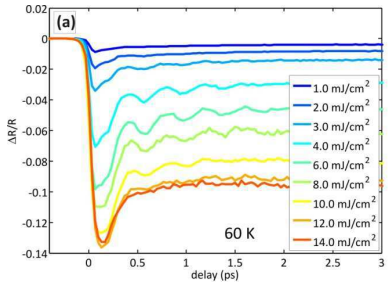

SLS Symposium on

Complex Oxides and Low Dimensional Systems

Tuesday, April 3, 2012

10:00 to 12:15, WBGB/019

10:00 Observation of electronic density change associated with the $TbMnO_3$ multiferroic (polar) phase
V. Scagnoli, U. Staub, R. S. W. Huang, M. Garganourakis, M. Koohpayeh, S.-W. Cheong, and S.W. Lovesey

10:30 Dynamics of the Structural Transition in Mixed Valence Manganites
A. Caviezel, U. Staub, S. L. Johnson, S. O. Mariager, G. Ingold, E. MöhrVorobeva, M. Garganourakis, S. W. Huang, C. J. Milne, Q. X. Jia, S.W. Cheong, and P. Beaud

11:00 Coffee

11:15 Studying size-dependent magnetization curves of individual iron nanoparticles at finite temperatures
A. Balan, A. Kleibert, F. Nolting, J. Bansmann, P. Derlet, A. Fraile Rodriguez

11:45 Pb/Si(111) - a potential candidate for spin-based electronics
B. Slomski, G. Landolt, G. Bihlmayer, J. Osterwalder and H. Dil

Observation of electronic density change associated with the $TbMnO_3$ multiferroic (polar) phase

V. Scagnoli[1], U. Staub[1], R. S. W. Huang[1], M. Garganourakis[1], M. Koohpayeh[2], S.-W. Cheong[3], and S.W. Lovesey[4]

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Multiferroics materials have recently attracted a great attention due to the interest in gaining a better understanding of the phenomenon of magnetically-induced polarization and for the appealing possibility to use such effect for practical applications, notably the prospect of controlling charges by applied magnetic fields and spins by applied voltages. In magnetically induced multiferroic, such as $TbMnO_3$, the presence of a spiral magnetic structure could induce electric polarization by shifting the oxygen atoms.
However, there is not yet consensus on the presence/role of the oxygen displacements (in the order of 10^{-4} Å as suggested by *ab initio* calculations) as opposed to the "pure electronic" mechanism, where no lattice distortions are invoked.
We use resonant X-ray diffraction at the manganese L edges to unravel this conundrum by probing the subtle changes in the manganese electronic structure occurring at the appearance of the multiferroic phase.

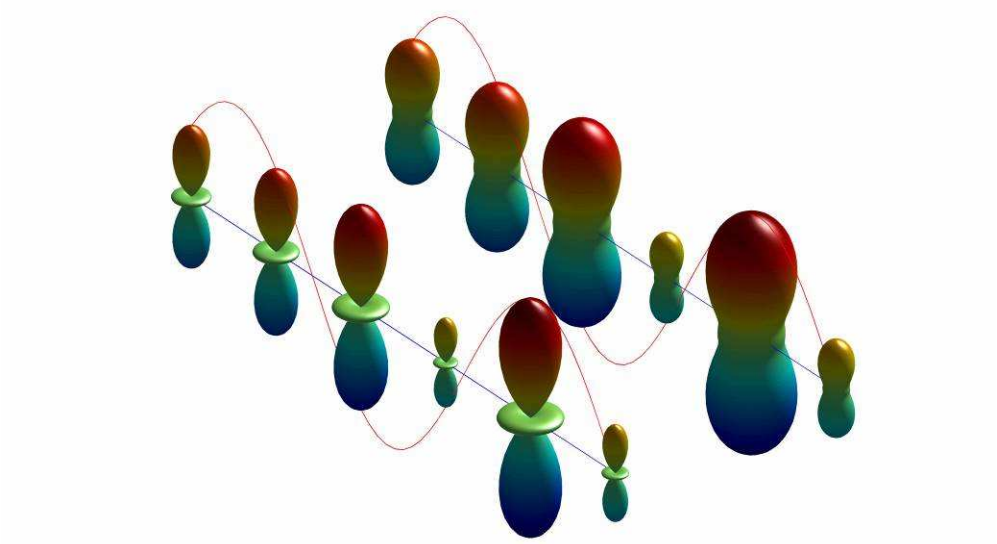

Figure 1: Pictorial view of the manganese electronic density modulation as reconstructed by resonant X-ray diffraction experiments performed at the manganese L_2 edge. On the left the reconstruction for the sinusoidal modulated magnetic phase and on the right for the multiferroic cycloidal phase. Asymmetric contributions are emphasized for clarity.

Dynamics of the Structural Transition in Mixed Valence Manganites

A. Caviezel[1], U. Staub[1], S. L. Johnson[2], S. O. Mariager[1], G. Ingold[1], E. Möhr-Vorobeva, M. Garganourakis[1], S. W. Huang[1], C. J. Milne[3], Q. X. Jia[4], S.-W. Cheong[5], and P. Beaud[1]

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Three dimensional manganites, transition metal oxides with a perovskite structure, feature multifaceted phase diagrams due to their close interaction of charge, atomic order and spin. Their high susceptibility towards external stimulation by controlling temperature, applied magnetic or electric fields or photo-excitation [1] yields various ways of manipulating these different phases. In two prominent members of these 3D manganites, $La_{1-x}Ca_xMnO_3$ (LCMO) and $La_{5/8-y}Pr_yCa_{3/8}MnO_3$ (LPCMO), the Jahn-Teller effect results in causes a distortion of the oxygen octahedra at the Mn^{3+} sites and establishes a superlattice along with a CE-type charge and orbital ordering below the ordering temperature T_{CO} [2]. Here, we present a time resolved study of the CO/OO phase dynamics upon photo-excitation in a thin LCMO (x=0.58) film and a single crystal of LPCMO (y=3/8), respectively.

Optical reflectivity data are collected with a high-power Ti:S laser system 800 nm single colour pump probe setup, equipped with a closed cycle refrigerator allowing temperatures from 5-300 K. Time resolved hard x-ray diffraction data have been collected on both samples at the FEMTO slicing beamline at the Swiss Light Source [3].

The temperature dependences show a displacively excited coherent phonon with a period of ~2.5 (2.0) THz only featuring in the charge and orbitally ordered phase for $T \leq T_{CO} \approx 210$ K (240 K). Fluence dependences recorded at various temperatures yield phase transition threshold values and insight on saturation behavior. Measurements on a superlattice reflection with time resolved x-ray diffraction confirms the displacive excitation of the coherent optical A_g phonon also seen in the optical transients at low excitation fluences and its disappearance above is direct evidence for a structural phase transition.

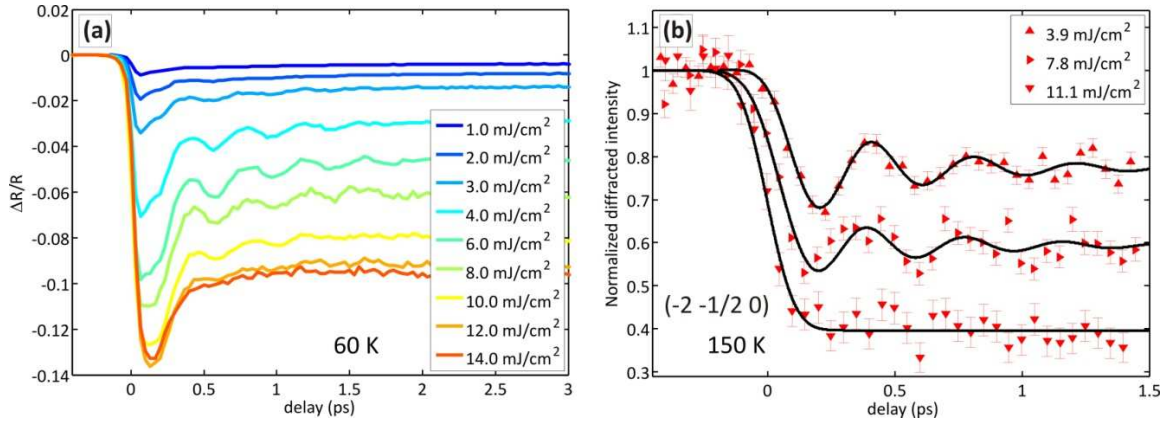

Fig. 1. **(a)** Reflectivity transients for fluence excitations ranging from F = 1.0-14.0 mJ/cm^2 for the mixed valence manganite $La_{0.25}Pr_{0.375}Ca_{0.375}MnO_3$ recorded at 60 K. The vanishing of the oscillatory behavior at around 10 mJ/cm^2 is clearly visible and is a strong indication of the photoinduced melting of the CO/OO state within 1 ps. **(b)** Time traces of the diffracted intensity of the superlattice (-2 -1/2 0) of LPCMO for low (3.9 mJ/cm^2), intermediate (7.8 mJ/cm^2) and high (11.1 mJ/cm^2) excitation fluences at 150 K. The appearance of the 2.5 THz coherent phonon below the melting threshold of ~10 mJ/cm^2 and its disappearance above is direct evidence for a structural phase transition.

[1] P. Beaud, S. L. Johnson, E. Vorobeva, U. Staub, R. A. D. Souza, C. J. Milne, Q. X. Jia, and G. Ingold, „Ultrafast structural phase transition driven by photoinduced melting of charge and orbital order“, Phys. Rev. Lett. **103**, 155702 (2009)
[2] Y. Tokura and N. Nagaosa, „Orbital physics in transition-metal oxides“, Science **288**, 462-468 (2000)
[3] P. Beaud, S. L. Johnson, A. Streun, R. Abela, D. Abramsohn, D. Grolimund, F. Krasniq, T. Schmidt, V. Schlott, and G. Ingold, "Controlling spatiotemporal stability of a femtosecond hard-x-ray undulator source studied by control of coherent optical phonons," Phys. Rev. Lett. **99**, 174801

Studying size-dependent magnetization curves of individual iron nanoparticles at finite temperatures

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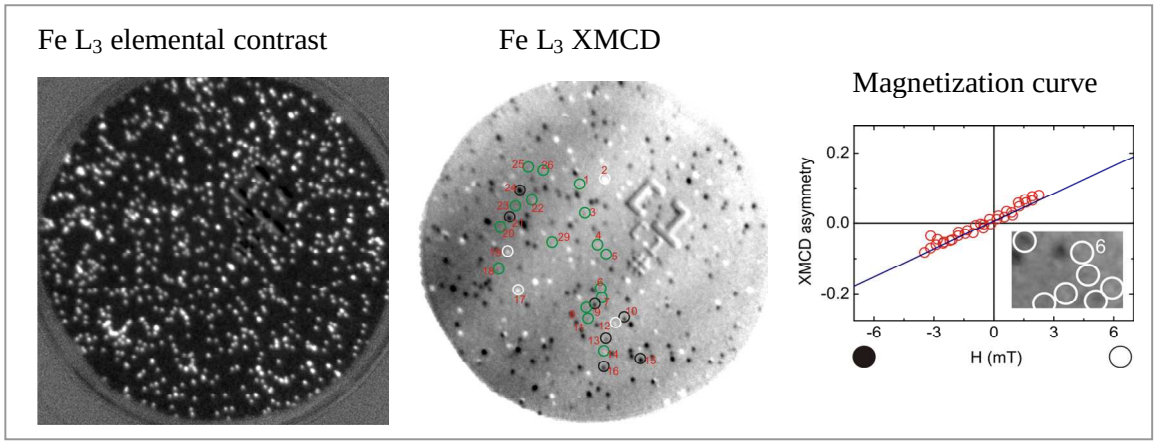
Magnetic nanoparticles show a variety of novel magnetic phenomena when compared to the respective bulk materials, mostly due to the effect of the surface and interface on the magnetic interactions and to critical magnetic length scales such as domain wall width and exchange length. For instance the size may determine whether a particle is in a single domain state or whether it will show a non-collinear spin structure [1]. A related aspect concerns magnetic switching processes in a nanoparticle. For sufficiently small structures it is assumed that the magnetic reversal occurs as a coherent rotation of the atomic spins at T = 0 K. However, at finite temperatures thermal excitations may disturb the ferromagnetic spin order and thus lead to complex reversal modes [2]. These modes are not only relevant for the quasi-static properties of the particles, but also determine their dynamical response to external stimuli.

We have used photoemission electron microscopy (PEEM) together with x-ray magnetic circular dichroism (XMCD) to detect the magnetization curves of individual Fe nanoparticles at room temperature, cf. Fig. 1. By varying the particle size we observe the transition from superparamagnetic fluctuations to stable ferromagnetic order at a particle size of about 12 nm. Applying a magnetic field allows us to record magnetization curves of the particles in both, the superparamagnetic and the ferromagnetic state, as well as in the transition regime. We compare these data with the predictions of conventional macro spin theory and discuss the role of thermal excitations and non-collinear spin structures on the magnetization reversal.

references:
[1] A. Fraile-Rodriguez *et al.*, *Phys. Rev. Lett.* **104**, 127201 (2010).
[2] S. Krause *et al.*, *Phys. Rev. Lett.* **103**, 127202 (2009).



Pb/Si(111) - a potential candidate for spin-based electronics

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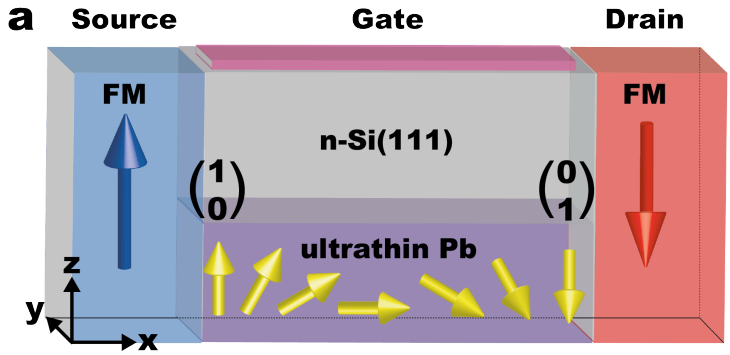
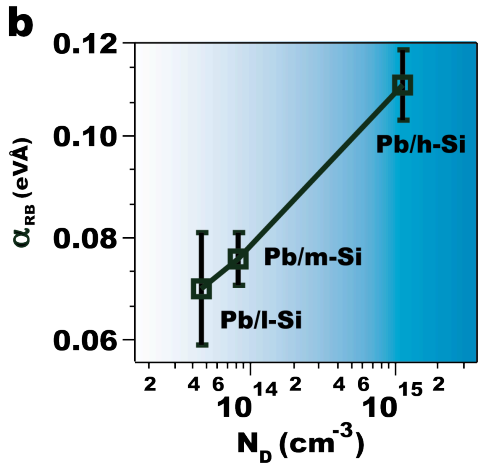
Spin-orbit interaction (SOI) in low-dimensional systems is a fascinating property that locks the spin direction of an electron to its momentum. In Pb on Si(111) the translational symmetry normal to the plane of a two-dimensional (2D) electron gas is broken by the surface and interface. This generates a spin texture in the momentum



space consisting of a pair of circles around the Gamma point with tangentially aligned spins of opposite directions, forming spin vortices of different radii. The difference of the radii, i.e. the momentum splitting of the Rashba pairs, depends on the strength of the SOI. The key-ingredient of a spin-based field-effect transistor (Fig. a) is the tuning of the SOI through any external parameter to change the momentum splitting between spins of opposite directions.

Here we will show that the doping level of the n-type Si(111) alters the Rashba splitting in a very efficient way - a change of the donor concentration by a factor of ~20 raises the strength of SOI by almost a factor of two, as shown in Fig b.



We explain our results in terms of a modified charge density distribution close to the Pb nuclei, which is sensitive to the potential gradient within the depletion area of Si(111).

Our results provide for the first time direct spectroscopic evidence of a Rashba-type spin splitting in QWS that can be tuned by an external control parameter.

Fig a) - Schematic working principle of a spin-FET
Fig b) - Measured Rashba constant vs donor concentration of n-Si(111)