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Charge density order and magnetic fluctuations in cuprate superconductors studied with Resonant (Inelastic) X-ray Scattering

Giacomo Ghiringhelli

CNR/SPIN and Dipartimento di Fisica, Politecnico di Milano, Italy

E-mail: giacomo.ghiringhelli@polimi.it

The appearance of superconductivity (SC) in layered cuprates upon doping with holes or electrons is still the matter of intense debate almost 30 years after the discovery of the so-called high Tc superconductors (HTcS). Given the strong superexchange interaction that stabilizes a 2D square lattice antiferromagnetic (AF) order in the parent compounds, the actual evolution of the spin order and its possible coupling to charge instabilities have been questioned and extensively studied over the years. In fact magnetic and/or charge fluctuations might play a central role in the superconductive transition. Moreover their possible relation with the pseudogap and the Fermi surface shape and size is still questioned.

Working at the ESRF and SLS, in the last 10 years we have developed high resolution resonant inelastic x-ray scattering (RIXS) and used it at the Cu L_3 edge of HTcS. This technique is the only alternative to inelastic neutron scattering for the study of magnons and paramagnons in those materials. RIXS has revealed that spin excitations persist up to very high doping levels, both in hole- and electron-doped compounds. The doping dependence of those magnetic excitations and their inherent character (spin-wave-like rather than Stoner mode) has been extensively characterized in several cuprate families. Moreover the energy selectivity allowed us to discover the reflection peak associated to charge density modulations, initially in underdoped YBCO and, more recently, in optimally doped Bi2212, LSCO and NdBCO. The evidence of persistent short range spin correlation and of ubiquitous charge density fluctuations in cuprates provided by R(I)XS has drastically reopened the debate over the basic mechanisms of HTcS. Finally, the new opportunities in terms of energy resolution, sample orientation control and detection efficiency to be provided by the forthcoming ID32-ERIXS facility at the ESRF and the perspective opened by time-resolved RIXS at the European XFEL will be discussed.