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Stripe Phases in High Temperature Superconductors

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Several novel types of complex ordered phases which arise in high temperature superconductors will be discussed. The superconducting cuprates have very puzzling properties, frequently attributed to competing instabilities. In the normal phase the competition between the magnetic and kinetic energy leads to stripe phases characterized by the coexisting modulation of charge and magnetization density, as shown first in Hartree-Fock calculations for the Hubbard model [1]. The possible types of such phases and their dependence on doping will be shortly discussed using the slave boson approach to the two-dimensional (2D) effective $t-t'-U$ Hubbard model [2]. It will be shown using the dynamical mean-field theory (DMFT) that the next-nearest neighbor hopping t' plays an important role in the evolution of the spectral properties with increasing hole doping and in the phenomenon of stripe melting [3]. In spite of taking into account local dynamic correlations within a real-space DMFT of the Hubbard model, one observes a mean-field-like melting of the stripe order irrespective of the choice of the hopping t' [4]. The temperature dependence of the single-particle spectral function shows the stripe induced formation of a flat band around the antinodal points accompanied by the opening a gap in the nodal direction. Furthermore, we argue that charge instabilities are generic for superconducting cuprates and may also take other forms. They can coexist with the superconducting phase, as shown by considering modulated superconductivity in the 2D t-J model with out-of-phase d-wave order parameter in neighboring domains [5].

Stripe phases occur also in other strongly correlated systems when the kinetic energy of doped holes competes with the superexchange. For instance, they form in doped systems with alternating t_{2g} orbital order [6] – the stripe takes here the form of a ferro-orbitally ordered domain wall separating domains with staggered orbital order and allowing for deconfined motion of holes along the stripe. At a finite hole concentration this gives rise to the stability of this solitonic type of stripes.

In pnictide superconductors electron correlations play also an important role and superconductivity occurs by charge fluctuations. In this case orbital degrees of freedom and the system properties are sensitive to Hund's exchange J_H [7]. A recent study of pairing symmetries in a two-orbital $t-U-J$ model for iron pnictides has shown that different competing pairing symmetries could be stabilized by small changes of the model parameters [8]. This suggests that a similar sensitivity to small details may occur among different compounds of the pnictide family.

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