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# The phenomenological view at the two-component physics of cuprates

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Currently there exist compelling experimental evidences that the high $T_c$-cuprates in the part of the $(T, x)$-phase diagram known as the "pseudogap" (PG) region, are actually electronically inhomogeneous in the real space. The tendency to the phase separation in cuprates into magnetic and conducting islands has been predicted by Gor'kov et al. [1] with lattice interactions between neighboring $Cu^{2+}$ ions as the driving mechanism. The electro-neutrality that otherwise would be violated by the presence of immobile Sr-charges was expected to severely restrict sizes of AFM islands, thus resulting in a dynamically frustrated first order transition. As shown in [2], it is energetically preferable for AFM phase, at least at small $x$, to appear in a form of so-called "stripes": charged incommensurate antiferromagnetic structures. Experimentally such stripe structures were observed by inelastic neutron scattering [3] which reveal the dynamical character of stripes' formation at temperatures above $T_c$ by observation of large peaks at the incommensurate wave vectors' values around the commensurate AFM $(\pi, \pi)$-point [4] and by extended X-Ray and diffraction methods [5].

Later it has been argued [6, 7] that the analysis of the ARPES and transport data together unequivocally indicates in favor of the two-component physics for cuprates also in the momentum representation. This observation provided a new avenue for study of the electronic spectrum in the pseudogap phase from which superconductivity evolves.

We address details of the electronic spectrum in the pseudogap (PG) phase critical for understanding mechanisms of high-temperature superconductivity (SC) in cuprates. The angle-resolved photoemission spectroscopy (ARPES) finds coherent excitations only at so-called "Fermi arcs" (FAs) [8, 9]. Another branch – small electronic pocket [10–12] is seen in the quantum oscillations (QOs) at low temperatures. The origin of the electron pockets as well as their existence at higher temperatures are intensively debated [10–14]. With tendency to a charge ordering (CO) revealed in few recent X-rays experiments [15–18] the view became popular [13, 14, 19–21] that pockets emerge via reconstruction of the Fermi surface (FS) in vicinity of the nodal points in a CO transition. However the residual metallic contribution into the specific heat deep in the SC phase of YBCO observed in [11, 22] contradicts the reconstruction scenario, as SC suppressing the CO would thereby destroy such pocket. The inconsistencies in the scenario associated with the reconstruction of the FS make it necessary to search for alternative origins of the electron pockets.

The main part of our short review is devoted to publications [6, 7, 23–29] in which a phenomenological approach has succeeded in constructing a consistent model of the electronic spectrum of cuprates in the pseudogap phase.

Based on the analysis of transport data in the PG phase for the three families of underdoped (UD) cuprates (YBCO, LSCO, and Hg1201) both above and below the CO transition it was shown [29] that:

(i) from data for resistivity and the Hall coefficient it follows that at low dopants concentration $(x)$ excitations on FAs are indeed the only charge carriers (holes) in the system;

(ii) the Hall data at higher doping $x > 0.08{-}0.10$ allow identifying the electron pocket at the $\Gamma$-point of the Brillouin zone as a *permanent* feature of the PG phase, contrary to the idea of a FS reconstruction in the CO transition. In fact, the experimental Hall numbers in LSCO and YBCO owing to contributions from a pocket of electrons *dragged* by the FAs holes deviate from proportionality to $x$;

(iii) on lowering the temperature the holes scattering strongly off fluctuating incommensurable charge density waves (CDW), their mobility rapidly decreases and their contribution to transport properties gives way to that of electrons on the pocket.

In conclusion, it should be emphasized that the phenomenological approach discussed in the present paper provided the self-consistent interpretation of the $(T, x)$-

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phase diagram and of the recent transport, X-ray and NMR data.

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