HIGH T_C UPDATE

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NOTA BENE:

As announced in the last two issues in the newsletter, we will discontinue the free hard-copy version of the *High-T_C Update* newsletter beginning May 1, 1999, due to lack of funds. We will e-mail all our current hard-copy subscribers a PDF version of the newsletter. <u>If you have not already done so, please inform us of your e-mail address immediately, so that we can add you to an e-mail recipient list.</u> You can send us this information by e-mail to mitra@ameslab.gov or fill out and send the form available in the previous two issues.

Vortices

A preprint by M.J.W. Dodgson et al. (ETH-Zürich) establishes a new interstitial-vacancy-unbinding transition, which transforms the three-dimensional pancake vortex lattice of a decoupled layered superconductor into a defected solid. The authors stress that this transition is the natural finite-field extension of the vortex-antivortex unbinding transition establishing the zero-field superfluid transition. At finite Josephson coupling, the defect-unbinding transition turns into a topological decoupling transition.

A preprint by S. V. Kuplevakhsky (Kharkov State) claims to obtain the first exact analytical solution of the Lawrence-Doniach model for layered superconductors in external magnetic fields. The author's solution has some peculiar, unexpected features. The local magnetic field is independent of the coordinate perpendicular to the layers, such that Josephson vortices (oriented parallel to the layers) must penetrate into the sample simultaneously and coherently, aligning themselves in planes that are perpendicular to the layers. Extra constraints imposed by the author exclude solutions corresponding to single, isolated Josephson vortices. The author's theory thus contradicts not only numerous theoretical papers by previous authors but also experimental observations of in-plane Josephson vortices by scanning SQUID microscopy [e.g., K. A. Moler et al., *Science* **279**, 1193 (1998)].

The vortex-state complex Hall conductivity σ_{xy} of superconducting *$YBa_2Cu_3O_{7-\delta}$ (YBCO)* epitaxial films has been investigated by D. A. Beam (Caltech) et al. from dc to radio frequencies (up to 7×10^6 Hz) using a direct transport measurement technique. The authors analyzed their results with a generalized model assuming that: (a) the occurrence of the sign reversal in the dc vortex-state Hall conductivity is the result of different carrier densities inside and outside the vortex core, (b) the Drude approximation is applicable, and (c) the anomalous sign reversal occurs in the flux-flow limit. The magnetic field (B) dependence of the complex Hall conductivity data reveals that both vortices (σ_{xy}^{v}) and quasiparticles (σ_{xy}^{q}) contribute to the vortex-state Hall conduction, where $\sigma_{xy}^{v} \propto B^{-1}$ and $\sigma_{xy}^{q} \propto B$, in agreement with the model.

The vortex-glass (VG) fluctuation contribution σ_{xy}^{vg} to the Hall conductivity in the vortex-liquid regime of layered superconductors under a field perpendicular to the layers has been studied perturbatively by R. Ikeda (Kyoto), taking into account both line-like and point-like pinning. The author compared σ_{xy}^{vg} with σ_{xy}^{vf}, the vortex-flow contribution to the Hall conductivity. For only line disorder, the author found that the ratio $r_{gf} = \sigma_{xy}^{vg}/\sigma_{xy}^{vf} < 0$, while in 3D-like systems with only point disorder, $r_{gf} > 0$. In the general case including both kinds of disorder, the sign of r_{gf} evidently depends upon both the relative amount of line-like and point-like disorder and the dimensionality of the thermal fluctuations.

The vortex-glass model for a disordered high-T_c superconductor in an external magnetic field has been studied by F. Pfeiffer (Köln) and H. Rieger (Köln and Jülich) in the strong-screening limit. With exact, numerical ground-state (T = 0) calculations, the authors found that (a) the ground state of the vortex configuration varies drastically with infinitesimal changes in the strength of the external magnetic field, (b) the minimum energy of global excitation loops of length scale L does not depend on the strength of the external field, but (c) the excitation loops themselves

depend sensitively on the field. From (b), the authors infer the absence of a true superconducting state at any finite temperature, independent of the external field.

The dependence of the ohmic magnetoresistivity of clean twinned and detwinned $YBa_2Cu_3O_{7-\delta}$ single crystals upon temperature and field angle has been studied by R. M. Langan (Southampton) et al. The authors found that the thermodynamic properties of the vortex system are controlled by the effective field $B_{eff} = B\varepsilon_\theta$, where $\varepsilon_\theta = (\cos^2\theta + \varepsilon^2\sin^2\theta)^{1/2}$, $B = \mu_0 H$, θ is the angle of **B** relative to the c axis, and $\varepsilon = \gamma^{-1} = (m_{ab}/m_c)^{1/2} = 0.134$ for $YBa_2Cu_3O_{7-\delta}$. The authors found that the melting kink (a fingerprint of the first-order melting transition) is suppressed when the applied field is larger than the multicritical field B_{mc} but that this transition recovers when the sample is tilted at an angle θ such that $B\varepsilon_\theta < B_{mc}$.

Transport and magnetic-relaxation measurements in the mixed state of strongly underdoped $Y_{1-x}Pr_xBa_2Cu_3O_{7-\delta}$ crystals have been carried out by T. Stein (Kent State) et al. The authors observed a transition from thermally activated flux creep to temperature-independent quantum flux creep in both transport and magnetic relaxation at temperatures $T \leq 5$ K. Flux-transformer measurements indicate that the crossover to quantum creep is preceded by a coupling transition. Based on these observations, the authors argue that below the coupling transition, the current is confined to a very thin layer, just a few unit cells thick, beneath the current contacts.

The distributions of vortices and antivortices in a superconducting slab after a sudden reversal of a parallel magnetic field have been studied theoretically by F. Bass (Bar-Ilan) et al. The authors find that structural defects can result in the creation of long-lived, spatially inhomogeneous, metastable flux-antiflux distributions.

Flux-noise spectra around the Kosterlitz-Thouless transition in a two-dimensional superconductor have been obtained by B. J. Kim and P. Minnhagen (Umeå) from simulations of two-dimensional arrays of resistively shunted Josephson junctions. The authors investigated the dependence of the noise upon the distance d between the pickup coil and the sample. The authors identify features that distinguish between the large- and small-d limit, and they discuss the possibility of experimentally observing these features.

Hysteresis and ac Losses

Exact analytical results have been obtained by D. V. Shantsev (Oslo and St. Petersburg) et al. for the hysteretic magnetization of a superconducting thin strip with a general behavior $J_c(B)$ of the critical current density. Using the critical state model with $B = \mu_0 H$, the authors show that the magnetization M of a strip as a function of applied field B_a has an extremum located exactly at $B_a = 0$. If $J_c(B)$ decreases monotonically with B, the magnitude of the hysteretic magnetization will have a peak at $B_{cp} = 0$ in both decreasing and increasing magnetic fields. (This result differs from the behavior in a slab or cylinder in a parallel magnetic field, for which the magnitude of the magnetization has a peak at $B_{cp} < 0$ for the B_a-decreasing branch of the hysteresis loop, and a peak at $B_{cp} > 0$ for the field-increasing branch.) The authors find that this result is in excellent agreement with their experiments on an $YBa_2Cu_3O_{7-\delta}$ thin film. However, when artificial granularity is introduced by patterning the film, the central peak is shifted to $B_{cp} > 0$ on the field-decreasing branch of the hysteresis loop, and to $B_{cp} < 0$ for the field-increasing branch. These results show that a positive B_{cp} on the field-decreasing branch of the hysteresis loop is a definite signature of granularity in a thin-film superconductor.

A related paper by M. R. Koblischka (Oslo and SRL-ISTEC) et al. describes further details of magnetic flux penetration into an $YBa_2Cu_3O_{7-\delta}$ thin film patterned into a hexagonal-close-packed lattice of disks (diameter = 50 μm), which are touching each other at the circumference to enable the flow of an intergranular current. The authors had previously suggested such a sample as a model of a granular high-temperature superconductor. The magnetization of this sample exhibits a peak at $B_{cp} > 0$ on the field-decreasing branch of the hysteresis loop. Magneto-optical observations revealed that this peak is associated with magnetic flux trapped inside the disks.

The critical-state magnetic-field and current-density distributions in a thin superconducting platelet with elliptical shape in an increasing perpendicular applied magnetic field have been obtained approximately by G. P. Mikitik (Kharkov) and E. H. Brandt (MPI-Stuttgart) using the Bean model (J_c = const). In the limits of a circular disk or a long strip, the solutions are exact; i.e., the current density is constant in the region fully penetrated by magnetic flux. For ellipses with arbitrary axis ratio, the obtained current density is constant to typically 10^{-3}, and the magnetic moment deviates by less than 10^{-3} from the exact value. In increasing applied magnetic field, the penetrating flux fronts are approximately concentric ellipses whose axis ratio $b/a \leq 1$ decreases and shrinks to zero when the flux front reaches the center, the long axis staying finite in the fully penetrated state. The authors present and discuss analytic expressions for these axes, the sheet current, magnetic moment, and perpendicular magnetic field. The authors' solution also applies to superconductors with anisotropic critical current if the anisotropy has a particular, but realistic form.

The ac losses and current distributions in a high-T_c superconducting layered conductor consisting of 15 thick-film

$Bi_2Sr_2CaCu_2O_{8+\delta}$ (Bi-2212) tapes in parallel, with interlayer insulation, have been investigated by H. Noji (IRC-Cambridge and Tsuruoka National College of Technology). The author used an electric-circuit model to calculate the ac electromagnetic properties of the conductor. The calculated and measured losses were found to be in good agreement in the high-current region.

Measurements and calculations of the real (χ') and imaginary (χ'') parts of the ac magnetic susceptibility of a monofilamentary silver-sheathed *Bi-2223* tape as a function of temperature (T = 4 K - 130 K), frequency ($\omega/2\pi$ = 5 Hz - 5 kHz), and ac magnetic-field amplitude ($\mu_0 H_m$ = 0.02 mT - 7 mT) are presented in a preprint by N. Savvides and K.-H. Müller (CSIRO). The susceptibilities consist of a hysteretic component due to induced currents in the superconductor core and an eddy-current component due to induced eddy currents in the silver sheath. At low frequencies (< 50 Hz) and high temperatures, the measured χ'' and hence ac loss per cycle are dominated by the hysteretic loss, which varies with amplitude but is essentially independent of frequency. At higher frequencies and low temperatures, the eddy-current loss of the silver sheath becomes dominant and increases with increasing frequency.

The dynamic resistance in a slab-like superconductor has been calculated by M. P. Oomen (Siemens) et al., taking into account a field-dependent critical current density $J_c(B)$. In superconductors carrying a dc transport current in an ac external magnetic field, the dynamic resistance causes a transport loss that depends on the amplitude and frequency of this field, as well as on the transport current. At small field amplitudes and low transport currents, the model accurately predicts the dependence of the dynamic resistance upon field amplitude, field frequency, and transport current. For larger field amplitudes and higher transport currents, however, the resistance is found to be larger than the model predicts.

Voltages, voltage waveforms, and losses in hard superconductors carrying ac and dc transport current have been calculated by A. N. Ulyanov (Donetsk). The calculated results are in good agreement with experiment. The author explains the origin of a voltage-rectification effect for a superconductor carrying transport current $I(t) = I_{dc} + I_{ac} \cos\omega t$ as a consequence of the nonlinear current-voltage characteristics.

Bi Cuprates

A detailed compositional analysis of high-critical-current-density (J_c = 55 and 65 kA/cm^2 at 77 K) *$(Bi,Pb)_2Sr_2Ca_2Cu_3O_{10+\delta}$ (Bi-2223)* tapes has been undertaken by T. G. Holesinger (Los Alamos) et al. using energy-dispersive spectroscopy in the transmission electron microscope (TEM). The overall average composition of the *Bi-2223* phase within the tapes was determined to be *$Bi_{1.88}Pb_{0.23}Sr_{1.96}Ca_{1.95}Cu_{2.98}O_{10+\delta}$.* However, spatial variations in the *Bi-2223* composition and differing phase equilibria were found throughout the filament structure. In particular, the *Pb* content of the *Bi-2223* phase was found to be significantly depressed in the vicinity of secondary and amorphous phases. The implications are that (a) different equilibrium conditions can exist on a local scale within the same tape, (b) the reaction kinetics can influence the final microstructure and prevent the system from reaching true chemical equilibrium, (c) the range of influence of the secondary phases is larger than their physical size, (d) a considerable range of *Bi-2223* compositions can be found within a single tape, and (e) transport currents in *Bi-2223* tapes must traverse or detour around boundaries separating regions of differing composition and phase content.

The critical current density J_c of *Ag/(Bi,Pb)-2223* tapes in as-deformed and as-sintered states at various stages of tape processing has been studied by V. Beilin et al. (Hebrew University of Jerusalem). Intermediate pressing and rolling were found to result in significant I_c degradation. Bending tests showed that the I_c reduction was due to deformation-induced microcracks, which easily can be healed during the first hour of the next sintering. Intermediate deformation after the first sintering cycle was shown to significantly accelerate the *2212* to *2223* phase transformation during the first hours of the second sintering step. The authors found that I_c growth during the first hour of the second sintering step is not connected with the *2212* to *2223* transformation but is probably the result of increased pinning and structure-connectivity enhancement.

The in-plane and out-of-plane magnetoresistance of moderately overdoped *$Bi_2Sr_2CaCu_2O_{8+\delta}$ (Bi-2212)* single crystals has been studied by G. Heine (Wien) et al. from T_c + 5 K to T_c + 100 K with the magnetic field oriented perpendicular and parallel to the current, respectively. The authors found that the in-plane magnetoresistance is positive, the out-of-plane magnetoresistance is negative, and their temperature variations depend on the orientation of the magnetic field. The authors applied a recent theory for superconducting order-parameter fluctuations to account for the interaction of carrier spins with the magnetic field. The authors found that the anomalous, anisotropic magnetoresistance can be described well by a unique set of physical parameters, which were found to agree with estimates from the normal-state transport properties.

$La_{2-x}Sr_xCuO_{4+\delta}$

The results of an angle-resolved photoemission (ARPES) study of *$La_{2-x}Sr_xCuO_4$ (LSCO)* from a slightly

doped insulator (x = 0.03) to an optimally doped superconductor (x = 0.15) are reported by A. Ino (Tokyo) et al. As x increases, ARPES spectral weight is transferred between two components which coexist around the superconductor-insulator transition at x ~ 0.05, suggesting a microscopic inhomogeneity of the doped-hole distribution. For underdoped *LSCO* ($x \leq 0.1$), the dispersive band crossing the Fermi level disappears in the (0,0)-(π,π) direction, unlike the behavior in $Bi_2Sr_2CaCu_2O_{8+\delta}$. The authors reconcile these observations with the evolution of holes in the insulator into fluctuating stripes in the superconductor.

Measurements of the penetration depths $\lambda_{ab}(T)$ (**H**||c) and $\lambda_{\perp}(T)$ (**H**$\perp$c) in $La_{1.85}Sr_{0.15}Cu_{1-x}M_xO_4$ for x = 0, 0.005, 0.01, 0.015, 0.025, and 0.035 for *M* = *Ni* and x = 0, 0.005, 0.01, and 0.02 for *M* = *Zn* have been carried out by A. J. Zaleski and J. Klamut (Wroclaw). The authors obtained the penetration depth from ac susceptibility measurements of powdered samples, immersed in wax, and magnetically oriented in a static magnetic field of 10 T. To understand the results, the authors suggest that both the effective mass and the density of charge carriers must be taken into account in theories describing high-temperature superconductivity.

Neutron-scattering measurements of spin-density-wave order within the superconducting state of a single crystal of predominantly stage-4 La_2CuO_{4+y} with a T_c(onset) of 42 K are reported by Y. S. Lee (MIT) et al. The low-temperature elastic magnetic scattering is incommensurate with the lattice and is characterized by long-range order in the copper-oxide plane with the spin direction identical to that in the insulator. Between neighboring planes, the spins exhibit short-range correlations with a stacking arrangement reminiscent of that in the undoped antiferromagnetic insulator. Within experimental error, the elastic magnetic peak intensity appears at the same temperature as the superconductivity, suggesting that the two phenomena are strongly correlated. The authors assert that these observations directly reveal the persistent influence of antiferromagnetic order as the doping level increases from the insulator to the superconductor. In addition, the results confirm that spin-density-wave order for incommensurabilities near 1/8 is a robust feature of the La_2CuO_4-based superconductors.

A preprint by F. Cordero (Roma) et al. reports combined anelastic and ^{139}La NQR relaxation measurements that demonstrate the existence of relaxation-type dynamics of the *O* octahedra in La_2CuO_4. The combined data, which are in excellent agreement with each other, are interpreted in terms of soliton-like solutions of the one-dimensional equation of motion for the interacting octahedra, following a theoretical analysis by R. S. Markiewicz [*Physica C* **210**, 264 (1993)]. On that basis, the authors propose a connection between the lattice excitations and the lattice stripes observed in *La*-based and *Bi*-based high-T_c superconductors.

Films

Measurements of mm-wavelength radiation from two-dimensional arrays of underdamped $Nb/Al/AlO_x/Nb$ Josephson junctions are reported by P. Barbara et al. (Maryland) [*Phys. Rev. Lett.* **82**, 1963 (1999)]. The authors report that all of their samples emit coherently in a novel synchronized state, which is triggered by a resonance in the array structure. Measurements of the detected power as a function of the number N of active junctions show a threshold, suggesting population inversion. Above threshold, the power scales with N^2 up to an array size bigger than the free-space radiation wavelength. The highest measured conversion efficiency from dc to ac power is about 17%. The authors stress that their data are consistent with stimulated emission causing coherence and cannot be explained by existing classical coupling mechanisms.

The current in a clean superconductor/normal-metal/superconductor (S/N/S) junction of length d and width w in the presence of an applied magnetic field H has been studied theoretically by U. Ledermann et al. (ETH-Zürich). The authors show that both the geometrical pattern of the current density and the critical current $I_c(\Phi)$, where Φ is the total flux in the junction, depend on the ratio of the Josephson vortex separation $a_0 = \phi_0/Hd$ to the range $r \sim (d\xi_N)^{1/2}$ of the nonlocal electrodynamics [$\phi_0 = hc/2e$, $\xi_N = hv_F/2\pi T$, and $r(T \rightarrow 0) \sim d$]. In particular, the critical current has the periodicity of the superconducting flux quantum ϕ_0 only for $r < a_0$ and becomes, due to boundary effects, $2\phi_0$ (pseudo-) periodic for strong nonlocality, $r > a_0$. The authors find good agreement between their results and recent experiments by J. P. Heida et al. [*Phys. Rev. B* **57**, R5618 (1998)].

The power-dependent microwave properties of a weak link in an $YBa_2Cu_3O_{7-\delta}$ thin film formed by writing a line of damage using a focused ion beam have been measured by A. Cowie (Imperial) et al. The measurements were made using a parallel-plate resonator at 5.5 GHz with the weak link written across the width of one of the plates. The ion-induced damage was characterized using a TRIM computer simulation, and the dc properties of similar weak links were measured. Using a 200 eV *Si* ion dose of 2×10^{13} cm^{-2}, the T_c of the damaged region was reduced by 5.5 K and the normal resistivity was doubled. Surprisingly, the microwave measurements did not show any Josephson-junction characteristics. Rather, the ion-damaged region exhibited a greatly increased microwave resistivity, which was constant as a function of microwave power up to rf fields of 20 mT at 21 K.

Thermoelectric response times in the picosecond (ps) time domain have been observed by Th. Zahner et al. (Regensburg) in dynamical heating experiments with thin off-c-axis-grown $YBa_2Cu_3O_{7-\delta}$ films in the normal state. The thermoelectric response is due to the transverse Seebeck

effect occurring in materials with anisotropic thermopower. Fast heating was accomplished by film irradiation with ps laser pulses, and response times of about 400 ps were observed for thin films of ~10 nm thickness at room temperature.

New phenomena manifesting nonequilibrium superconductivity induced by spin-polarized quasiparticles in perovskite ferromagnet/insulator/superconductor (F/I/S) heterostructures are reported by N.-C. Yeh (Caltech) et al. Measurements of the critical current density J_c, using a pulsed-current technique to minimize Joule heating, reveal a monotonic increase with increasing insulator thickness. For F/I/S with thin insulating barriers, a slight increase in J_c is observed under small injection currents I_m from the ferromagnet, followed by a strong suppression of J_c under large I_m. In contrast, no effect of injection on J_c was detected in an N/I/S control sample (N = nonmagnetic metal).

As reported by J.Y.T. Wei (Caltech) et al., scanning tunneling microscopy has been performed at 4.2 K on epitaxial thin-film $YBa_2Cu_3O_{7-\delta}/La_{0.7}Ca_{0.3}MnO_3$ heterostructures to study the microscopic effects of spin-polarized quasiparticle injection from the half-metallic ferromagnetic manganite on the high-T_c cuprate superconductor. The quasiparticle tunneling characteristics observed were consistent with d-wave pairing symmetry, with a gap maximum of $\Delta_0 \approx 22$ meV, up to at least 35 mA (7×10^3 A/cm^2) injection. Spectral smearing observed at higher injections could be fitted to elevated effective quasiparticle temperatures, although negligible sample heating was detected by *in-situ* thermometry. The overall spectral evolution with the injection current also appears to be nonthermal, showing a nonmonotonic change in both the zero-bias tunneling conductance and the area under the conductance spectrum.

A preprint by F. Taddei (Lancaster) et al. predicts that giant magnetoresistance (GMR) for current perpendicular to the plane (CPP) in a phase-coherent magnetic multilayer is suppressed when one of the contacts is superconducting. This is a consequence of a superconductivity-induced magnetoresistive (SMR) effect, whereby the conductance of the ferromagnetically aligned state is drastically reduced by superconductivity. To demonstrate this effect, the authors compute the GMR ratio of clean $(Cu/Co)_nCu$ and $(Cu/Co)_nPb$ multilayers, described by an *ab-initio* spd tight-binding Hamiltonian. By analyzing a simpler model with two orbitals per site, the authors also show that the suppression survives in the presence of elastic scattering by impurities.

A description of spin-polarized transport in mesoscopic ferromagnet/superconductor (F/S) systems where the transport is diffusive and the interfaces are transparent has been developed by F. J. Jedema et al. (Groningen). The authors show that the spin reversal associated with Andreev reflection generates an excess spin density close to the F/S interface, which leads to a spin contact resistance. Expressions for the contact resistance are given for two-terminal and four-terminal geometries. For the latter case, the sign depends on the relative magnetization of the ferromagnetic electrodes.

Applications

A YBCO thin-film rf SQUID has been fabricated by N. Khare (NPL) using a bicrystal junction. The *YBCO* film was deposited on a $SrTiO_3$ 36.8° bicrystal substrate, and the rf SQUID structure was fabricated by a laser-patterning technique. The geometry consisted of one hole of dimension $50 \times 10\ \mu m^2$ with two asymmetric bicrystal junctions of widths 5 μm and 20 μm. The rf SQUID operated in hysteretic mode, and its peak to peak amplitude of V-Φ oscillations was 60 μV at 77 K. The flux-noise density of the bicrystal junction rf SQUID was found to be $2 \times 10^{-4}\ \phi_0\ Hz^{-1/2}$ at 2 Hz and 77 K.

Theory

A preprint by C. Honerkamp (ETH-Zürich) et al. compares different scenarios for the low-temperature splitting of the zero-energy peak in the local density of states at (110) surfaces of $d_{x^2-y^2}$-wave superconductors, observed by M. Covington et al. [*Phys. Rev. Lett.* **79**, 277 (1997)]. Using a tight-binding model in the Bogoliubov-de Gennes treatment, the authors find a surface phase transition towards a time-reversal-symmetry-breaking, (s + id)-wave surface state carrying spontaneous currents. Alternatively, the authors show that electron correlation leads to a surface phase transition towards a magnetic state corresponding to a local spin-density-wave state.

A method to compute the exact density of states induced by N nonmagnetic impurities in a system of two-dimensional Dirac fermions in the unitarity limit is presented in a preprint by C. Pépin and P. A. Lee (MIT). The authors review the case of the π-flux phase of the Heisenberg model and also treat the disordered d-wave superconductor. In both cases, the authors find additional states in the gap.

The effects of a magnetic field on the superconducting T_c and the spin pseudogap T* are discussed in a preprint by O. Zachar (Orsay). As a testable prediction, the author argues that a spin pseudogap should be observed in NMR experiments on overdoped samples in a magnetic field, even though there is no pseudogap above T_c in the absence of a magnetic field. The author finds that different theoretical approaches have marked differences in their predictions for overdoped high-T_c cuprates.

As noted in a preprint by Z. Y. Weng (TCSUH), underestimating the antiferromagnetic (AF) fluctuations in a fermionic resonating-valence-bond (RVB) state leads to an

overestimate of the superconducting transition temperature T_c in the same system. The author points out that by starting with a bosonic RVB description where both the long-range and short-range AF correlations can be accurately described, the AF fluctuations can effectively reduce T_c to a reasonable value through the phase-string effect, by controlling the phase coherence of the superconducting order parameter.

Key features of antiferromagnetic dynamical correlations in high-T_c superconducting cuprates are discussed by Ph. Bourges (Saclay) et al. In the underdoped regime, the sharp resonance peak, occurring exclusively in the superconducting state, is accompanied by a broader contribution located around 30 meV, which remains above T_c. The authors suggest that the interplay of these features may induce incommensurate structure in the superconducting state.

A quantum Monte Carlo study of the thermodynamic properties of arrays of spin ladders with various widths, coupled via a weak interladder exchange coupling αJ, where J is the intraladder coupling both along and between the chains, has been carried out by Y. J. Kim (MIT) et al. This coupled-ladder system serves as a simplified model for the magnetism of presumed ordered spin and charge stripes in the two-dimensional CuO_2 planes of hole-doped copper oxides. The authors discuss the implications of their results for the interpretation of neutron-scattering experiments on the dynamic spin fluctuations in $La_{2-x}Sr_xCuO_4$.

An efficient algorithm for obtaining the gauge-invariant gradient expansion of the local density of states and the free energy of a clean superconductor is presented in a preprint by L. Bartosch and P. Kopietz (Göttingen). The authors' method is based on a new mapping of the semiclassical linearized Gor'kov equations onto a pseudo-Schrödinger equation for a three-component wave function, where one component is directly related to the local density of states. Because this wave function satisfies a linear equation of motion, successive terms in the gradient expansion can be obtained by simple linear iteration. The authors confirm a recent calculation of the fourth-order correction to the free energy by I. Kosztin et al. [*Phys. Rev. B* **58**, 9365 (1998)], who obtained a discrepancy with an earlier result by L. Tewordt [*Z. Phys.* **180**, 385 (1964)]. The authors also give the fourth-order correction to the local density of states.

As noted in a preprint by I. I. Mazin and D. J. Singh (NRL), the *Ru*-based perovskites demonstrate an amazing richness in their magnetic properties, including 3D and quasi-2D ferromagnetism, antiferromagnetism, and unconventional superconductivity. The authors present first-principles calculations demonstrating that in both Ca_2RuO_4 and Sr_2RuO_4, ferromagnetic and antiferromagnetic fluctuations coexist, leading to an instability in Ca_2RuO_4 and to a close competition between p-wave and d-wave superconducting symmetries in Sr_2RuO_4.

On the basis of recent experiments, M. Sigrist (Kyoto) et al. argue that the symmetry of the superconducting phase of Sr_2RuO_4 is the odd-parity pairing state $\mathbf{d}(\mathbf{k}) = \mathbf{z}(k_x \pm ik_y)$. The experimental evidence for this so-called orbital-dependent superconductivity leads to a single-band description of superconductivity based on a spin-fluctuation mechanism. The authors show that the state $\mathbf{z}(k_x \pm ik_y)$ can be stabilized both by a spin-fluctuation feedback mechanism, as in the A phase of ^3He, and by spin-orbit coupling effects.

Overviews

A lengthy review of the interplay of the electron-phonon interaction and strong correlations and its role in high-T_c superconductors (HTS) has been prepared by M. L. Kulic (Bayreuth and Bordeaux). The author argues that contrary to low-T_c superconductors (LTS), where the electron-phonon mechanism leads to s-wave pairing, strong electronic correlations in HTS renormalize the electron-phonon interaction in such a way that a forward scattering peak appears and backward scattering is suppressed. This leads to (a) a relative increase of the coupling constant for d-wave pairing, (b) a T-linear normal-state resistivity, (c) a suppression of scattering by nonmagnetic impurities, and (d) robustness of d-wave pairing in the presence of nonmagnetic impurities. For optimally hole-doped HTS, the forward scattering peak leads to a small isotope effect and strong temperature dependence of the gap anisotropy. For overdoped oxides, the forward scattering peak mechanism is suppressed, which leads to anisotropic s-wave pairing with moderate gap anisotropy and an increase of the isotope effect (393 refs.).

In a review by A. Houghton (Brown) et al., the authors outline an approach via bosonization to the problem of many interacting fermions in spatial dimensions greater than one. The authors stress the simplicity of the approach, as the virtue of multidimensional bosonization lies in the reduction of complicated four-fermion interactions to a Gaussian problem. The authors recover well-known results of Landau theory, and they test the limits of multidimensional bosonization by considering several examples of non-Fermi liquids, in particular the composite fermion theory of the half-filled Landau level (124 refs.).

A survey of current theoretical understanding of the statics and dynamics of the flux-line lattice in realistic geometries has been prepared by E. H. Brandt (MPI-Stuttgart). The author discusses phenomenological theories, flux-line-lattice statics, flux-line dynamics, geometry effects, and nonlinear and linear ac susceptibilities. The author also describes a numerical method by which the magnetic response of superconductors can be computed in any geometry (74 refs.).

An overview by A. I. Braginski (Jülich) characterizes the status of the superconducting electronics (SCE) market. The author discusses the degree of acceptance of SQUID magnetometers and susceptometers in magnetoencephalography (MEG), magnetocardiography (MCG), liver SQUID susceptometry, materials science, physical research, geomagnetic measurements, and nondestructive evaluation or testing (NDE, NDT); and he summarizes the potential role of SCE in analog filters for cellular telephony and in future analog components for wireless systems and satellite communications. The author notes that while rapid single flux-quantum (RSFQ) digital electronics has no market share today, it still has the largest long-term potential for a large market in telecommunications and massive data processing. The author also summarizes findings of a survey of 45 industrial organizations that have been involved in SCE by manufacturing products for the market, performing prototype trials with potential customers, or conducting pre-prototype R&D (58 refs.).

The experimental trends in a database of specific-heat measurements near T_c in high magnetic fields for type-II superconductors with a large value of $\kappa = \lambda/\xi$, including mostly high-temperature superconductors, are considered in a paper by A. Junod et al. (Genève). The authors present evidence from specific heat, scanning tunneling microscopy (STM), and other measurements that support the idea of a crossover near $k_F\xi \approx 1$ from BCS-like superconductivity for weak coupling ($k_F\xi >> 1$) to Bose-Einstein-condensation-like (BEC-like) superconductivity for strong coupling ($k_F\xi << 1$) (55 refs.).

The technical status of high-temperature SQUID magnetometers and gradiometers has been reviewed by A. I. Braginski (Jülich) with emphasis on single-layer sensors currently used in applications. The author discusses the use of high-T_c SQUIDs for nondestructive evaluation and geomagnetic measurements, especially the exploration of mineral deposits. The author also presents selected highlights of recent developments with an emphasis on applications already implemented in practice or approaching that stage (53 refs.).

A brief overview of why a new mechanism and a many-body theory of superconductivity are required for the cuprates, which are doped correlated insulators, has been prepared by V. J. Emery (Brookhaven) and S. A. Kivelson (UCLA). The authors review the essential features of their approach, in which the physics is driven by the kinetic energy, and they summarize experimental support for such a theory (46 refs.).

A preprint by E. H. Brandt (MPI-Stuttgart) summarizes theoretical results for the complex magnetic ac susceptibility χ as a function of frequency ω and amplitude H_0 for various geometries, including thin-film disks, rings, and strips, and thicker platelets in a perpendicular magnetic field. The author discusses how the linear $\chi(\omega)$ depends on the linear resistivity $\rho_{ac}(\omega) = E/J$ or penetration depth $\lambda_{ac}(\omega)$ and how the nonlinear $\chi(H_0,\omega)$ depends on the nonlinear current-voltage law E(J,B) (45 refs.).

A chapter on ultrafast time-resolved optical spectroscopy in high-temperature superconductors has been prepared by D. Mihailovic and J. Demsar (Ljubljana). This method enables the direct real-time measurement of nonequilibrium quasiparticle recombination dynamics. The authors use experimental data and relevant theories to develop a consistent picture of the low-energy electronic structure in $YBa_2Cu_3O_{7-\delta}$ (26 refs.).

Contributed by John R. Clem

Contents:

***High-T_c Update* is available without charge to interested persons. Recipients are expected to participate in this information exchange by sending us preprints, reprints, meeting news, research news, etc. Contributions to defray the cost of newsletter printing and mailing are welcome.**

PREPRINTS

To obtain a particular preprint, contact the first author at the address given at the end of the citation. Help us expand this list by sending us your complete preprint. **Please specify where and when your paper was submitted.** An * next to an entry indicates it is a correction or revision of a previous entry. PACS codes and/or key words are given at the end of the citation.

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COMING EVENTS

*(An * indicates a previously listed event. Also see complete listing of upcoming conferences and workshops at our Web site http://www.iitap.iastate.edu/htcu/comevents.html.)*

April 25 - 28, 1999: 5th Twente Workshop: Digital Applications, Josephson Junctions and Sensors, University of Twente, Enschede, The Netherlands.

Aim is an international exchange of latest results on the electronic applications of superconductors. The workshop should yield an extended review on the following areas of research: digital applications, RSFQ-logic, sensors, film growth, Josephson junctions, and interconnects. Morning sessions will be devoted to invited talks with discussion breaks; afternoon sessions will consist of presentations of contributed papers. Opportunities will be offered for a daily poster session to stimulate discussions. **Abstract deadline, March 15, 1999, (preferably by e-mail).** Papers will be published as a special issue of *Physica C.* Contact Ir. H.J.H. Smilde, University of Twente, Department of Applied Physics, (TN/LT), P.O. Box 217, 7500 AE Enschede, The Netherlands; phone +31 53 489 3841; fax +31 53 489 1099; e-mail h.j.h.smilde@tn.utwente.nl.

May 31 - Aug. 27, 1999:

Topological Defects in Non-Equilibrium Systems and Condensed Matter Seminar, Max-Planck-Institut Für Physik Komplexer Systeme, Dresden, Germany. In conjunction with the International Workshop on Computer-Aided Analysis of Dynamical Structures and Defects (July 20 - 29, 1999). Aim is to bring together scientists from the non-equilibrium physics community with those in equilibrium condensed-matter physics community, to discuss methods and tools of studies of dynamics of disordered media dominated by formation, motion, and annihilation of topological defects. The applications include nonequilibrium patterns in fluid mechanical, chemical, and nonlinear optical systems, as well as dynamics of superfluids, superconductors, liquid crystals, and other ordered media. Scope may range from understanding the appearance, structure, and dynamics of weakly disordered states to elucidating the role of different forms of vorticity in various strongly turbulent states, and understanding different

forms of frozen disorder ("vortex glass") and relation between topological defects and other localized structures. For further information and application forms, contact Visitors Program, Max-Planck-Institut für Physik Komplexer Systeme, Nöthnitzer Str. 38, D-01187 Dresden, Germany; telephone +49 351 871 2105; telefax +49 351 871 2199; e-mail canla@mpipks-dresden.mpg.de; Web site http://www.mpipks-dresden.mpg.de/~canla/index.html.

Aug. 1 - 3, 1999: Symposium on Micro- and Nanocryogenics (MNC), University of Jyvaskyla, Jyvaskyla, Finland. Satellite to the LT-22 Conference in Helsinki, Finland (Aug. 4-11, 1999). Will focus on the growing field of cryogenic applications of micro- and nanometer size systems. Topics of the symposium include: microrefrigeration, thermometry, microbolometers and other space applications, SQUIDs and their applications, and other cryogenic applications of micro- and nanostructures. **Abstract deadline, March 31, 1999.** Limited to about 100 persons. For further information, contact Minna Ranta (MNC), Department of Physics, University of Jyvaskyla, P.O. Box 35 (Y5), FIN-40351 Jyvaskyla, Finland; telephone +358 14 602354; telefax +358 14 602351; e-mail mnc@phys.jyu.fi. Or contact Jukka Pekola (Conference Chair) at ukka.Pekola@phys.jyu.fi, or Antti Manninen (Co-Chair) at Antti.Manninen@phys.jyu.fi. Also see the MNC Web page at http://www.phys.jyu.fi/jyflweb/latest/mnc.html.

Nov. 2 - 4, 1999: The Third International Workshop on Material Science (IWOMS'99), Hanoi, Vietnam. Workshop covers various aspects of materials science, from bulk to nanoscale materials, including fundamentals and technical applications. Main objective is to provide a forum where most relevant and recent results are discussed. Topics include: intermetallics – phase diagram, microstructure, and physical properties; magnetic materials and applications; thin films – materials and applications; high-T_c superconductors and superconductivity-related phenomena; advanced ceramic materials; physics of nanostructures; and others. Invited and contributed papers. Workshop language is English. **Abstract deadline, April 15, 1999.** For information, contact Secretary IWOMS'99, International Training Institute for Materials, Science (ITIMS), ITIMS Building, Dai hoc Bach Khoa Hanoi, 1 DAI CO VIET Road, Hanoi, Vietnam; telephone +84 4-869-2518 or -868-0787; telefax +84 4-869-2963; e-mail iwoms@itims.edu.vn.

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Position open: A postdoctoral position is available at the University of Maryland to run scanning near-field microwave-microscopy program. Work funded by NSF Materials Research Science and Engineering Center on Oxide Thin Films. Primary responsibility is to supervise three graduate students and develop new quantitative imaging techniques of ferroelectric, ferromagnetic, and superconducting oxide materials. Goals are to develop quantitative images of electric polarization, ferromagnetic domains, and superconducting nonlinearities, all on sub-micron length scales and at microwave frequencies. A secondary objective is to contribute to another NSF-funded program to image microwave electromagnetic fields from cryogenic devices. The candidate should be familiar with microwave-measurement techniques and have an interest in the physics and materials properties of novel oxide materials. For information, contact Prof. Steven Anlage, Physics Department, University of Maryland, College Park, MD 20742-4111; telephone (301) 405-7321; telefax (301) 405-3779; e-mail anlage@squid.umd.edu; Web site http://www.csr.umd.edu.

Research positions open: The following positions are available for PhD students and postdoctoral fellows at the Condensed Matter Physics Department of the Vrije Universiteit.

Position 1: Complex Oxide Films – Growth and Physical Properties – The target of this activity is to synthesize hetero-epitaxial complex oxides such as bismuth-doped garnets, superconducting compounds, and magnetoelectric films and to study their physical properties. In general, the main aim of this material-science activity is to unravel the fascinating links between physical properties, defect structure, and growth conditions of complex oxides.

Position 2: Vortex Dynamics in Superconductors – Vortex matter in high-T_c superconductors is investigated by means of high-resolution torque magnetometers and magneto-optics. Setup is especially well-suited to study roughening and growth of flux penetration in films which exhibit essentially the same characteristics as burning paper! Vortex matter is thus an attractive model system to study nonlinear diffusion phenomena.

Applicants should have obtained recently a M.Sc. degree (for PhD student positions) or a PhD degree (for postdoc positions) in experimental physics, physical chemistry, or materials science. They should have an excellent knowledge of condensed-matter physics. The PhD-student positions are for four years and the postdoctoal positions for two years.

Candidates should send a curriculum vitae and the names of three references to Prof. R. Griessen, Faculty of Sciences, Division of Physics and Astronomy, Vrije Universiteit, De Boelelaan 1081, 1081 HV Amsterdam, The Netherlands; telephone +31 20 4447915; e-mail griessen@nat.vu.nl; Web site http://www.nat.vu.nl/vakgroepen/vstof/english/tmr/index.html.

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