ESRF	**Experiment title: Chiral symmetry of the copper site structure in high Tc superconductors by X-ray natural circular dichroism**	**Experiment number**: **HC-2651**
Beamline: ID12	**Date of experiment**: **from:** 15 set 2016 **to:** 20 set 2016	**Date of report**: 26-FEB-2018
Shifts: 9	Local contact(s)**:** Fabrice Wilhelm (email: wilhelm@esrf.fr)	*Received at ESRF:*

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Report: $Bi_2Sr_2CaCu_2O_{8+y}$ (Bi2212) is the most studied cuprate superconductor discovered in 1988, and studied by the most sophisticated experimental methods in 30 years to unveil the mechanism of high temperature superconductivity which reaches here the critical temperature of 90 K for optimum oxygen interstitials concentration. The need of a multiband Hubbard model (MBHM) [2] to grab the essential physics of this system was pointed out by the discovery that a) carriers are partially in the Cu 3d orbital with large Hubbard U=6 eV and partially in the oxygen 2p orbital [3-6] b) different electronic components with multiple orbitals contribute to the Fermi surface and pseudogap topology [7] and c) the lattice is inhomogeneous showing local anisotropic local lattice distortions detected by resonant x-ray diffraction [8] and Cu K-edge and Cu-L-edge x-ray absorption [9-11].
Although its crystallographic structure was investigated by many authors the large majority of theories, proposed to interpret unconventional high T_c superconductivity in $Bi_2Sr_2CaCu_2O_{8+y,}$ assume a centrosymmetric tetragonal CuO_2 lattice for the $[CuO_2]Ca[CuO_2]$ bilayer. In this experiment we have found new compelling results providing evidence for local non-centrosymmetric symmetry at the Cu atom. We have measured polarized Cu *K*-edge XANES (x-ray absorption near edge structure) and the *K*-edge X-ray magnetic circular dichroism (XMCD) of a Bi2212 single crystal near optimum doping. The Cu K edge XMCD signal was measured at ID12 beamline of ESRF with the k-vector of x-ray beam parallel to c-axis i.e. with the electric field of x-ray beam **E**//**ab**, using a 17 T magnetic field parallel to the c-axis of a Bi2212 single crystal. Numerical simulations of the XMCD signal of Bi2212 by multiple scattering theory have shown agreement with the experimental C K-edge XMCD signal at the Cu K-edge XANES [12-14] only for the local structure with non-centrosymmetric Bb2b space group of $Bi_2Sr_2CaCu_2O_{8+y}$.

These results of the experiments published in Journal of Superconductivity and Novel Magnetism [15] open novel perspective for the role of spin-orbit coupling in the spitting of states with different spin polarizations at the Fermi level and for unconventional Lifshitz transitions playing a key role in high temperature superconductivity.

1. H. Maeda, Y. Tanaka, M. Fukutomi, T. Asano A new high-Tc oxide superconductor without a rare earth element. *Jpn. J. Appl. Phys.* **27,** L209 (1988) doi:10.1143/jjap.27.l209.
2. A. Bianconi, Lifshitz transitions in multi-band Hubbard models for topological superconductivity in complex quantum matter. *Journal of Superconductivity and Novel Magnetism* **31**, 603 (2018). doi:10.1007/s10948-017-4535-1
3. A. Bianconi, P. Castrucci, M. de Santis, et al., Symmetry of the hole states in BiCaSrCuO High-Tc superconductors. Modern Physics Letters B (MPLB) **2**, 1313 (1988), URL http://www.worldscinet.com/mplb/02/0211n12/S0217984988001302.html
4. M. De Santis, A. Di Cicco, P. Castrucci, et al. Evidence for 3d9-ligand hole induced by doping in Bi-Sr-Ca-Cu-o and Tl-Ca-Ba-Cu-O. Physica B: Condensed Matter **158**, 480 (1989) doi:10.1016/0921-4526(89)90355-4
5. M. De Santis, *et al.* Joint analysis of the Cu L3 XAS and XPS spectra of hIgh Tc superconductors for determination of states induced by doping. In Bianconi, A. & Marcelli, A. (eds.) *High Tc Superconductors: Electronic Structure*, 313+ (Pergamon press 1989; Elsevier 2016, 1989).
6. A. Bianconi, S. Della Longa, C. Li, et al. Linearly polarized Cu $_{L3}$-edge x-ray-absorption near-edge structure of $Bi_2CaSr_2Cu_2O_8$. Phys. Rev. B **44**, 10126 (1991). doi:10.1103/physrevb.44.10126
7. N. L. Saini, J. Avila, A. Bianconi, et al. Topology of the pseudogap and shadow bands in Bi2Sr2CaCu2O8+δ at optimum doping. Phys. Rev. Lett. **79**, 3467 (1997), doi:10.1103/physrevlett.79.3467
8. A. Bianconi, M. Lusignoli, N. L. Saini, et al. Phys. Rev. B **54**, 4310 (1996), doi:10.1103/physrevb.54.4310
9. A. Bianconi, *et al.* Stripe structure in the CuO2 plane of perovskite superconductors. *Phys. Rev. B* **54**, 12018 (1996). doi:10.1103/physrevb.54.12018
10. N. L. Saini, A. Lanzara, A. Bianconi, and H. Oyanagi, Asymmetric local displacements in the Bi2Sr2CaCu2O8+β superconductor The European Physical Journal B - Condensed Matter and Complex Systems **18**, 257 (2000), doi:10.1007/s100510070056
11. N. Saini, H. Oyanagi, M. Molle, K. Garg, C. Kim, and A. Bianconi, Evidence for anisotropic atomic displacements and orbital distribution in the inhomogeneous CuO2 plane of the Bi2Sr2CaCu2O8+δ system, Journal of Physics and Chemistry of Solids **65**, 1439 (2004). doi:10.1016/j.jpcs.2003.12.011
12. A. Bianconi, S. Doniach, D. Lublin, X-ray Ca K edge of calcium adenosine triphosphate system and of simple Ca compunds *Chemical Physics Letters* **59**, 121 (1978) doi:10.1016/0009-2614(78)85629-2.
13. A. Bianconi, M. Missori, The instability of a 2D electron gas near the critical density for a wigner polaron crystal giving the quantum state of cuprate superconductors. *Solid State Communications* **91**, 287 (1994). doi:10.1016/0038-1098(94)90304-2.
14. A. Bianconi, *et al.* Cu k -edge polarized x-ray-absorption near-edge structure of Bi2CaSr2Cu2O8. *Physical Review B* **44**, 4560 (1991). http://dx.doi.org/10.1103/physrevb.44.4560.
15. A. A. Ivanov, V. Ivanov, A. P. Menushenkov, F. Wilhelm, A. Rogalev, A. Puri, B. Joseph, W. Xu, A. Marcelli, and A. Bianconi, Local noncentrosymmetric structure of Bi2Sr2CaCu2O8+y by x-ray magnetic circular dichroism at cu K-Edge XANES. Journal of Superconductivity and Novel Magnetism **31**, 663 (2018), doi:10.1007/s10948-017-4418-5