PAUL SCHERRER INSTITUT

PSD Mini Symposium

Magnetism and Detector

Tuesday, June 11, 2019

10:00 to 12:15, WBGB 019

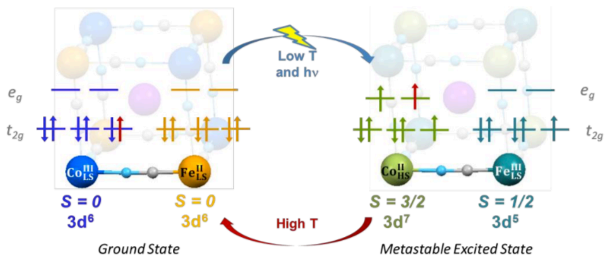
10:00 X-ray Magnetic Spectroscopy Study of Switchable Photomagnetic Cubes
Niéli Daffé, J-R Jiménez, M. Studniarek, A. Benchohra, M-A Arrio, R. Lescouëzec and J. Dreiser

10:30 Characterization of MÖNCH0.3 detector for soft X-ray applications
Sabina Chiriotti, M. Andrä, R. Barten, A. Bergamaschi, G. Borghi, M. Boscardin, M. Brückner, R. Dinapoli, E. Fröjdh, D. Greiffenberg, M. Langer, C. Lopez-Cuenca, M. Meyer, D. Mezza, A. Mozzanica, J. Raabe, S. Redford, S. Ronchin, C. Ruder, B. Schmitt, X. Shi, D. Thattil, G. Tinti, S. Vetter and J. Zhang

11:00 Coffee break

11:15 Development of the MYTHEN III microstrip detector
Marie Andrä, A. Bergamaschi, R. Barten, M. Brückner, N. Casati, A. Cervellino, S. Chiriotti, R. Dinapoli, E. Fröjdh, D. Greiffenberg, C. Lopez-Cuenca, M. Meyer, D. Mezza, A. Mozzanica, S. Redford, C. Ruder, B. Schmitt, X. Shi, D. Thattil, G. Tinti, S. Vetter and J. Zhang

11:45 Manipulation of the spin-orbital and charge degrees of freedom upon tuning the lattice environment of strontium iridates
Eugenio Paris, Y. Tseng, E. Pärschke, W. Zhang, D.E. McNally, M. Naamneh, M. Upton, A. Efimenko, V.N. Strocov, K. Rolfs, T. Shang, L. Maurel-Velazquez, D. Casa, M. Medarde, C. Schneider, E. Pomjakushina, K. Wohlfeld, M. Radovic and T. Schmitt



X-ray Magnetic Spectroscopy Study of Switchable Photomagnetic Cubes

Niéli Daffé[1], Juan-Ramón Jiménez[2], Michał Studniarek[1], Amina Benchohra[2], Marie-Anne Arrio[3], Rodrigue Lescouëzec[2], and Jan Dreiser[1].

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Switchable molecules exhibiting tunable physical properties as a function of external stimuli (electric or magnetic fields, temperature, light, pressure etc.) have promising applications in molecule-based electronic devices (molecular switches, sensors or qubits). Therefore, the past decade witnesses considerable interest in the design of new molecular systems in the field of molecular material science. One of the most encouraging groups of compounds have emerged from the family of Prussian Blue Analogues (PBAs) that are known to exhibit concomitant changes in their magnetic and optical properties induced by a metal-to-metal electron transfer when they are submitted to a temperature or light stimulus [1]. Molecular cubes based on Co and Fe linked by cyanide bridges is a prime example of a reversible conversion occurring between the diamagnetic Fe^{II}_{LS}-CN-Co^{III}_{LS} pairs and the paramagnetic Fe^{III}_{LS}-CN-Co^{II}_{HS} one (Figure 1). However, the acquisition of key information to determine the geometry and the nature of the coordinated atoms to understand the metal-to-metal transfer remains one of the main issues faced when studying PBAs. To this end, X-ray Absorption Spectroscopy (XAS) and X-ray Magnetic Circular Dichroism (XMCD) measured at the $L_{2,3}$ edges of 3d transitions metals is a powerful method to gain better insight regarding the spin and oxidation states of the metals ions [2]. With the adjunction of light and temperature, we follow the oxidation state changes of the Fe and Co ions, while XMCD measurements yield the element specific magnetic moments delivering insight into their spin states. The calculations of the X-ray spectra allow us to quantify the distribution of diamagnetic Fe^{II}_{LS}-CN-Co^{III}_{LS} pairs and of the paramagnetic Fe^{III}_{LS}-CN-Co^{II}_{HS} ones in the ground and light-induced excited state, respectively. XAS and XMCD investigation of this system provide an atomic scale picture of the switching mechanism and address the pertinent question on the nature of the magnetic interaction between the Fe and Co ions in molecular PBAs. Our results provide a feedback to the synthesis of such molecular cages that can help in return to design cages with further improved properties.

[1] Aguilà et al. Chem. Soc. Rev. (2015)
[2] Daffé et al., J. Phys. Chem. Lett. (2019)

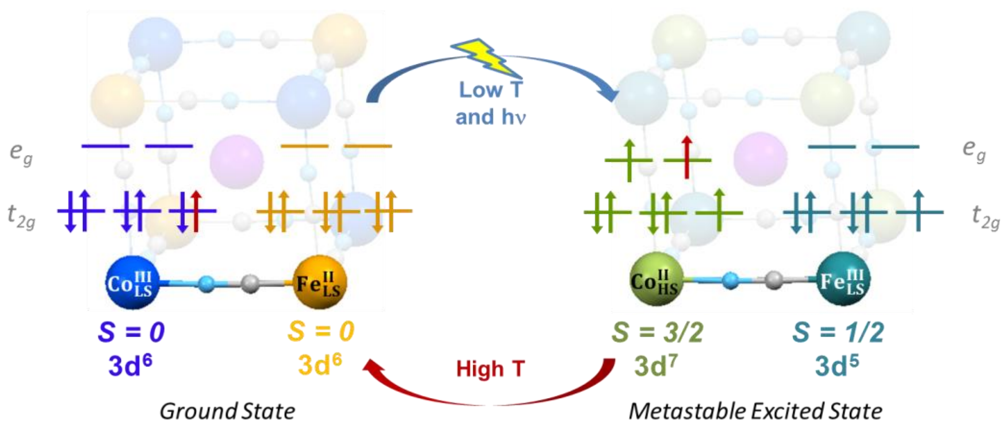

Figure 1. Scheme of the Co and Fe electronic and spin states of the heterocubane Fe_4Co_4 molecules in the ground state and in the light-induced photoexcited state.

Characterization of MÖNCH0.3 detector for soft X-ray applications

S. Chiriotti[1],*, M. Andrä[1], R. Barten[1], A. Bergamaschi[1], G. Borghi[2], M. Boscardin[2], M. Brückner[1], R. Dinapoli[1], E. Fröjdh[1], D. Greiffenberg[1], M. Langer[1], C. Lopez-Cuenca[1], M. Meyer[1], D. Mezza[1], A. Mozzanica[1], J. Raabe[1], S. Redford[1], S. Ronchin[2], C. Ruder[1], B. Schmitt[1], X. Shi[1], D. Thattil[1], G. Tinti1, S. Vetter[1], J. Zhang[1]

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The MÖNCH [1] detector (Micropixel with enhanced pOsition rEsolution usiNg CHarge integration) is a low-noise charge-integrating hybrid pixel detector with 25 µm pixel pitch. MÖNCH is currently being developed by the PSI detector group targeting mainly high resolution and soft X-ray applications at synchrotrons and X-ray free electron lasers (XFELs).

Until now, three prototypes have been characterized and tested. MÖNCH0.3 [2] is the latest working prototype consisting of an array of 400x400 pixels with an active area of 1x1 cm^2. It has been successfully used at several experiments [3] at SLS beamlines down to 700 eV photon energies thanks to its low noise performance of 36 e- ENC. This noise value of less than 150 eV r.m.s. allows the detection of 700 eV photons with a Signal-to-Noise Ratio (SNR) close to 5 or equivalently providing an energy resolution of about 350 eV FWHM.

However, there are still some critical issues in the development of detectors for the soft X-ray range (250–2000 eV) like improving the SNR to achieve single photon resolution at low energies, extending the dynamic range using gain switching, increasing the frame rate above 1 kHz for synchrotron applications and obtaining high quantum efficiency by developing dedicated sensors with shallow backplane thicknesses. Moreover, a reliable operation under high vacuum conditions is required.

In this presentation, we will discuss the main challenges needed for having a detector suitable for low energy detection and we will show the characterization of MÖNCH0.3 using sensors with shallow backplanes. Moreover, the first results obtained with MÖNCH in a new soft X-ray spectromicroscope based on ptychography at the SIM beamline will be presented.

[1] R. Dinapoli et al, J. Instrum. 9 (2014) p. C050115.

[2] M. Ramilli et al, J. Instrum. 12 (2017) p. C01071.

[3] A. Bergamaschi et al. (2018) Synch. Rad. News 31, 11.

Development of the MYTHEN III microstrip detector

Marie Andrä, Anna Bergamaschi, Rebecca Barten, Martin Brückner, Nicola Casati, Antonio Cervellino, Sabina Chiriotti, Roberto Dinapoli, Erik Fröjdh, Dominic Greiffenberg, Carlos Lopez-Cuenca, Markus Meyer, Davide Mezza, Aldo Mozzanica, Sophie Redford, Christian Ruder, Bernd Schmitt, Xintian Shi, Dhanya Thattil, Gemma Tinti, Seraphin Vetter and Jiaguo Zhang

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The MYTHEN detector is a single photon counting microstrip detector with 50 µm pitch developed at the Swiss Light Source for powder diffraction experiments [1]. After more than ten years of operation of MYTHEN II, a new readout chip MYTHEN III was designed in 110 nm UMC technology to upgrade the current detector. It is designed to improve all aspects, specifically noise performance, count rate capability, threshold dispersion and frame rate.

Each strip in the MYTHEN III chip features three comparators and gateable 24-bit counters. The internal counting logic allows for different modes of operation: energy-windowing, charge sharing suppression, count rate improvement and pump-probe with multiple time slots.

The first two prototypes have been tested in the lab and at the synchrotron. The untrimmed threshold dispersion was measured to be 70% lower than in MYTHEN II) and the noise is reduced by 24% compared to MYTHEN II [2], which means that the minimum threshold energy is 3.2 keV.

Thanks to the three thresholds in the chip, we can exploit pile-up of the analog signal in the shaper at high photon flux and thereby reach a count rate of 25 MHz.

Based on these results, a full scale chip with 128 channels was developed and is now under test.

The architectures of the chips, characterisation results and the design of the final 120° detector will be presented.

[1] A. Bergamaschi et al, The MYTHEN detector for X-ray powder diffraction experiments at the SwissLight Source, Journal of Synchrotron Radiation, vol 17., pp 653-668. (2010)

[2] M. Andrä et al, Towards MYTHEN 3: Characterization of prototype chips, Nuclear Instruments and Methods in Physics Research Section A, https://doi.org/10.1016/j.nima.2018.11.026 (2018)

Manipulation of the spin-orbital and charge degrees of freedom upon tuning the lattice environment of strontium iridates

E. Paris [1], Y. Tseng [1], E. Pärschke [2], W. Zhang [1], D.E. McNally [1], M. Naamneh [1], M. Upton [3], A. Efimenko [4], V.N. Strocov [1], K. Rolfs [1], T. Shang [1], L. Maurel-Velazquez [1], D. Casa [3], M. Medarde [1], C. Schneider [1], E. Pomjakushina [1], K. Wohlfeld [5], M. Radovic [1] & T. Schmitt [1]

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In strontium iridates, the combination of electron-electron correlations and high spin-orbit coupling leads to exotic ground states with electronic and magnetic properties strongly coupled with the lattice degree of freedom.
For instance, in the Mott-insulating state of Sr_2IrO_4, the complex isospin interactions are sensitive to the length and angle of the Ir-O bond. We use epitaxial strain to manipulate the ground state properties of Sr_2IrO_4 and Resonant Inelastic X-ray Scattering (RIXS) to probe the evolution of the low-energy elementary excitations. We find epitaxial strain to control the magnetic correlations, with the spin-wave mode showing an anisotropic softening. By comparison with simulations based on band structure calculations, we assign a dispersive mode at 400 meV to electron-hole pair excitations. Both energy and bandwidth of this mode are highly affected by strain, connecting its development to the evolution of the band structure and the charge gap upon lattice distortions.
When combined with titanates in the form of a superlattice, $SrIrO_3$ undergoes a metal-insulator transition (MIT) with magnetism developing in the highly confined limit. We use RIXS to probe the response of the elementary excitations upon confinement in heterostructures of the form $(SrIrO_3)_m/(SrTiO_3)_n$, by varying the thickness of the iridate layer. We detect a collective mode in the highly confined samples, similar to the spin-wave observed in the Sr_2IrO_4 system. Surprisingly, we find the bandwidth and spectral weight of this excitation to increase above the magnetic transition, being prominent in the paramagnetic metallic phase.