Long-Range Incommensurate Charge Fluctuations in $(Y,Nd)Ba_2Cu_3O_{6+x}$ competing with superconductivity

G. Ghiringhelli[1], M. Le Tacon[2], M. Minola[1], S. Blanco-Canosa[2], C. Mazzoli[1], N.B. Brookes[3], G.M. De Luca[4], A. Frano[2,5], D. G. Hawthorn[6], F. He[7], T. Loew[2], M. Moretti Sala[3], D.C. Peets[2], M. Salluzzo[4], E. Schierle[5], R. Sutarto[7,8], G. A. Sawatzky[8], E. Weschke[5], B. Keimer[2], L. Braicovich[1]

[1] CNR-SPIN, CNISM and Dipartimento di Fisica, Politecnico di Milano, piazza Leonardo da Vinci 32, I-20133 Milano, Italy
[2] Max-Planck-Institut f¨ur Festk¨orperforschung, Heisenbergstraße 1, D-70569 Stuttgart, Germany
[3] European Synchrotron Radiation Facility, BP 220, F-38043 Grenoble Cedex, France
[4] CNR-SPIN, Complesso MonteSantangelo - Via Cinthia, I-80126 Napoli, Italy
[5] Helmholtz-Zentrum Berlin f¨ur Materialien und Energie, Albert-Einstein-Straße 15, D-12489 Berlin, Germany
[6] Department of Physics and Astronomy, University of Waterloo, Waterloo, Canada N2L 3G1
[7] Canadian Light Source, University of Saskatchewan, Saskatoon, Saskatchewan, Canada S7N 0X4
[8] Department of Physics and Astronomy, University of British Columbia, Vancouver, Canada V6T 1Z4

Science 337, **821** (2012)

High temperature superconductivity remains one of the most fascinating, yet unsolved, puzzles of condensed matter physics. Since the discovery of superconducting cuprates, theorists have suggested the coexistence of several electronic orders. At the same time, recently, it has been shown that the typical excitations of antiferromagnetic and insulating parent compounds (magnons) survive in the superconducting state at the optimal doping even in the case of the most studied High Tc material, i.e. $Y_1Ba_2Cu_3O_7$ [Fig.1]. These results were interpreted as a possible hint of a "magnetic" origin of the attractive interaction necessary for the formation of the Cooper pairs at high temperatures.

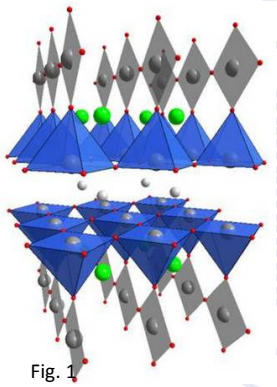

Fig. 1
The structure of (YNd)1Ba2Cu3O7 superconductor. Ghiringhelli, G. et al. Science 337, 821–825 (2012)

However, an estimation of the superconducting critical temperature deduced from the experimentally measured magnon-dispersion, yield values about two times higher than the experimental ones [1].

A possible reason of discrepancy was the simultaneous presence of competing electronic orders. However a direct, experimental, demonstration of the existence of such competing electronic phases remained elusive until now. Here, scientists of the Politecnico di Milano, of the Max-Planck Institute of Stuttgart and of the CNR-SPIN, found the first evidence of a charge density wave (CDW) in the high Tc family of $(Y,Nd)Ba_2Cu_3O_{6+x}$ cuprates [2]. By using the bulk sensitive resonant x-ray scattering, two-dimensional charge fluctuations with an incommensurate periodicity of ~3.2 lattice units have been identified in the copper-oxide planes of the superconducting $(Y,Nd)Ba_2Cu_3O_{6+x}$, with hole concentrations between 0.09 to 0.12 per planar Cu ion. The intensity and the correlation length of the fluctuation signal increase strongly upon cooling down the sample to the superconducting transition temperature (Tc); however, the divergence of the charge correlations abruptly reverses its trend below Tc. In combination with earlier observations of a large gap in the spin excitation spectrum, these data indicate an incipient charge density wave instability that competes with superconductivity [3].

[1] M. Le Tacon, G. Ghiringhelli, J. Chaloupka, M.M. Sala, V. Hinkov, M.W. Haverkort, M. Minola, M. Bakr, K.J. Zhou, S. Blanco-Canosa, C. Monney, Y.T. Song, G.L. Sun, C.T. Lin, G.M. De Luca, M. Salluzzo, G. Khaliullin, T. Schmitt, L. Braicovich, and B. Keimer, Nature Physics 7, 725 (2011).
[2]G. Ghiringhelli, M. Le Tacon, M. Minola, S. Blanco-Canosa, C. Mazzoli, N.B. Brookes, G.M. De Luca, A. Frañó, D.G. Hawthorn, F. He, T. Loew, M.M. Sala, D.C. Peets, M. salluzzo, E. Schierle, R. Sutarto, G.A. Sawatzky, E. Weschke, B. Keimer, and L. Braicovich, Science 337, 821 (2012).
[3] J. M. Tranquada, Cuprates Get Orders to Charge Science 17 August 2012 Vol. 337 no. 6096 pp. 811-812 DOI: 10.1126/science.1227082