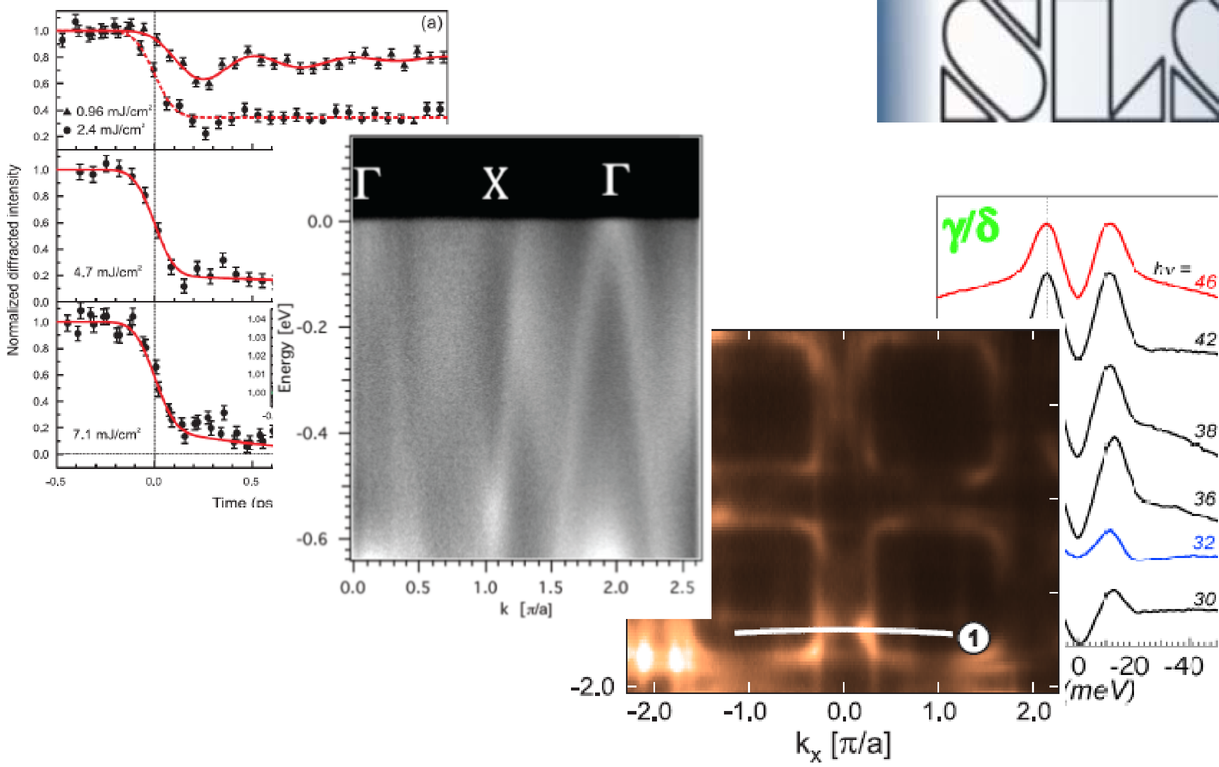

SLS Symposium on

Correlated Electron Systems

Tuesday, February 1, 2011

10:00 to 12:15, WBGB/019

10:00 Ultrafast Dynamics in Correlated Electron Systems
Paul Beaud, S. Johnson, E. Vorobeva, A. Cavizel, C. Milne, G. Ingold, R. De Souza, U. Staub

10:30 Revealing the Ortho-II Band Folding in YBa2Cu3O$_{7-\delta}$ Films
Yasmine Sassa, M. Radovic, M Månsson , E. Razzoli, X. Cui, S. Pailhès, S. Guerrero, M. Shi, P.R. Willmott, F.M. Granozio, J. Mesot, M.R. Norman and L. Patthey

11:00 Coffee

11:15 Electronic structure of $LaRu_2P_2$ superconductor probed by angle resolved photoemission spectroscopy
Elia Razzoli, M. Shi, J. Mesot

11:45 Observation of a ubiquitous three-dimensional superconducting gap function in iron-pnictide $Ba_{0.6}K_{0.4}Fe_2As_2$
Y.-M. Xu, Yaobo Huang, X-Y. Cui, E. Razzoli, M. Radovic, M. Shi, G.-F. Chen, P. Zheng, N-L. Wang, C-L. Zhang, P-C. Dai,6,7, J-P. Hu, Z. Wang, H. Ding

Ultrafast Dynamics in Correlated Electron Systems

Paul Beaud[1], **_Steven Johnson_**[1], **_Ekaterina Vorobeva_**[1], **_Andrin Cavizel_**[1], **_Christopher Milne_**[1,2], **_Gerhard Ingold_**[1], **_Racquel De Souza_**[1], **_Urs Staub_**[1],

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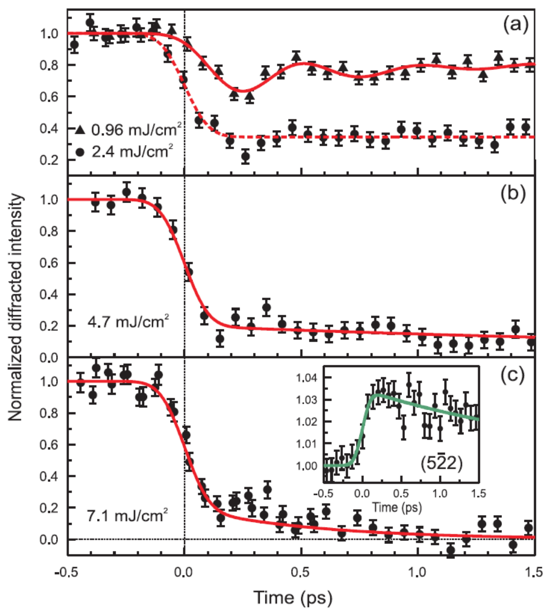
In the past decades modern solid state research has discovered many new materials with exotic but highly technologically relevant properties such as high-temperature superconductivity, colossal magnetoresistance, and multiferroicity. A common feature of these materials, often referred to as strongly correlated electron systems, is a complex phase diagram arising from strong interactions among local charges, orbitals, spins, and distortions of the atomic lattice. *Pump-probe* experiments on an ultrafast time scale may offer new insights into these strong correlations by separating correlated effects in the time domain. Correlated effects are often dominated by the dynamic atomic and electronic long range structure and ultrashort x-rays may be employed to probe these dynamics.

With the successful implementation of the femtosecond slicing technique at the SLS [1], it is now possible to follow atomic motion on the fundamental time scale of atomic vibrations [2]. In collaboration with the ReSoXS-group we have recently started to study the dynamics of correlated materials in the vicinity of phase transitions initiated by exciting the electronic system with an ultrashort optical laser pulse. Initial experiments have concentrated on using hard x-ray diffraction at the FEMTO/microXAS beamline to probe the laser-induced lattice dynamics in diverse electronically-ordered systems [3,4]. In order to measure the dynamics of the electronic structure a soft x-ray FEL is required [5]. More recently we have used time-resolved resonant x-ray diffraction at the LCLS to study magnetic dynamics in a multifferoic material [6]. Here we summarize our results, and discuss future directions concentrating on the need to develop complementary and more specific *pump* schemes offered by ultrashort pulses in the THz energy range.



The structural response of a charge- and orbitally-ordered thin film of $La_{0.42}Ca_{0.58}MnO_3$ to ultrafast optical excitation at 1.55 eV is directly probed with femtosecond hard x-ray diffraction. At low excitation fluence the crystal rearranges the atomic positions within the unit cell via the displacive coherent optical phonon mechanism, but still maintains its symmetry. At fluences above 2 mJ/cm^2 we observe the sudden collapse of the (5 -5 2) superlattice reflection demonstrating an ultrafast non-thermal phase transition. Remarkably the crystal changes its symmetry within a sub-picosecond time range with initial dynamics significantly faster than the time resolution of our experiment of 200 fs [3].

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[3] P. Beaud et al., *Phys. Rev. Lett.* **103**, 155702, 2009.
[4] E. Vorobeva et al.; S. Mariager et al., *to be published*.
[5] G. Ingold, et al., *Z. Kristallogr.* **223**, 292-306, 2008.
[6] S. L. Johnson et al., *submitted*, 2011.

Revealing the Ortho-II Band Folding in $YBa_2Cu_3O_{7-\delta}$ Films

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Xiaoyu Cui,[3] Stéphane Pailhès,[5] Sebastian Guerrero,[6] Ming Shi,[3] Philip R. Willmott,[3]
Fabio Miletto Granozio,[7] Joël Mesot,[8] M. R. Norman,[9] and Luc Patthey[3]

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(Dated: January 22, 2011)

Since more than 20 years, the unconventional behavior of high-temperature superconductors (HTSC) is far from being understood even though, experimentally, HTSC materials are rather easy to measure. Indeed, these compounds are layered materials with quasi-two-dimensional electronic structure, which simplifies the data analysis and make experiments like angle-resolved photoelectron spectroscopy (ARPES) achievable. ARPES is a powerful technique, which requires a flat and clean crystalline surface usually obtained after cleaving the crystal. However, not all high-temperature superconductor materials present an easy cleavage plane. For instance, $YBa_2Cu_3O_{7-\delta}$ (YBCO) single crystals, which have been intensively studied by various bulk techniques, do not have a natural cleavage plane making surface-sensitive experiments delicate. Moreover, due to polarity, the cleaved surface tends to be strongly overdoped [1] even though the bulk is underdoped. As a result, very few significative ARPES investigations were achieved. To overcome the cleaving procedure, the solution suggested in this work is to grow high-quality epitaxial superconducting YBCO thin-films and to transfer them *in situ* to the ARPES set-up. For this purpose, the pulsed laser deposition (PLD) technique was chosen as growing method since it is one of the most reliable technique to synthesize oxide films. Our data reveal an underdoped YBCO surface with an additional band folding [Fig. 1], which can be connected to ordered oxygen vacancies of the Ortho-II phase [2, 3]. Until now, the Ortho-II band folding was not detected by ARPES and thought to be negligible.

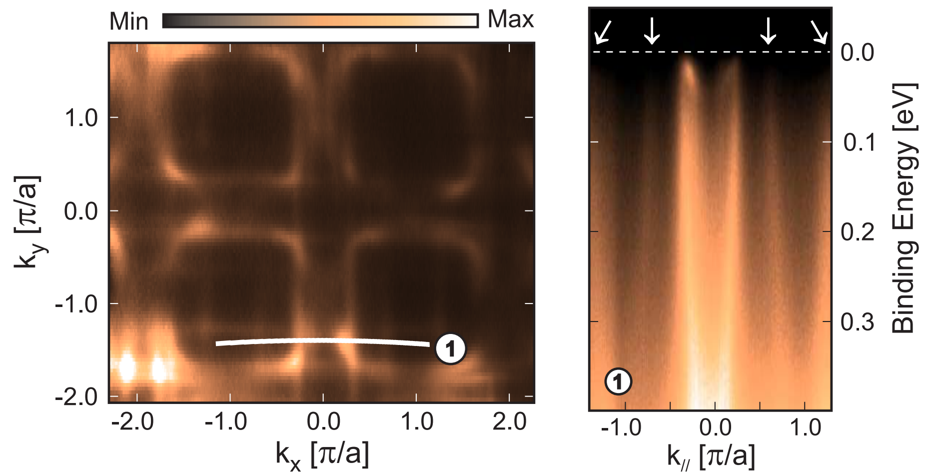

FIG. 1: Left: Spectral intensity map acquired at a photon energy of 70 eV. Right: ARPES spectra acquired at cut ① in k-space as indicated by the white solid line in the energy intensity map. The white arrows indicate the Ortho-II band folding.

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Electronic structure of $LaRu_2P_2$ superconductor probed by angle resolved photoemission spectroscopy

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The details of the electronic structure are really important for understanding how superconductivity emerges in Iron pnictides. The presence of long parts of Fermi surface (FS) connected by a fixed wave vector **Q**, the so-called FS nesting, has been proposed to be the driving force for the formation of the Spin Density Wave (SDW) and superconductivity in the phase diagram of pnictides [1]. To exam this idea we made a comprehensive study of the electronic structure of $LaRu_2P_2$ which does not have a SDW at low temperature and is superconducting (T_c = 4 K) without adding additional charge carries into the system. In this contribution we will discuss the quantitative difference in the band structures between $LaRu_2P_2$ and the much more studied $Ba_{1-x}K_xFe_2As_2$ in the normal state. The relevance of the Fermi surface nesting in $LaRu_2P_2$ will also be examined.

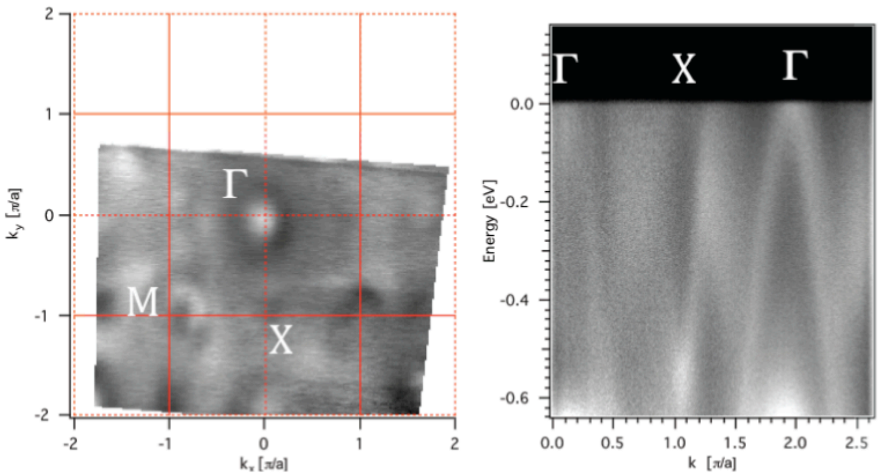

Figure 1: ARPES Data obtained in the normal state of $LaRu_2P_2$. (Left) Spectral weight map in k-space at the Fermi Level (photon energy hν = 68 eV). (Right) ARPES data along the high symmetry line Γ- X.

References:

[1] I.I. Mazin , J. Schmalian Physica C 469, 614–627 (2009)

Observation of a ubiquitous three-dimensional superconducting gap function in iron-pnictide $Ba_{0.6}K_{0.4}Fe_2As_2$

Y-M. Xu[1], Y-B. Huang[2,3], X-Y. Cui[3], E. Razzoli[3,4], M. Radovic[3,4], M. Shi[3], G-F. Chen[5], P. Zheng[2], N-L. Wang[2], C-L. Zhang[6], P-C. Dai[2,6,7], J-P. Hu[2,8], Z. Wang[1], H. Ding[2]

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The iron-pnictide superconductors have a layered structure formed by stacks of [FeAs] planes from which the superconductivity originates. Unlike cuprates superconductors, band structure calculation predicts that they have remarkable three-dimension(3D) dispersion[1]. In order to determine it's quasi-3D band structure and to understand it's superconducting properties, we performed high-resolution angle-resolved photoemission spectroscopy(ARPES) on the optimal doped sample $Ba_{0.6}K_{0.4}Fe_2As_2$.

By using the k_z capability of ARPES, we determined the SC gap on all five Fermi surfaces in three dimensions and found a marked k_z dispersion of the SC gap [Fig.1], which can only derive from the intralayer paring. Interestingly, the SC energy gaps can be described by a single 3D gap function with two energy scales characterizing the strengths of intralayer Δ_1 and interlayer Δ_2 pairing. The ratio Δ_1/Δ_2, determined from the gap function is close to the *c*-axis anisotropy ratio of the magnetic exchange coupling J_c/J_{ab} in the parent compound[2]. This ubiquitous gap function reveals that pairing is short-ranged and suggests the short-range anti-ferromagnetic fluctuations be a suitable candidate for the paring force in this superconducting system.

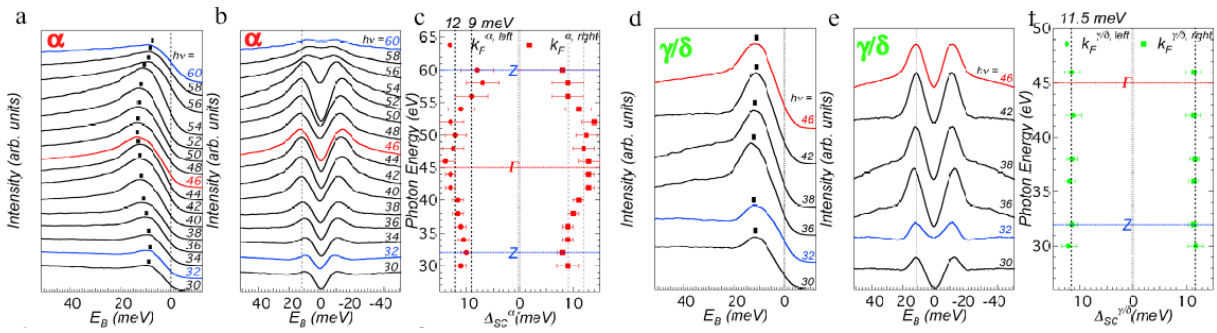

Fig.1, ***kz* dependence of the superconducting gaps.** a(d),Photon-energy-dependent EDCs measured at the k_F on the *α(γ/δ)* FSs along Γ–X(Γ-M) or its parallel directions with different k_z The red and blue EDCs correspond to k_z=0 and k_z=π, respectively. b(e),Corresponding symmetrised EDCs of the ones shown in panel a(d). c(f),Extracted values of the SC gap.

Reference

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