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Droplet formation in first order phase transitions with long range Coulomb interaction

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We analyze the combined effect of the long range Coulomb (LRC) interaction and of surface energy on first order density driven phase transitions between two phases A and B in the presence of a compensating rigid background. In the coexistence region we study a mixed state formed of bubbles of B phase in A. We derive the general equations for the chemical potential and pressures of each phase and generalize Maxwell construction to this situation. We find that quite generally the transition to the mixed state is abrupt i.e. drops appear with a finite value of the radius and of the volume fraction of the B phase. Contrary to the ordinary Maxwell construction case, the inverse specific volume of each phase depends here on the global density in the coexistence region. The range of densities in which coexistence is observed shrinks as the LRC interaction increases until it reduces to a singular point. We argue that close to this singular point the system undergoes a lattice instability regardless of how rigid is the lattice as long as the inverse lattice comprensibility is finite. These general ideas are applied to electronic phase separation in the t—J model and in the Manganites near the charge ordered phase and to the analysis of possible instabilities in the low density electron gas.

Keywords: *phase separation, manganites, cuprates*.

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The case against cuprate-plane superconductivity

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Using magnetic resonance data, surface resistance measurements, muon spectra, the dependence of pair-breaking on angular momentum L, and the rather widespread occurrence of superconductors that do *not* rely on cuprate-plane superconductivity, we show that high-temperature superconductivity (i) resides *primarily* in the charge-reservoir layers, not in the cuprate planes, (ii) suffers pair-breaking by L=0 magnetic ions (Gd, Cm), (iii) is invariably *p*-type, (iv) is nearly BCS-like, and (v) involves electronic or phononic Cooper pairing, not magnetic pairing.
Using these ideas, we predicted that $PrBa_2Cu_3O_7$, $Pr_{2-z}Ce_zSr_2Cu_2NbO_{10}$, $Gd_{2-z}Ce_zSr_2Cu_2TiO_{10}$, and $Eu_{2-z}Ce_zSr_2Cu_2TiO_{10}$ would all superconduct, and then showed that all four materials in fact *do superconduct.*
Muon data for $Sr_2YRu_{1-u}Cu_uO_6$ indicate that the $(SrO)_2$ layers are likely *p*-type and do superconduct, and reside in nearly zero magnetic field, while the $YRu_{1-u}Cu_uO_4$ layers are magnetic, very likely *n*-type, and not superconducting. A flux lattice occurs in the SrO layers. The Ru orders ferromagnetically in the *a-b* planes at ≈23 K, but adjacent Ru planes in the *c*-direction are aligned antiferromagnetically with respect to one another. Cu orders at ~86 K, and remains ordered through T_c, indicating that Cu plays at most a minor role in the superconductivity.
The superconducting critical temperatures for $Sr_2YRu_{1-u}Cu_uO_6$, $GdSr_2Cu_2RuO_8$, and $Eu_{2-z}Ce_zSr_2Cu_2RuO_{10}$ are all about ≈45 K, strongly suggesting that the superconducting elements in all three compounds are the same: SrO, not CuO_2 planes (which do not occur in $Sr_2YRu_{1-u}Cu_uO_6$).
The concept of cuprate-plane superconductivity is in serious trouble.

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Magnetic properties of $La_{1.875}Ba_{0.125-x}Sr_xCuO_4$

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Superconducting transition temperature was systematically investigated in the single crystals of $La_{1.875}Ba_{0.125-x}Sr_xCuO_4$ by measuring the magnetic susceptibility. We found that T_c in low temperature tetragonal (LTT) phase with $0 \leq x < 0.07$ and in low temperature orthorhombic (LTO) phase are almost constants with 8K and 31K, respectively, suggesting LTT structure strongly connects with the suppression of superconductivity in this system. Furthermore, anomalous behavior in the susceptibility was observed in x=0.05 sample when the magnetic field is applied vertical to the CuO_2 plane. As decreasing the temperature, the susceptibility shows rapid increment at 38K, which temperature is identical with the phase transition temperature determined by neutron diffraction measurement. This result suggests that the spin structure changes at low temperature associated with the crystal structure.

Keywords: *1/8 problem,, structural phase transition, phase diagram of* T_c

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Correlated charge and spin variations in cuprates from NMR

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Application of NMR single and new double resonance methods to various cuprates reveals that there are typically large distributions of the static local magnetic susceptibility and electric field gradients. The variations are of very short wavelength (on the order of the inter nuclear magnetic coupling), showing that they are not merely caused by long wavelength inhomogeneities such as crystallite to crystallite variations in doping or alignment. In particular, although the magnetic field distributions experienced by the apical and planar oxygen are caused by a variation of the electron spin susceptibility, the Cu nuclei experience a much bigger distribution which can only be explained by invoking field induced variations of orbital currents (orbital shifts). The susceptibility modulation is shown to be a linear function of the electric field gradient modulation at the planar oxygen nuclei. The correlated modulations of the magnetic shift and electric field gradients are strongly temperature dependent and generally increase with lowering the temperature apart from the pseudogap phenomenon for the electron spin susceptibility. The doping dependence of the effects will be discussed. It will be argued that a stripe-like geometry for the modulation might explain the experimental data.

Keywords: *NMR, cuprates, electronic modulation, double resonance.*

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Resistive upper critical field of superconducting spin-ladder $Sr_{14-x}Ca_xCu_{24}O_{41}$

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We report the resistive upper critical field $H_{c2}(T)$ of the hole-doped two-leg ladder $Sr_{14-x}\,Ca_x\,Cu_{24}\,O_{41}$ *(x = 12)* single crystal, which becomes superconducting with T_c ~ 5 K in a pressure range above ~ 3.0 GPa.
Using a newly developed compact high-pressure cell, the magneto-transport measurements have been performed at temperatures down to ~140 mK under high pressure above 3.5 GPa. It is found that H_{c2}^b(perpendicular to the ladder $Cu_2\,O_3$ plane) increases anomalously as the temperature is decreased having positive curvature and shows no saturation down to T/T_c ~0.03. Also, its temperature dependence is found to resemble that of high-T_c superconductors such as $Tl_2Ba_2CuO_6$ and $Bi_2Sr_2CuO_y$.
Therefore, this fact suggests that the anomalous behavior of H_{c2} has a common origin between the ladders and the two-dimensional high-T_c superconducting oxides. The other unconventional behavior of H_{c2} is observed along the a-axis (perpendicular to the ladder in the Cu_2O_3 plane) such that zero resistivity persists at least 20 T in spite of having T_c ~5 K in 0 T, which indicates H_{c2}^a exceeds the Pauli limit by a factor of more than 2. This fact suggests a possibility of triplet-pairing in $Sr_{14-x}Ca_xCu_{24}O_{41}$ system.

Keywords: *Spin ladders, superconductors, low-dimensional system, high pressure.*

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Stripe and spin dynamics in hole doped La_2NiO_4, La_2CuO_4, $Bi_2CaCu_2O_8$, and electron doped Nd_2CuO_4 seen by nuclear resonance

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The relation between the NMR and NQR signal intensities (wipe-out effects), relaxation rates and line shapes with the charge and spin ordering features seen by a.o. neutron scattering in hole doped La_2NiO_4, La_2CuO_4, $Bi_2CaCu_2O_8$ and electron doped Nd_2CuO_4 are investigated.
We show what the typical signatures are for stripe physics, what is understood and which questions are still open. We especially focus on the observation that the wipe out effects continue down to the lowest measured temperatures and argue that these might be the signature of a glassy dynamics of an entirely new kind, associated with the special nature of stripe order.

Keywords: *stripes, NMR/NQR, hole and electron doping, glassy dynamics*.

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The cluster spin glass phase of $La_{2-x}Sr_xCuO_{4+\delta}$ as a precursor of stripe formation

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We studied the cluster spin-glass (CSG) transition in $La_{2-x}Sr_xCuO_{4+\delta}$ by means of anelastic spectroscopy measurements. The step-like increase in the acoustic absorption, found around the CGS transition temperature, is attributed to the size change of the antiferromagnetically correlated clusters, produced through magnetoelastic coupling by the vibration stress. Our measurements support the evidence, deduced from nuclear quadrupolar resonance and muon spin rotation experiments, that in the CGS phase, high temperature superconductors are microscopically divided into magnetic domains, which are separated by charge rich “rivers”. Some recent theoretical models have pointed out that the domain walls corresponding to spin twists between clusters of locally ordered spins can be the precursor of stripe formation [1].

Keywords*: precursor of stripe formation, cluster spin-glass phase*.

[1] K.S.D. Beach and R.J. Gooding, cond-mat/0001095, to appear in The European Journal of Physics B.

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