Electronic orders and the the Fermi surface reconstruction in the cuprate superconductors

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A major difficulty in understanding high-T_c systems is the complexity of the materials, the presence of strong electron-electron interactions, and their rich phase diagrams. Synchrotron X-ray scattering is a powerful tool allowing to explore the electronic and structural degrees of freedom of complex materials. Furthermore, high magnetic fields play an important role in studying the high-T_c phenomenon, because such fields weaken the superconducting state and enable us to explore the competing states. One of such states is the spontaneous self-organized charge modulation, so called the charge density wave (CDW) order. Although its presence has been demonstrated within the CuO_2 plane of each family of cuprate superconductors [1], the extent of the CDW order as a function of doping, temperature, or magnetic field remains controversial.

I will present our recent results of the resonant X-ray scattering experiments in the model cuprate $HgBa_2CuO_{4+\delta}$ (Hg1201). While resonant X-ray scattering (RXS) allowed us to establish the doping-temperature range of the static CDW or-der in this compound [2,3], resonant inelastic X-ray scattering (RIXS) enabled the discovery of the short range CDW correlations at temperatures exceeding the onset of the static correlations observed by RXS. Such coexistence of static and dynamic CDW correlations is consistent with theoretical predictions [4]. The following electronic transport measurements in magnetic fields up to 70 T allowed to investigate the reconstruction of the Fermi surface by the CDW order.

Recent X-ray diffraction experiments at magnetic fields up to 28 T have shown that in addition to the described above CDW order within CuO_2 planes, an additional 3D charge order sets in at fields above approximately 18 T in the cuprate $YBa_2Cu_3O_{6+x}$ (YBCO) [5]. Our recent XAS measurements in fields up to 30 T suggest that the Cu-O chains, specific to this compound, contribute in the formation of this additional 3D CDW order. This demonstrates, that the 3D electronic order may be specific to YBCO and not generic to the cuprates.

The combined results allow to draw a universal electronic phase diagram of the cuprates.

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