SESSION 4

(September 26, 2000)

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On the stability of stripes and d-wave superconductivity in the t-J model

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We have performed an extensive numerical study of the t-J model by using exact diagonalization and a recently developed technique [1] used to filter out the ground state from the lowest energy Jastrow-Slater singlet wavefunctions. Such wavefunctions do not break any finite size symmetry of the model, thus representing the most reasonable and unbiased wavefunctions, that can be used to study the symmetry breaking phenomena with an effective but approximate ground state projection scheme [1].
With this technique, and recent improvements [2], it is possible to detect for instance long range antiferromagnetic order even when the initial variational wavefunction is magnetically disordered. However in many test cases where the exact solution is known, our starting singlet variational wavefunctions reproduce accurately the long distance correlation functions of the model even without further corrections. These variational wavefunctions, which imply off diagonal superconducting long range order at zero temperature, appear to be very stable in 2D square lattice, with a d-wave symmetry of the pairing order parameter, consistently with HT_c cuprates. These results strongly support the idea that HT_c superconductivity can be understood with a model that contains only strong electronic correlation, and in particular the superexchange interaction between spins on neighboring Cu sites.
Previous numerical studies [3], based on DMRG, have instead lead to completely opposite conclusions, namely that "stripes" are stabilized in the t-J model, but with a clear suppression of d-wave superconductivity. We resolve this controversial issue, by presenting evidence that stripes are indeed stabilized in the t-J model, provided suitable boundary conditions are taken. In particular for the rectangular lattices L_x x L_y with $L_x \ll L_y$ typically used in DMRG calculations, we show evidence of stripes, with incommensurate peaks in the charge and spin correlations not present at the variational level and consistent with experimental findings. Our interpretation at present is that any physical perturbation of the 2D *t-J* model, that breaks the rotation symmetry of the square lattice may easily stabilize stripes.

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Striped superconductors in the extended Hubbard model

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We present a minimal model of a doped Mott insulator that simultaneously supports antiferromagnetic stripes and d-wave superconductivity. We explore the implications for the global phase diagram of the superconducting cuprates. At the unrestricted mean-field level, the various phases of the cuprates, including weak and strong pseudogap phases, and two different types of superconductivity in the underdoped and the overdoped regimes, find a natural interpretation. We argue that on the underdoped side, the superconductor is intrinsically inhomogeneous -- striped coexistence of of superconductivity and magnetism -- and global phase coherence is achieved through Josephson-like coupling of the superconducting stripes. On the overdoped side, the state is overall homogeneous and the superconductivity is of the classical BCS type.

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Stripes, pseudogap, and SC-SDW resonance in HTSC perovskites

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Now, the onset temperature for stripes is treated as that of pseudogap at the Fermi surface in HTSC. Such a picture may be considered as strong support for the model of formation of SDW (and hence CDW) state in the HTSC system before SC transition, which is characteristic for the itinerant electron systems with interplay between SC and magnetism. The indirect evidence for such modulated (stripe) magnetic structure formed in the normal state of HTSC was obtained in [1].
Here, the symmetry of the order parameter measured by ARPES methodics in HTSC system, with stripes in CuO_2 planes, are discussed. The analytical and numerical study of influence of the superlattice of quantum stripes in CuO_2 plane on the behavior of HTSC (depending on magnetic field) is performed. The evidence for the resonance of SC order parameter with SDW(CDW) one in CuO_2 plane of HTSC system is obtained. The new proposals for diagnostics (e.g., high frequency probes) of such stripe structures in HTSC are presented. The new dynamical mechanism for Tc amplification is proposed. The possibilities to realize the artificial dynamical stripe structure in the HTSC system at T = 300K are discussed. The treatment of observed twofold amplification of T_c in thin film of LSCO is considered on the basis of stripe (SDW/CDW) concept. The proposals for growth of HTSC nanostructures with artificial stripes are presented.

Keywords*: stripes, pseudogap, spin fluctuations, Tc amplification*.

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Quantum nucleation of soliton pairs in density waves, Josephson junctions, and stripes

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A number of many-body systems, including charge and spin density waves, Wigner crystals, etc., exhibit a sharp threshold electric field for inducing nonlinear transport, without showing the requisite polarization below threshold that one would expect classically. Similarly, many Josephson junctions, especially in the cuprates, have $I_c R_n$ products up to three orders of magnitude lower than predicted by the Ambegaokar-Baratov formula. These observations suggest that the observed critical field or current is a pair creation threshold for nucleating soliton-antisoliton pairs – essentially a macroscopic Coulomb blockade effect. Transport above threshold occurs in a manner analogous to time-correlated single electron tunneling. The concept of a quantum dynamical phase transition is introduced, and the possibility of nucleating topological solitons in stripes is discussed.

Keywords: *soliton, quantum tunneling, stripes, density wave, Josephson junction.*

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Evolution of the spin gap upon doping n-leg ladders

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The evolution of the spin gap of a ladder upon doping depends upon the nature of the lowest triplet excitations in a ladder with 2 holes. We have studied this evolution using numerical techniques for a 2-leg t-t'-J ladder as the next-nearest-neighbor hopping t' is varied. We find that depending on the value of t', the spin gap can evolve continuously or discontinuously and the lowest triplet state can correspond to a magnon, a bound magnon-hole pair, or to two separate quasiparticles. Previous experimental results on the superconducting two-leg ladder $Sr_{12}Ca_2Cu_{24}O_{41}$ are discussed in the light of our numerical findings. We shall also present extensions of this work to 4-leg ladders as well as a careful analysis of the role of a spin twist applied in the boundary conditions providing some insights on the mechanism of stripe formation.

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Fluctuating fractionally charged kinks as a doped stripe liquid: a possible scenario for dimensional crossover in the cuprates

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There is a growing body of evidence supporting the idea that the inter-stripe spacing is proportional to the doping x, for x<1/8. The local charge conservation thus implied would also suggest that the doped stripes are locally insulating, contradicting the experimental findings. We have tried to address this apparent paradox by proposing that for doping larger than 1/8, every added hole decays into two fractionally charged kinks. The presence of these transversal kinks is favored when the curvature energy is smaller than the charge compression energy. When these soliton-like kinks proliferate, they tend to slant the stripes on which they reside, away from the major crystal axes, and we present some specific predictions regarding the tilting stripe angle, which can be measured directly. The appearance of kinks introduces sideways motion, or meandering, of the stripes, hence rendering the doped hole motion effectively two dimensional. We shall argue that this dimensional crossover has been observed already in angle resolved photoemission spectroscopy (ARPES). We provide a plausible scenario by which every added hole to a quarter filled stripe decays into two holon-like solitons (kinks), coupled to a spinon with a well-defined Fermi wave vector. We shall comment on the relevance of this non-Fermi liquid description of the kinks on stripes as a promising new paradigm for the understanding of the high temperature superconducting cuprates.

Keywords*: Stripes, ARPES, kinks*.

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