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Role of the charge correlations in the mechanism of high temperature superconductivity

High-temperature superconductivity in cuprates is one of the most important conceptual problems in contemporary condensed matter physics, yet bearing a tremendous technological potential. Since its discovery, more than 30 years ago, cuprates were investigated with great enthusiasm, what resulted in an enormous number of published articles. However, there are still many aspects of these systems that are heavily disputed in the scientific community. These include the origin of the pseudogap, linear temperature dependence of resistivity near the optimal doping, or the role of the antiferromagantic fluctuations in various phases and regimes. Most importantly, the mechanism of superconductivity, that is presumably universal in all cuprate compounds, has yet to be understood. These unsolved issues and the significance of the challenge inspired the author of this Thesis to investigate these materials.

The approach of studying the mechanism of superconductivity in cuprates proposed in this Thesis is atypical. Instead of focusing on the factors that cause the increase of the critical temperature, we were attracted by the phenomena that decrease it. By identifying a key parameter for the suppression of the critical temperature, insight into the microscopic mechanism behind superconductivity was aimed to gain. In particular, the main interest was in studying the symmetry breaking fields that affect the main building block of the cuprates - the CuO_2 plane. This symmetry breaking can be achieved by uniaxial pressure, or it emerges naturally (in a particular region in the cuprate phase diagram) in the form of the charge density wave (CDW) order that coexists, yet competes with superconductivity. Therefore, the general aim of this Thesis is to first thoroughly characterize the CDW order, and then describe its interplay with superconductivity. In order to achieve these goals, selected experiments using synchrotron radiation were performed. The standard synchrotron techniques were furthermore extended by the application of the in-situ uniaxial pressure. For this purpose, three uniaxial pressure cells were designed and built.

Altogether, the experimental results provide evidence that the short-range CDW order is a universal phenomenon in cuprates, which exists in a limited range of temperatures and doping, and, although very weak, has a detrimental influence on superconductivity. The local distortion of the lattice caused by uniaxial pressure application does not influence the strength of these charge correlations. Moreover, CDW does not significantly impact the lattice dynamics observed through the optical phonons. However, under magnetic field and at sufficiently low temperatures, it reconstructs the Fermi surface into a small electron pocket. The presented results are consistent with the empirical model of superconductivity, where the pairing is associated with an excitation of *the one* localized carrier per CuO_2 unit cell.

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