SESSION 17

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D-wave bipolaronic stripes in cuprates

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There is a strong evidence for pairing of polaronic carriers above T_c in underdoped cuprates as predicted by the strong-coupling bipolaronic extension of the BCS theory [1]. At the same time there is a convincing evidence for superconducting stripes at the atomic level [2]. We show that the electron-phonon and magnetic interactions can hardly lead to a charge segregation in the region of parameters typical for cuprates [3]. At the same time the bipolaron (center of mass) energy-band dispersion explains both the d-wave superconducting order parameter and the striped ground state of doped Mott insulators such as cuprates. Also fitting well the superconducting T_c [4] and tunnelling spectra [5] the bipolaron theory provides a unified approach to a new electronic state of matter in cuprates, which is the charged Bose liquid [6].

References

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Direct evidence for electronic phase separation in high T_c cuprates and CMR manganites

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One of the most exciting recent revolution in condensed matter Physics has been the concept of electronic phase separation, reported in the high T_c cuprates and the magnetoresistive manganites, both belonging to the family of doped antiferromagnets. These phase separations are accompanied by large static and mostly dynamic lattice distortions, which are difficult to be measured by direct techniques as the distortions tend to be incoherent. We have obtained experimental evidence of incoherent lattice fluctuations showing a non-analytic behavior as a function of temperature in optimally and underderdoped $YBa_2Cu_3O_{7-x}$ (T_c = 92.5, 60 and 45K respectively) by using Ion Channeling which is an ultrafast direct real space probe of incoherent atomic displacements. The observed transitions seem to be consistent with the electric and magnetic phase evolution as predicted by the stripe phase model. The stripe dynamics in YBCO has been predicted to undergo three phase crossovers/transitions as a function of temperature, at the stripe phase (T_1 ~ 200K), spin gap formation temperature (T_2 ~ 150K) and the superconducting transition temperature T_c. Three similar temperatures are seen in the form of non analyticities in the incoherent lattice fluctuations.
The femtosecond optical response measurements in $YBa_2Cu_3O_{7-x}$ have shown three very sharp features with FWHM of the order of ~30 meV in the superconducting state. The existence of sharp features in the optical pair breaking spectrum suggests the presence of intrinsic inhomogenities even in the superconducting state of YBCO.

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Plane-c-axis coupling: The origin of incommensurate charge density wave formation in high T_c superconductors

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The striped phase, observed in high-T_c cuprates, is modelled by a spin-charge-phonon interaction Hamiltonian, where multiphonon processes arise as a natura1 consequence of doping and plane buckling. The spin-charge multiphonon interactions introduce a c-axis component in the spin dynamics dominated planes and a planar component in the c-axis related charge channel. While harmonic spin-charge-phonon couplings are shown to lead to a commensurate spin-, charge-density wave instability, the anharmonic terms give rise to an incommensurate dynamical pattern which is related to the formation of the striped phase. The transition temperature T* to this phase is calculated as function of doping and large isotope effect on T* is obtained which is in good agreement with recent experimental data.

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Local lattice distortions and stripe formation in the cuprates

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We have used high resolution X-ray absorption spectroscopy, a fast (~10^{-15} sec) and local (~5-6Å) tool, to study response function of the charge-stripe ordering to understand driving force for the stripe formation in the perovskite superconductors. A particular change in the instantaneous local lattice fluctuations at the charge-stripe ordering temperature has been found. Here we report experimental results on various superconducting and insulating cuprates to show that the change in the local lattice structure is a response function of the charge-stripe ordering in these materials. A large isotope effect on the charge-stripe ordering temperature provides a direct evidence for the vital role of the electron-lattice interactions to be an important ingredient for the charge-stripe ordering in the cuprate superconductors.

This work was mainly done in collaboration with A. Bianconi, A. Lanzara and Y. Oyanagi.

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Coexistence of small and large polarons

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The coexistence of metallic and insulating domains characterized by different lattice distortions is investigated in a system of interacting electrons and phonons on the basis of a variational method. A simple mean-field approach indicates the existence of competing phases suggesting charge segregation.
The implications of the results for manganites and cuprates are discussed.

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