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This is the last issue of the hard-copy version of *High-T_C Update.* You will receive the PDF version of the newsletter beginning with the May 1 issue, if you have informed us of your current e-mail address. If you have not yet done so, it is still not too late! Forward your e-mail address immediately to mitra@ameslab.gov.

Vortices

Two preprints by Y. Fasano (Bariloche) et al. report on a new type of vortex pinning, which the authors call Bitter pinning. The authors decorated the vortex lattice in *$NbSe_2$* with ferromagnetic particles, which form clumps on the sample surface where the vortices exit. The authors present data showing that the resulting array of magnetic dots act as pinning sites for vortices in subsequent experiments. The authors note that this method allows one to produce periodic, quasiperiodic, or disordered pinning structures for static and dynamic vortex experiments.

Using an ac susceptibility technique and an ultrapure *$YBa_2Cu_3O_{6.993}$* crystal, made possible by the recent breakthrough in crystal growth of high-T_C oxide superconductors using *$BaZrO_3$* crucibles, J. Shi (Brown) et al. have observed a giant peak in the critical current density $J_C(T)$. At H = 2.0 T (**H**||c), the authors found that $J_C(T)$ exhibited a 35-fold increase with a temperature rise of 0.5 K. The authors find that the peak coincides with the vortex-lattice melting transition.

A preprint by Z. L. Xiao (Rutgers) et al. reports on flow-induced organization and memory of a vortex lattice in an *Fe*-doped single crystal of 2H-*$NbSe_2$*. As is typical of weak-pinning superconductors, the samples exhibited a strong peak effect in the critical current density J_C. By using fast transport measurements to follow the vortex organization, the authors also found that the current enables the vortex system to explore its energy landscape and to access new configurations, ending up, after a characteristic response time, in a state whose pinning depends on the driving current. The authors present a dynamic phase diagram that contains a regime where the critical current can be increased or decreased by applying an appropriate driving current.

Vortex pinning in textured *Ag*-clad *$Bi_2Sr_2CaCu_2O_{8+\delta}$ (Bi-2212)* superconducting tapes containing randomly oriented columnar defects produced by *Bi* fission after irradiation with 0.8 GeV protons has been studied by J. R. Thompson (Oak Ridge and Tennessee) et al. The authors found that the thermally activated decay of the current density J was much less than in unirradiated tapes. The authors conclude, however, that temperature-independent quantum tunneling of vortices considerably limits J and its temporal stability over a significant fraction of the finite-T_C region.

The influence of thermally created vortices on the low-field vortex phase diagram of slightly underdoped *$Bi_2Sr_2CaCu_2O_{8+\delta}$ (Bi-2212)* single crystals has been investigated by L. Miu (NIMR, Bucharest-Magurele) et al. using resistive and dc magnetic measurements. The authors found that the resistive tail observed in these samples could be used to determine the layer decoupling temperature.

The nature of quasiparticles in the vortex lattice of unconventional superconductors in low and intermediate fields has been explored theoretically by M. Franz and Z. Tesanovic (Johns Hopkins). For a periodic vortex lattice, the authors find that the natural quasiparticle states are Bloch waves and not Landau levels.

The effective mass of a single quantized vortex in a BCS superconductor at finite temperature has been calculated by J. H. Han (APCTP-Seoul) et al. The authors argue that the mass and viscous drag are closely related because they arise from the same mechanism: interaction with the surrounding fermionic degrees of freedom.

A preprint by M. Ozaki (Kochi) et al. presents a theoretical study of local symmetric order parameters

(s-wave, p-wave, and d-wave) of the vortex-lattice states in singlet superconductors with s-wave, p-wave, and d-wave symmetry.

A Giaever dc-dc transformer, which involves flux-flow vortex motion in two superimposed thin films separated by a thin insulating layer, has been fabricated by S. Berger et al. (Thomson-CSF) using a ramp-based multilayer technology and an $YBa_2Cu_3O_{7-\delta}$-based SIS structure grown by pulsed laser deposition. Transport measurements exhibiting coupling and decoupling of the vortex arrays in the two superconducting films were carried out.

The superconducting behavior of a 100 nm *TiN* thin film (T_c = 4.6 K) in a perpendicular magnetic field has been studied by F. Lefloch et al. (Grenoble). The authors observed an electronic instability at high vortex velocities, and from its dependence upon the applied magnetic field, the authors extracted the inelastic scattering time and the diffusion length of the quasiparticles.

Vortices in Layer-Parallel Fields

The hysteresis in the magnetization **M** of a melt-textured $YBa_2Cu_3O_{7-\delta}$ *(Y-123)* superconducting plate in the critical state has been studied experimentally and theoretically by L. M. Fisher (Moscow) et al. The hysteresis was found to be suppressed by a sweeping magnetic field **h**(t) applied perpendicular to a dc magnetic field **H**, both fields being parallel to the plate. For every quarter period of the sweeping field with amplitude h_0, a noticeable decrease in the magnitude of M was observed for both paramagnetic and diamagnetic initial states, even for $h_0 << H$. Both the double critical state model and a two-velocity hydrodynamic model were used to analyze the experiments, but the latter was found to give better agreement.

As reported by K. Deligiannis (Southampton) et al., an oscillating magnetization appears in high-purity $YBa_2Cu_3O_{7-\delta}$ *(Y-123)* single crystals when the applied field is applied parallel to the layers. The authors show that these oscillations are the fingerprints of interlayer Josephson vortices and that they directly yield the anisotropy factors $\gamma_{cb} = (m_c/m_b)^{1/2}$ and $\gamma_{ca} = (m_c/m_a)^{1/2}$ when the applied field is parallel to the a or b axis, respectively. The temperature dependence of this lock-in magnetization, however, is not in agreement with theory.

Oscillations of the magnetization induced by commensurability between vortex-plane and CuO_2-plane distances in $YBa_2Cu_3O_{7-\delta}$ *(Y-123)* single crystals have been studied by A. A. Zhukov (Imperial, Karlsruhe, and Moscow State) et al. The authors found a sharp peak in the temperature dependence of the amplitude of oscillations at $T_f \sim 60$ K, which they suggest reflects the vortex freezing transition from a smectic to a solid phase. The authors also construct the phase diagram as a function of the angle of the field relative to the CuO_2 layers.

The mixed-state c-axis resistivity of $YBa_2Cu_4O_8$ *(Y-124)* has been measured by N. E. Hussey (Tokyo and CREST) et al. with the magnetic field applied parallel to the a, b, and c axes. For all orientations of the magnetic field, a kink is observed in the resistive transition, associated with the first-order melting of an anisotropic three-dimensional vortex lattice. While the melting lines for **H**||b and **H**||c obey the relation $H_m = H_0(1\text{-}T/T_c)^n$ with n = 1.5, $H_m(T)$ for **H**||a follows a different T dependence with a lower exponent. The authors attribute this to a reduction in the dimensionality of *Y-124* in this field geometry, as observed in normal-state magneto-resistance measurements.

$RBa_2Cu_3O_{7-\delta}$

Local magnetic measurements vs temperature by D. Giller (Bar-Ilan) et al. in an untwinned $YBa_2Cu_3O_{7-\delta}$ crystal reveal a number of features along the same line $B_k(T)$ in the field-temperature plane well below the melting line: (a) an abrupt increase in the local magnetization vs temperature, (b) a pronounced kink in curves of the magnetization vs field, (c) a marked change in the behavior of the magnetic relaxation rate with field, and (d) a time-independent B_k unlike the peak field, which drifts with time to lower fields. The authors fit $B_k(T)$ to a model describing a disorder-induced vortex solid-to-solid phase transition that explains similar behavior in $YBa_2Cu_3O_{7-\delta}$ *(YBCO),* $Nd_{1.85}Ce_{0.15}CuO_{4-\delta}$ *(NCCO),* and $Bi_2Sr_2CaCu_2O_{8+\delta}$ *(Bi-2212),* and they infer that the microscopic origin of pinning in *YBCO* is fluctuations in the charge-carrier mean free path near lattice defects.

As reported by Z. A. Zhu et al. (Princeton), in underdoped $YBa_2Cu_3O_{7-\delta}$ *(YBCO)* with x = 6.63, the opening of the pseudogap at $T_S \approx 160$ K has a strong effect on the Hall angle $\tan\theta$. While the Hall response is significantly reduced, the diagonal current is relatively unaffected. The authors present evidence that the Hall suppression continues below T_c down to 40 K. In the flux-flow state, the Hall conductivity is also qualitatively different from that in optimally doped *YBCO*.

Superconducting transitions in field-cooled-cooling (FCC) and field-cooled-warming (FCW) modes in external magnetic fields ranging between 1 mT and 7 T in various *Nd*-based *123* superconductors ($NdBa_2Cu_3O_{7-\delta}$ single crystals and melt-processed samples, and melt-textured ternary compounds) have been measured by M. R. Koblischka (SRL-ISTEC) et al. Most of the *Nd*-based superconductors exhibited a two-step transition when cooled or warmed in fields larger than 4 T. The authors ascribe this effect to the

presence of a *Nd*-rich phase producing spatial variation of the transition temperature T_c throughout the sample. A single crystal with an extremely high T_c of 95.7 K, indicating that the *Nd/Ba* solid solution is nearly completely suppressed, does not show the second step.

The superconducting and magnetic properties of oxygen-controlled-melt-grown (OCMG) *(Nd,Eu,Gd)-$Ba_2Cu_3O_{7-\delta}$ (NEG-123)* superconductors containing *Pr* in the concentration range x = 0 to 0.15 are reported by M. Muralidhar et al. (SRL-ISTEC). The *Pr* doping suppresses the superconducting transition temperature T_c somewhat, but reduces the critical current density J_c at the fishtail peak by about five orders of magnitude. The authors attribute these effects to partial substitution of *Pr* on the rare-earth site and hole localization due to trivalent ions on the *Ba* site.

Two preprints by V.P.S. Awana (UNICAMP) et al. report results on structure, superconducting T_c, and antiferromagnetic ordering temperature T_N in various *Pr*-substituted cuprates, including *$Y_{1-x}Pr_xBaSrCu_3O_7$, $La_{1-x}Pr_xBaCaCu_3O_7$,* and *$Nd_{1-x}Pr_xBaCaCu_3O_7$.* The authors find that the suppression of superconductivity due to *Pr* in all these systems is less than that in the *R-123* counterparts, *$Y_{1-x}Pr_xBa_2Cu_3O_7$, $La_{1-x}Pr_xBa_2Cu_3O_7$,* and *$Nd_{1-x}Pr_xBa_2Cu_3O_7$.* The authors also report a correlation between the T_c suppression due to *Pr* and the value of T_N of the fully substituted *Pr* moments in these systems; a less deleterious effect on superconductivity is associated with a lower T_N.

Bi Cuprates

The c-axis transport of *$Bi_2Sr_2CaCu_2O_{8+\delta}$ (Bi-2212)* stacked intrinsic junctions fabricated from single crystal whiskers by a double-sided ion-beam-processing technique has been studied by Yu. I. Latyshev (Tohoku) et al. The authors measured the I-V characteristics and obtained the superconducting gap, the Josephson critical current, and the temperature and voltage dependence of the quasiparticle c-axis conductivity. The authors show that the BCS clean-limit d-wave model for resonant intralayer impurity scattering with a significant contribution from coherent interlayer tunneling satisfactorily describes the low-temperature and low-energy c-axis transport of both quasiparticles and Cooper pairs.

The far-infrared sphere resonance in *$Bi_2Sr_2CaCu_2O_{8+\delta}$ (Bi-2212)* samples with various oxygen concentrations has been measured in zero applied magnetic field by H. Shibata and A. Matsuda (NTT) down to 5 cm^{-1}. Although no peaks were observed in this frequency range for the optimally doped sample, the Josephson plasma peak was observed at 5 cm^{-1} for a 1 atm *O_2*-annealed sample. The peak was found to shift to higher frequencies as the doping increased, and was observed at 11 cm^{-1} for a 150 atm *O_2*-annealed sample.

The c-axis penetration depth λ_c obtained from the peak frequencies was determined to be 77 to 35 μm. The doping dependence is qualitatively explained by the Josephson-coupled-layer model.

The magnetic-field dependence of the magneto-thermopower $\Delta S(T,H)$ in textured *$Bi_2Sr_2CaCu_2O_{8+\delta}$ (Bi-2212)* is theoretically explained by S. Sergeenkov and M. Ausloos (Liège) by introducing a field-dependent chemical potential of holes $\mu(H)$ into the Ginzburg-Landau theory.

Two related papers, one by J. Jiang (Birmingham) et al. and the other by D. C. Larbalestier (Wisconsin) et al., report experiments elucidating the current-limiting mechanisms in *Ag*-sheathed *$Bi_2Sr_2Ca_2Cu_3O_{10+\delta}$ [(Bi,Pb)-2223]* tapes. The authors find that cracks, actual or incipient, exist on the submicron to several hundred micron scale, and that even composites with the highest values of J_c exhibit strong signs of unhealed rolling damage. The authors of both papers assert that today's best *2223* tapes are still far from being fully optimized, and they suggest that the performance could be further improved by controlling the liquid phase to better heal the cracks.

Experiments by K.-H. Müller et al. (CSIRO) et al. show that the remanent magnetic moments of *YBCO* thin-film networks and of *Bi-2223/Ag* monofilamentary tapes show remarkable similarities, as their magnetic moments are composed of intersquare (intergrain) and intrasquare (intragrain) magnetic moments. Starting from the geometrical definition of connectivity in a thin-film network, the authors show that connectivity in a *Bi-2223/Ag* monofilamentary tape is defined solely by the ratio of the average grain size to the width of the superconducting core and by the ratio of the intergrain to intragrain remanent magnetic moments at saturation. The measured upper limit for the connectivities ranged from 4.2×10^{-3} in a tape with low critical current density J_c to 2.9×10^{-2} in a tape with $J_c(77K,0T) \approx 2 \times 10^4$ A/cm^2. The authors conclude that even good *Bi-2223/Ag* tapes suffer from very low grain connectivity, and they estimate that in the case of perfect connectivity a $J_c(77K,0T)$ between 8×10^5 A/cm^2 and 6×10^6 A/cm^2 would be achievable.

A method for incorporating nanosize *MgO* particles into the *Bi-2223* grains of *Ag/Bi-2223* multilayer composite tapes has been developed by H. Wu et al. (TCSUH). The authors found, however, that the *MgO* particles do not have a significant effect on the field performance of the critical current density at 77 K.

Other Cuprates

A preprint by A. W. Hunt et al. (MIT) demonstrates that one can measure the charge-stripe order parameter in the hole-doped planes of *$La_{1.875}Ba_{0.125}CuO_4$,*

$La_{1.48}Nd_{0.4}Sr_{0.12}CuO_4$, and $La_{1.68}Eu_{0.2}Sr_{0.12}CuO_4$ utilizing the wipeout effects of ^{63}Cu NQR. Application of the same approach to $La_{2-x}Sr_xCuO_4$ reveals the presence of similar stripe order for the entire underdoped superconducting regime $1/16 \le x \le 1/8$.

A ^{63}Cu and ^{139}La NMR/NQR study of a superconducting (T_c = 7 K) $La_{1.94}Sr_{0.06}CuO_4$ single crystal is reported by M.-H. Julien (Pavia and Iowa State/Ames Lab) et al. ^{139}La NMR relaxation revealed the coexistence of spin-glass and superconducting phases below ~5 K. ^{63}Cu and ^{139}La NMR spectra show that, upon cooling, CuO_2 planes progressively separate into two magnetic phases, one of them having enhanced antiferromagnetic correlations. The results establish the antiferromagnetic-cluster nature of the spin glass. The authors also discuss how this phase can be related to the microsegregation of mobile holes and to the possible pinning of charge stripes.

The effect of zinc doping on the anomalous temperature dependence of the magnetoresistance and the Hall effect in the normal state has been studied by A. Malinowski (Rutgers and Warsaw) et al. in a series of $La_{2-x}Sr_xCu_{1-y}Zn_yO_4$ films with values of y between zero and 0.12. The orbital magnetoresistance at high temperatures was found to be proportional to the square of the tangent of the Hall angle, as predicted by the model of two relaxation rates, for all *Zn*-doped specimens, including nonsuperconducting films.

Data on the suppression of T_c in *Bi-2212* and *Tl-2212* by substitution of *Co* impurities at *Cu* sites are analyzed in a preprint by B. Chattopadhyay et al. (SINR-Calcutta). Using the Abrikosov-Gor'kov formalism and a tight-binding model accounting for suppression of the Fermi-level density of states, the authors extract the pseudogap.

Two preprints by L. Zhang (Cal State-Stanislaus) et al. report measurements of the magnetic properties in single crystals of the four-CuO_2-layer compound $TlBa_2Ca_3Cu_4O_{11+\delta}$ (*Tl-1234,* T_c = 128 K). In one of the papers, the authors obtained a Ginzburg-Landau parameter $\kappa = 109$ and an extrapolated $H_{c2}(0) = 160$ T for magnetic fields along the c axis. In the other, the authors report measurements of the flux-creep rate dlnM/dlnt as a function of temperature and magnetic field, which yielded a temperature-independent energy barrier in the range 2-30 K.

Microwave (2-18 GHz) measurements of the complex susceptibility $\chi(\omega,T) = \chi' + i\chi''$ of $Sr_{14-x}Ca_xCu_{24}O_{41}$ are reported by Z. Zhai (Northeastern) et al. The authors observed a frequency- and temperature-dependent loss peak, which they associate with a rapid decrease of spin disorder and corresponding spin relaxation rate with decreasing temperature, representing a spin-freezing transition accompanying charge ordering, which occurs at temperatures ~250 K for the x = 0 compound.

Films

The competition between a-axis and c-axis growth in $RBa_2Cu_3O_{7-\delta}$ (*R* = rare earth or *Y*) superconducting thin films has been analyzed by F. Miletto (Napoli) et al. The relative a/c-axis content was estimated by x-ray diffraction and plotted as a function of deposition temperature. The authors found that the a/c-axis content, plotted vs a normalized deposition temperature, has a universal behavior, valid for all $RBa_2Cu_3O_{7-\delta}$ oxides. The authors present a theoretical model that agrees with the observations.

$YBa_2Cu_3O_{7-\delta}$ films grown on both $SrTiO_3$ single crystals and rolling-assisted biaxially textured *Ni* substrates (RABiTS) carry high critical current densities. As pointed out by H. R. Kerchner (Oak Ridge) et al., a geometrical barrier to vortex motion at the edge of the film increases the apparent J_c but also raises the ac transport-current power losses at high ac current amplitudes above the losses expected for bulk pinning only. The authors present evidence that the ferromagnetic *Ni* substrate makes no significant contribution to the tape self-field loss.

A preprint by C.-J. Kim (SRL-KAERI) et al. reports on the control of *YBCO* growth at the compact/substrate interface by bottom seeding and Yb_2O_3 coating in seeded melt-growth-processed *YBCO* oxides using an *MgO* substrate.

The magnetic-field and angular dependencies of the critical current density and resistive broadening of a textured $Bi_{1.84}Pb_{0.4}Sr_2Ca_2Cu_3O_{10+\delta}$ thick film in applied magnetic fields up to 0.3 T are reported by Z. H. Wang (Shanghai). The author reports angular scaling laws for $J_c(\mathbf{H})$ and the characteristic temperature at which the magnetoresistance $R(\mathbf{H})$ drops to a fraction (e.g., 1%) of the normal-state resistance R_n.

The effects of the oxygen-annealing temperature upon the superconductivity of epitaxial $HgBa_2Ca_2Cu_3O_{8+\delta}$ *(Hg-1223)* thin films fabricated by pulsed laser deposition are reported by W. H. Kang (POSTECH) et al. The highest transition temperature of 133 K for the films grown on (100) $SrTiO_3$ were obtained after oxygen annealing at 340°C for 12 hours. The observed critical current density of 2.6×10^5 A/cm^2 at 120 K in zero field is high enough for applications in SQUIDs operated at 120 K.

A phenomenological model proposed by A. V. Velichko (Birmingham and IRE-NAS, Ukraine) accounts for the effects of both dc and rf magnetic fields on the surface impedance $Z_S = R_S + jX_S$ of a superconducting weak link. Under certain conditions, the predicted values of $Z_S(H)$ fall below the zero-field values.

Nonlinear microwave (8 GHz) surface-impedance measurements on three *YBCO* thin films in dc magnetic fields

H_{dc} (parallel to the c axis) up to 2 mT have been carried out by A. P. Kharel (Birmingham) et al. using a coplanar resonator technique. In zero dc field, the three films, deposited by the same method, show a spread of low-power residual surface resistance R_{res} and penetration depth $\lambda(T = 15\ K)$ within a factor of 1.9. However, while X_S vs microwave field H_{rf} is nearly the same for all three films, the surface resistance R_S vs H_{rf} is dramatically different for the three films. Application of a dc field was found to affect both the absolute values of R_S and X_S and the functional dependencies $R_S(H_{rf})$ and $X_S(H_{rf})$. For some of the samples, the dc field was found to decrease R_S below its zero-field low-power value.

Junctions

According to a preprint by A. M. Zagoskin (UBC), the unique properties of a ballistic D/N/D (d-wave superconductor / normal metal / d-wave superconductor) or a grain-boundary D/D junction, possessing a doubly degenerate ground state with a tunable potential barrier between the up and down states and nonquantized spontaneous magnetic flux, make it a good candidate for a solid-state qubit (SSQ) in a quantum computer. (Other SSQ candidates are quantum dots, mesoscopic Josephson junctions, and superconducting single-electron transistors or parity switches.) The author asserts that the role of the quantum spin variable is played by the sign of the equilibrium superconducting phase difference on the junction, which is revealed in the direction of spontaneous supercurrent flow in equilibrium. The author discusses possibilities of design-specific simultaneous operations with several integrated qubits.

Anisotropic microwave emission properties of *$ErBa_2Cu_3O_7$*/insulator/*Au* (S/I/N) tunnel junctions resulting from direction-oriented quasiparticle injection are reported by K. Lee et al. (Tokyo Tech and CREST). Two types of samples with different S/I/N tunnel junction geometries were prepared, one allowing quasiparticle injection mainly along the c axis and the other only into the ab plane. Microwave emission was observed, and a strongly nonequilibrium state was established, only for quasiparticle injection along the c axis.

Strong suppression of supercurrent through a *$YBa_2Cu_3O_{7-\delta}$ (YBCO)* superconductor upon injection of spin-polarized quasiparticles from a ferromagnetic *Co* injector is reported by K. Lee (Tokyo Tech and CREST) et al. The authors report that the injection of spin-polarized quasiparticles generates a much larger nonequilibrium population than does an unpolarized injection current. The differential conductance of a *YBCO/Au/Co* junction exhibited a zero-bias conductance peak when the thickness of the *Au* interlayer (d_{Au}) was about 15 nm, but when d_{Au} was increased, the conductance peak was converted to a zero-bias resistance peak. The authors suggest that these results may be due to spin-scattering processes at a ferromagnet / d-wave superconductor junction.

Tunneling spectroscopy on near optimally doped single crystals of *$Tl_2Ba_2CuO_{6+\delta}$ (Tl-2201)* is reported by L. Ozyuzer (Argonne and Izmir) et al. S/I/N tunneling conductances, obtained via the point-contact technique with a Au tip, reproducibly show a sharp cusplike subgap, prominent quasiparticle peaks with a consistent asymmetry, and weakly decreasing backgrounds. The authors note that the tunneling density of states of *Tl-2201* is reproducibly consistent with $d_{x^2-y^2}$-wave gap symmetry.

Experimental results on c-axis tunneling in *Nb/Au/$YBa_2Cu_3O_{7-\delta}$* structures are reported by P. V. Komissinski (IREE-Moscow) et al. The authors observed no Josephson critical current and no *YBCO* gap feature.

Numerical calculations of the conductance of an interface between a phase-coherent two-dimensional electron gas and a superconductor with a quantum point contact in the normal region are presented by N. A. Mortensen (TU Denmark, Lyngby) et al. The normalized conductance is found to depend strongly on the position of the Fermi level, and to be enhanced by a factor of two when the Fermi level corresponds to a conductance plateau.

Nonequilibrium proximity effects in wide mesoscopic superconducting/normal/superconducting (S/N/S) junctions are studied theoretically in a preprint by N. Argaman (ITP-Santa Barbara). The author examines the behavior at temperatures for which the equilibrium Josephson effect is exponentially small and the second harmonic of the Josephson frequency dominates the supercurrents.

A strong mutual influence between superconductors (S) and ferromagnetic (F) conductors in hybrid F/S (i.e., *Ni/Al*) nanostructures has been observed by V. T. Petrashov (London and Chernogolovka) et al. The magnitude of the proximity-induced conductance on the F side is more than two orders of magnitude larger than that predicted by theory.

A scattering treatment of transport in S/F/S junctions, i.e., between superconductors with a small ferromagnetic metal region inside the junction, is presented in a preprint by R. Mélin and O. Bourgeois (Grenoble). The authors find reasonable agreement between their theory and experiments in *Al/Gd/Al* junctions.

A preprint by T. K. Kopec (Northeastern and Wroclaw) and J. V. José (Northeastern) reports a study of a quantum Hamiltonian that models an array of ultrasmall Josephson junctions with short-range Josephson couplings E_J and charging energies E_C due to the small capacitance of the junctions. In the self-capacitive limit and in the presence of an external uniform background of charges q_x, the authors obtain the zero-temperature superconductor-insulator phase diagram $E_J^{crit}(E_C,q_x)$. The authors also obtain a closed-form expression for the conductivity of a square array and derive a

universal scaling relation valid about the zero-temperature quantum critical point.

Applications

As noted by K. Barthel (Jülich) et al., dc SQUIDs made from high-T_c superconductors typically exhibit a still unexplained higher white noise and a smaller transfer function than numerical simulations based on the coupled Langevin equations predict. The authors present a systematic study that compares experimental results with both numerical simulations and a recently developed analytical approach based on a Fokker-Planck equation. To cover a wide range of SQUID parameters, two samples of different inductances were measured at variable temperature. While several predictions of the analytical theory could be verified and good qualitative agreement with both theories was found, only one sample showed good quantitative agreement. The simulations performed in the limit of large thermal fluctuations showed excellent agreement with the analytic theory.

A closely related paper by B. Chesca (Jülich) presents an analytical analysis of dc SQUIDs with small inductances operating in the presence of thermal fluctuations. The author uses the Fokker-Planck equation to derive expressions for the output voltage across the Josephson junctions and the circulating current in the SQUID loop. The author notes that it then is straightforward to obtain and optimize all the important SQUID characteristics (current-voltage curves, dynamic resistance, transfer function, and energy sensitivity).

Theory

A preprint by E. Demler (UC-Santa Barbara) and S.-C. Zhang (Stanford) reviews their explanation for resonant neutron-scattering experiments in $YBa_2Cu_3O_{7-\delta}$ and $Bi_2Sr_2CaCu_2O_{8+\delta}$ from the point of view of a triplet excitation in the particle-particle channel, the π excitation. The authors discuss the relation of such resonances to the superconducting condensation energy and their role in stabilizing the superconducting state. The authors note that because of superconducting fluctuations, the π resonance may appear as a broad peak above T_c.

An SU(4) model of high-T_c superconductivity is presented in a preprint by M. Guidry (Tennessee) et al. One dynamical symmetry of this model corresponds to the SO(5) unification of superconductivity and antiferromagnetism [S.-C. Zhang, *Science* **275**, 1089 (1997)], but there are two additional dynamical symmetries: SO(4), associated with antiferromagnetic order, and SU(2), associated with a d-wave pairing condensate. These provide a three-phase microscopic model of high-T_c superconductivity and permit an understanding of the role played by the SO(5) symmetry.

A theoretical example of a quantum spin liquid with a superconducting phase in a 2D electron system close to an electronic topological transition is presented by F. Onufrieva and P. Pfeuty (Saclay). The authors apply the theory to the high-T_c cuprates to shed light on the 40 meV resonance peak, incommensurability at lower ω, and the spin gap.

A model study for the coexistence of spin-density waves and superconductivity is presented by H. Ghosh (Arizona) et al. The authors assume the presence of nested energy bands. The single-band Hubbard model, when treated within the Hartree-Fock mean-field theory, leads to a spin-density-wave (SDW) ground state. The authors find that the phase diagram, describing the amplitudes of the superconducting and spin-density-wave gaps vs band filling, resembles that of the high-T_c cuprates only when the superconducting order parameter has d-wave symmetry.

Pseudogap phenomena of high-T_c cuprates have been examined by S. Onoda and M. Imada (ISSP-Tokyo). Using self-consistent renormalization, the authors calculate the NMR relaxation rate T_1^{-1}, the spin correlation length ξ_σ, and the pairing correlation length ξ_d. From this calculation, a mechanism of pseudogap formation emerges as the region where d-wave short-range order dominates over antiferromagnetic short-range order.

Two-leg t-J ladders have been investigated by Y. L. Lee (National Tsing Hua) et al. in the framework of a combination of the phase-string formulation and the bond-operator representation. The authors develop a mean-field theory in the strong rung interaction regime, i.e., $J_\perp >> (J, t)$, which provides a unified description of the undoped insulating phase and the low-doping phase. Both are characterized by a resonating-valence-bond (RVB) order parameter, with a gap opened up in all spin excitations. The ground state of the doped phase in intrinsically a superconductor with d-wave symmetry, driven by RVB correlations, and the ground-state energy is in good agreement with numerical results.

The spin-gap effect on dc resistivity in the t-J model of high-T_c cuprates has been calculated by M. Onoda (Tokyo) et al. using Ginzburg-Landau theory coupled with a gauge field as its effective field theory. The authors obtain $\rho(T) \propto T[1 - c(T^*-T)^d]$, where T^* is the spin-gap onset temperature and d is a nonuniversal exponent.

To investigate non-Fermi-liquid behavior, O. Sushkov (New South Wales) has considered the extended 2D t-J model including additional hopping t''. The author solved the model analytically in the regime (t, J) << t'' and found a rich phase diagram including the antiferromagnetic (AF) insulator and AF strange metal with different kinds of pseudospin-singlet superconducting pairings (p-, d-, and g-wave). The author also found a collective triplet excitation with energy below the superconducting gap.

A preprint by A. S. Alexandrov (Loughborough) and V. V. Kabanov (JINR-Dubna and Ljubljana) presents an adjustable-parameter-free expression for the superconducting critical temperature of layered cuprates, which allows T_c to be expressed in terms of experimentally measured parameters (e.g., λ_{ab}, λ_c, and R_H). The resulting theoretical values of T_c are in fair agreement with the experimental T_c values of about 30 *La-, Y-,* and *Hg*-based cuprates for different levels of doping. The authors conclude that many cuprates are close to the Bose-Einstein condensation regime.

A model for the superconducting cuprates with multiple components of the pairing amplitude in different oxygen p-orbitals has been studied by I. Chaudhuri (IIT-Kharagpur) et al. The authors show that the model captures certain unusual features observed in the tunneling spectra of *Bi-2212* single crystals.

As shown by M. Houzet et al. (Bordeaux), in 3D superconductors the transition between the normal phase and a nonuniform superconducting phase, such as the Fulde-Ferrell-Larkin-Ovchinnikov (FFLO) state, is always of first order. The authors also determine the transition temperature and the structure of the modulated state using a generalized Ginzburg-Landau functional near the tricritical temperature and the exact Gor'kov equations over the entire temperature range.

A preprint by R. Weht et al. (UC-Davis) suggests that the most likely explanation for the coexistence of superconductivity and ferromagnetism in $RuSr_2GdCu_2O_{8-\delta}$ *(Ru-1212)* (superconducting $T_c \approx 35$ K, Curie temperature 132 K) is an FFLO-like inhomogeneous superconducting order parameter in the cuprate layers. The authors note that although magnetism in the *Ru* layer is strong, the exchange coupling to the *Cu* layers is quite small.

Local-density-functional results are presented by R. Weht et al. (UC-Davis) for the electron-doped quasi-2D metallochlorides A_xZrNCl and A_xHfNCl *(A = Li* or *Na),* which superconduct up to 25 K. The authors predict a change in behavior at a doping level of x = 0.3.

Other Activities

Both x-ray absorption spectroscopy (XAS) and x-ray photoemission spectroscopy (XPS) studies of single-crystal $Ba_{1-x}K_xBiO_3$ *(BKBO)* covering the whole composition range $0 \le x \le 0.60$ are reported by K. Kobayashi (Tokyo) et al. Comparison with XAS results in $BaPb_{1-x}Bi_xO_3$ reveal quite different doping dependencies between *BKBO* and *BPBO*.

Various electronic and transport anomalies observed in superconducting perovskites are discussed in a preprint by D. Pavuna (EPFL). The author considers (a) the complex electronic phase diagram, (b) the symmetry of the gap, and (c) non-Fermi-liquid resistivity in superconducting $Sr_2RuO_{4-\delta}$, which exhibits a linear resistivity up to 1050 K.

As noted by M. J. Graf (Boston) et al., the rate of suppression of T_c of UPt_3 is much larger for *Pd* substitution than for other impurity substitutions or by increased defect density. The authors note that this effect is correlated with an increase in the inelastic scattering coefficient and may be related to *Pd*-induced changes in the magnetic fluctuation spectrum.

A paper by V. N. Bogomolov (St. Petersburg) examines earlier experimental data on the absorption of light by xenon under high pressures up to 200 GPa and notes some discrepancies with theory that assumes metallization of *Xe* as a result of a band-gap closure. As an alternative explanation of the optical results, the author suggests a superconducting transition with a T_c of about 5000 K.

Overviews

The development of numerous scanning probe microscopes and their application to studies of high-temperature superconductors are discussed in a review by A. de Lozanne (Texas-Austin). The author emphasizes scanning microscopes based on tunneling (STM), atomic force (AFM), magnetic force (MFM), the Hall effect (SHPM), a SQUID sensor, microwaves, near-field optics, and magneto-optic techniques (107 refs.).

Experimental data and theoretical aspects of the thermal conductivity κ and magneto-thermal conductivity $\kappa(B)$ of high-T_c superconductors and heavy fermions are treated in a review by M. Ausloos and M. Houssa (Liège). The authors show how the experiments reveal the order-parameter symmetry. For the high-T_c cuprates, the experimental results in $YBa_2Cu_3O_{7-\delta}$ *(Y-123)* and $Bi_2Sr_2CaCu_2O_{8+\delta}$ *(Bi-2212)* are inconsistent with an isotropic s-wave energy gap but are well described by an anisotropic $d_{x^2-y^2}$ gap with nodes (100 refs.).

The Faraday effect in ferrimagnetic garnet films and its application to magneto-optical imaging of magnetic flux in magnetic materials and high-temperature superconductors are reviewed by A. A. Polyanskii et al. (Wisconsin). Using composite multilayer indicator films, this technique operates in fields up to 0.2 T and over a temperature range 2-400 K with μm to mm spatial resolution (88 refs.).

Contributed by John R. Clem

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June 16 - 17, 1999: Workshop on Applications of SQUID Magnetometry, INSA de Lyon, Lyon, France. Current and emerging applications of both HTS and LTS SQUIDs will be covered by the following lecturers: A. Braginski, Jülich (Geophysics); J. Clarke, Berkeley (rf Amplifiers and Biophysics); G. Donaldson, Strathclyde (Nondestructive Evaluation); R. Fagaly, Tristan Technologies (Commercial SQUIDs & Gastrointestinal Applications); G.-L. Romani, Chieti (Magnetoencephalography, Basic Research & Clinical Applications); A. Schirdewan, Berlin (New Clinical Application of Magnetocardiography); H. Weinstock, AFOSR (Introduction & Overview of SQUID Magnetometry & Its Applications). Limited to 50 participants. Workshop will conclude with D.H.C. award to H. Weinstock. For further information, contact Pierre-Louis Vuillermoz, INSA de Lyon; telephone +33 4 7243 8067; telefax +33 4 7243 6082; e-mail plv@insa.insa-lyon.fr.

Aug. 4 - 11, 1999:* 22nd International Conference on Low Temperature Physics (LT22), Helsinki University of Technology (HUT), Otaniemi, Espoo and Helsinki, Finland. Topics will include: quantum gases, fluids, and solids; superconductivity; magnetism and lattice properties; quantum electron transport; applications; materials; and techniques. LT22 will have limited funds to assist graduate students, junior faculty, as well as participants from institutions and countries where support is difficult to obtain. **Preregistration and abstract deadline, April 15, 1999. Proceedings will appear as a special issue of *Physica B – Cond. Mat.,* in April 2000. For information, contact Conference Service Bureau, TSG-Congress Ltd., Kaisaniemenkatu 3 B 31, FIN-00100 Helsinki, Finland; telephone +358 9 628044; telefax +358 9 667675; e-mail info@tsgcongress.fi. For technical information, contact the LT22 Office, Low Temperature Laboratory, Helsinki University of Technology, P.O. Box 2200, FIN-02015 HUT, Finland; telephone +358 9 451 2962; telefax +358 9 451 2969; e-mail info@LT22.hut.fi; Web site http://lt22.hut.fi/lt22/lt22.html.

Aug. 17 - 20, 1999:* 1999 Taiwan International Conference on Superconductivity (TICS'99) & 6th Workshop on Low Temperature Physics (WLTP6), Kenting, Taiwan, ROC. Continuation of the five previous TICS conferences. Topics are: superconducting materials (new, bulk, single crystal, and thin film); material characterization and physical properties; theories and applications of superconductivity; strongly correlated electron systems; and other low-temperature-physics-related topics. All papers will be refereed and published in the Chinese Journal of Physics (Taipei) as a special issue. Conference language is English. **Abstract deadline, May 1, 1999. For information, contact Hsiung Chou, Department of Physics, National Sun Yat-Sen University, Kaohsiung, Taiwan 804, Republic of China; telephone +886 7 5253700; telefax +886 7 5253709; e-mail chou@mail.phys.nsysu.edu.tw or tics99@mail.phys.nsysu.edu.tw; Web site http://www2.nsysu.edu.tw/Physics/tics99.

Sept. 8 - 12, 1999: 9th International Workshop on Weak Superconductivity (WWS'99), Papiernicka, Slovak Republic. Organized by the Institute of Electrical Engineering SAS, Bratislava, in collaboration with University of Erlangen and Friedrich-Schiller University, Jena. Co-chairs: Stefan Benacka, Paul Müller, and Paul Seidel. Aim of WWS'99 is the international exchange of latest results in the study of Josephson effects in low-and high-critical-temperature superconductors and their applications. Workshop will concentrate on the following areas: physics of Josephson effects and tunneling; Josephson effects in arrays, stacks, and mesoscopic systems; intrinsic Josephson effects; properties and role of interface in multilayer thin films with Josephson coupling; materials for thin film Josephson junctions and devices; rf properties and applications in low- and high-frequency range. Invited talks, oral and poster presentations. **Abstract deadline, May 15, 1999.** Papers to be published as a special issue of *Physica C.* Attendance limited to about 100 persons. For further information, contact Organizing Committee, WWS'99, Institute of Electrical Engineering SAS, Dubravska cesta 9, 842 39 Bratislava, Slovak Republic; telephone +421 7 54775820, ext. 2139 or 2059; telefax +421 7 54775816; e-mail elekws99@savba.sk; Web site http://cryo.savba.sk/conf.htm. Or contact Stefan Benacka, Conference Chair, at e-mail benacka@savba.sk.

Sept. 19 - 23, 1999:* Superconducting Materials Aspects: Research & Technology (SMART 99), Giens Peninsula, Hyeres, France. Second SMART Conference; satellite to the EUCAS'99 Conference in Sitges, Barcelona, Spain (Sept. 14-17, 1999). Will provide an opportunity to present new results and exchange ideas on the following research and technology topics: phase chemistry and processing of bulk and thick-film materials, crystal-growth processes, relationships between materials structure and relevant properties, electromagnetic interactions, and applications. Materials of interest are mainly superconducting ceramics, superionic conductors, giant-magnetoresistive materials, nanocrystals, ferroelectrics, organic electronics and photonics materials, nanotubes, thermoelectric materials, and ceramic matrix composites. Organizers plan for four working days without parallel sessions. Program will consist of keynote and contributed papers (oral or posters). Industrial participants are encouraged to present technological state-of-the-art and to raise practical questions. Level of the meeting is that of an advanced research workshop with ample time for discussions. Attendance limited to about 80 persons. **Abstract deadline,

May 15, 1999. For information, contact Gilbert Vacquier, Co-Chair and Conference Secretary, LPCM (Case 26), Centre Saint-Charles, 3 Place V. Hugo, F-13331 Marseille Cedex 03, France; telephone +33 491 10-6271; telefax +33 491 10-6448 or -6237; e-mail smart@newsup.univ-mrs.fr; Web site http://www.supras.phys.ulg.ac.be/smart-99.html. ***Note extended abstract deadline.**

*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.

*Feb. 20 - Feb. 25, 2000:

6th International Conference on Materials and Mechanisms of Superconductivity and High Temperature Superconductors (M^2S-HTSC-VI), George R. Brown Convention Center, Houston, Texas. Hosted by the Texas Center for Superconductivity at the University of Houston and sponsored by federal agencies and industry. Co-Chairs: C. W. Chu, W. K. Chu, and K. Salama. This series of meetings, established in 1988 two years after the discovery of high-temperature superconductors, is dedicated to superconductivity and related phenomena, and the host materials of these phenomena. The conference will bring together members of the international low- and high-temperature superconductivity community to focus on recent insights into LTS and HTS physics, materials, and devices. Emerging areas and future trends will also be highlighted. General conference topics include, but are not limited to: Experimental and Theoretical Studies of Superconducting Materials – low temperature, high temperature, fullerite, heavy fermion, organic, new; Physical Properties – mechanisms, magnetic, electrical, optical, thermal, mechanical, acoustic; Synthesis and Processing – thin films, superlattices, thick films, bulk; and Applications – small current (SQUIDs, junctions, microwave devices) and large current (cables, transformers,motors, generators, magnetic-levitation devices). **Abstract deadline, Sept. 15, 1999.** For information, contact M^2S-HTSC-VI Conference Secretariat, Texas Center for Superconductivity, University of Houston, 3201 Cullen Boulevard, Houston, TX 77204-5932; telefax (713) 7743-8216; Web site http://m2s-conf.uh.edu.

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