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Long-ranged Cu-based order at cuprate/manganite interface

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We present a resonant inelastic and elastic X-ray scattering (RIXS/REXS) study of epitaxial YBa2Cu3O7/Nd1-x(Ca1-ySry)xMnO3 heterostructures (NYN). We show that the Copper charge density wave (Cu-CDW) order of the near optimally doped YBa2Cu3O7 layers can be strongly modified via the hole doping and tolerance factor of Nd1-x(Ca1-ySry)xMnO3, i.e. by changing x and y.

At x=0.35 we observe a quasi-2D Cu-CDW order with dx2-y2 orbital character that resembles the one that is commonly found in strongly underdoped bulk YBCO. The strength of the corresponding Bragg peak at Q||=0.3 r.l.u. gets strongly enhanced as the tolerance factor of the manganite layers[1] is decreased and its CE-type antiferromagnetic and charge/orbital ordered (COO) is reinforced[1].

Upon increasing the hole doping of the manganite layers to x=0.5, we observe a new kind of Cu-CDW order which has a much smaller wave vector of Q||=0.1 r.l.u., a larger correlation length of about 40nm, and a different orbital character, i.e. dz2 rather than dx2-y2, than the one commonly found in the bulk cuprates[2].

The origin of this new Cu-dz2 charge order is presently not understood, but seems to be rooted in the particular properties of the cuprate/manganite interface. The RIXS and additional x-ray absorption spectroscopy (XAS) data provide evidence for an important role of the orbital reconstruction of the Cu-ions at the interface with the manganite and a related transfer of electrons from the manganite to the cuprate. In particular, they show that the Cu-dz2 orbital of the interfacial Cu ions is strongly shifted up in energy and lies close to the Fermi-level such that it contains a significant part of the hole carriers, which usually mainly reside in the Cu-dx2-y2 orbital. This orbital reconstruction may well exhibit a lateral modulation along the interface that is linked with the anomalous dz2-type Cu-CDW order.

While further studies are required to fully understand the interfacial coupling mechanism(s), the possibility of tuning the Cu-CDW holds great prospects for studying its relationship with high temperature superconductors and hopefully, for future quantum devices.

References

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Primary author: Dr GAINA CAPU, Roxana (University of Timisoara, Romania & University of Fribourg, Switzerland)

Co-authors: Dr SARKAR, Subhrangsu (University of Fribourg, Switzerland); Dr PERRET, Edith (University of Fribourg, Switzerland & EMPA, Switzerland); Dr SCHMITT, Thorsten (Paul Scherrer Insitute, Switzerland); Dr WESCHKE, Eugen (Helmholtz-Zentrum Berlin für Materialen und Energie, Germany); Prof. VIZMAN, Daniel (University of Timisoara, Romania); Prof. MONNEY, Claude (University of Fribourg, Switzerland); Prof. BERNHARD, Christian (University of Fribourg, Switzerland)

Presenter: Dr GAINA CAPU, Roxana (University of Timisoara, Romania & University of Fribourg, Switzerland)

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