SESSION 6

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Stripes and quantum criticality

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The stripe phase realizes the compromise between the local tendency of strongly correlated systems towards phase separation and the eloctrostatic cost to segregate charged carriers. This phase connects the high-doping regime, where charge fluctuations play a major role and enslave spin fluctuations, with the low-doping region of the phase diagram dominated by the spin degrees of freedom. Coming from the high-doping regime, the onset of a charge-ordering texture is governed by a quantum critical point (QCP), which, as confirmed by several experimental findings, was found by us within a Hubbard-Holstein model to occur around optimum doping. Quite generally, a major emergent low-energy property of the QCP is the possibility that critical fluctuations mediate a momentum- and frequency-dependent singular interaction betwecn quasiparticles providing at the same time a strong pairing mechanism, the non-Fermi-liquid behavior of the metallic phase, and the pseudogap formation in the underdoped regime. The role of phonons in producing the charge instability is relevant and may introduce a phonon-frequency dependence in the various energy scales. Within the above StripeQCP scenario, we elaborate on observable single-particle spectroscopic features. In particular we show that the leading-edge pseudogaps around the M-points in the metallic state of underdoped cuprates can arise directly from particle-hole scattering due to charge ordering and indirectly from particle-particle pairing mediated by chargefluctuation. In the first case a quasi-static charge ordering taking place in the underdoped regime can directly explain the coexistence of gaps and arcs on the Fermi surface if the charge texture has an eggbox form. Moreover, this preexisting normal-state pseudogap can be supplemented by a BCS (d-wave) pairing mechanism and, by introducing a phenomenological temperature dependence of the pseudogap, which finds a natural interpretation within the charge-ordering scenario for high-Tc superconductors, one can reproduce several spectroscopic properties, the general shape of the phase diagram of cuprates, and in particular the Tc-T* bifurcation near optimum doping.

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Competing orders and quasiparticle damping in doped antiferromagnets

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A number of large-N limits are employed to study the competition between ground states of doped square lattice antiferromagnets. Besides the usual d-wave superconducting state we find ($d+is$) and ($d+id$)-wave superconductors, Wigner crystals, orbital antiferromagnets and states with spin-Peierls and bond-centered charge-stripe order. We then identify the universal quantum field theories for the transitions between a d-wave superconductor and one of these states, and compute the finite-temperature quantum critical damping of the low-energy fermionic excitations near the nodes of the superconducting gap. It turns out that the experimentally observed very different behavior of the quasiparticle spectra near the nodes and near $(\pi,0)$, $(0,\pi)$ can be explained naturally by the proximity of a quantum phase transition between a d-wave and a ($d+id$)-wave superconductor.

Keywords: *d-wave superconductors, quantum phase transitions, charge stripes.*

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Is there a hidden order parameter in high T_c superconductors?

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Our microscopic understanding of superconducting cuprates has been hampered up to now due to a lack of any profound conviction about possible ground state (or states) of the system. The most outstanding problem seems to be a real difficulty of reconciling the al-pervading presence of Cu^{2+} spins and the superconductivity. Normally spins destroy pairing correlations. In the cuprates, photoemission measurements indicate a huge fermi surface (about 10^{22} spins per cm^3) yet the neutron measurements reveal the presence of order of magnitude less spins. How does the miracle of high T_c occurs ? We demonstrate that at least two sets of off-diagonal order parameter exist in the ground state: the usual d-wave superconducting order parameter and a second one given by an off-diagonal spin order. The resultant spin condensate houses all the spins and has a finite excitation energy which helps freezing out the floating spins as temperature falls thereby protecting the superconducting condensate as the latter develops its phase rigidity and phase coherence. The phase of the superconducting condensate and that of the spin condensate are related through simple gauge symmetry arguments which will be pointed out. The role of stripes and these two order parameters will be discussed.

Keywords: *superconductivity, spin fluctuation, stripes*.

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Inhomogeneous superconductivity: relation between T_c and incommensuration in spin structure in cuprates and QCP scenario

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Neutron scattering experiments reveal a simple linear relation between observed incommensuration and superconducting transition temperature in High-T_c materials. Used together with the Uemura relation this proportionality is consistent with inhomogeneous superfluid density in these materials. We also argue that effective Josephson coupling between stripes is decaying as inverse stripe-stripe separation. Possible explanation of this scaling, such as proximity to Quantum Critical Point will be proposed. Recent photodoping experiments in YBCO that are consistent with this proposal will be discussed as well.

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