HIGH T_c UPDATE

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NOTA BENE:

Vortex dynamics

As noted in a preprint by Y. Paltiel (Weizmann Institute) et al., recent studies of the vortex lattice in type-II superconductors have shown a number of puzzling phenomena including (a) low-frequency noise, (b) slow voltage oscillations, (c) history-dependent dynamic response, (d) memory of the direction, amplitude, duration, and even the frequency of the previously applied current, (e) high vortex mobility for ac current with no apparent vortex motion at dc current, and (f) strong suppression of an ac response by a small dc bias. The authors used an array of 19 2D-electron-gas (2DEG) Hall sensors, each of size 10 $\mu m \times 10$ μm, to determine the current distribution across single crystals of 2H-$NbSe_2$ under various dc bias conditions and ac currents. The results revealed a generic mechanism that accounts for the above puzzling observations in terms of a competition between the injection of a disordered vortex phase at the sample edges, and the dynamic annealing of this metastable disorder by the transport current. For an ac current, only narrow regions near the edges are in the disordered phase, while for dc bias, most of the sample is filled by the pinned disorder, preventing vortex motion. The resulting spatial profile of vortex-lattice disorder acts as an active memory of the previous history.

Investigations have been carried out by A. P. Rassau (Southampton) et al. on history dependencies with the driven-vortex-solid state of $YBa_2Cu_3O_{7-\delta}$ single crystals. The authors demonstrate that much of the dynamic behavior of the vortex system can be understood in terms of two dynamic states, one relatively ordered and the other more disordered. Irrespective of prior structural changes, the driven dynamic system has a tendency to stabilize on two specific voltage levels: a relatively high level, indicative of the ordered dynamic state, and a much lower level, indicative of a disordered state. Oscillations of the voltage amplitude, observed on applying an asymmetric drive, can be understood in terms of periodic changes over time in the proportions of two distinct domains, one in the ordered phase, the other disordered. The authors found support for this interpretation from the behavior of transient responses upon switching between asymmetric and unidirectional drives. From an analysis of such transient responses, the authors were able to demonstrate the stability of the ordered dynamic phase.

A detailed investigation of history effects in the magnetic hysteresis of pure $YBa_2Cu_3O_{7-\delta}$ single crystals with various types and densities of pinning sites has been carried out by S. Kokkaliaris (Southampton) et al. The authors used a partial-magnetization-loop technique that enabled them to detect the point where topological disorder first invades the vortex system. Studies of detwinned single crystals with very low densities of point defects revealed a transition in the mixed state of the superconductor separating a dislocation-free Bragg glass from a highly disordered vortex phase. The transition line was identified in the field-temperature phase diagram and found to lie near the onset of the second magnetization peak. Above the transition, metastable topological defects proliferate in the vortex lattice, resulting in prominent history effects in the critical current. A high concentration of twins as well as low densities of columnar defects suppress the transition and eliminate the memory effects.

A phenomenological model to describe history effects and metastability in the magnetization of weakly pinned superconductors is proposed in a preprint by G. Ravikumar (BARC) et al. The authors note that it accounts for the experimentally observed history-dependent behavior of the critical current density and metastability of the vortex state prior to and across the peak-effect region of superconducting systems such as $NbSe_2$, $CeRu_2$, and $YBa_2Cu_3O_{7-\delta}$. The model reduces to the Bean critical-state model as a limiting case.

Local magnetic measurements in a fixed field as a function of temperature [$m_H(T)$] in $Nd_{1.85}Ce_{0.15}CuO_{4-\delta}$

(NCCO) and untwinned $YBa_2Cu_3O_{7-\delta}$ *(YBCO)* crystals have been carried out by D. Giller et al. (Bar-Ilan). Both crystals show an abrupt increase in $m_H(T)$ at a field-dependent temperature. Moreover, both crystals exhibit a pronounced kink in the local magnetization vs field [$m_T(H)$] curve at a fixed temperature T. While in *YBCO* these anomalies occur along the same line in the field-temperature plane, in *NCCO* the (B,T) locations of the anomalies do not coincide. In both crystals the anomalies in $m_T(H)$ are identified as signifying a vortex solid-solid disorder-induced transition. However, the authors show that the anomalies in $m_H(T)$, though associated with the vortex solid-solid transition, do not necessarily indicate the location of the transition.

Supercooling across a first-order transition in vortex matter has been considered theoretically by P. Chaddah and S. B. Roy (Indore). The authors find that the observable region of metastability of the supercooled phase should depend upon the path followed in H-T space; they predict that this region is larger when T is lowered at constant H than when H is lowered at constant T.

Using large-scale molecular dynamics simulations on samples with nearly one million pinning sites, C. Reichhardt (Michigan and UC-Davis) et al. have investigated the pinning and driven dynamics of vortices interacting with twin boundaries. For low applied driving forces, the vortex lattice orients itself parallel to the twin boundary, and the authors observe the creation of a flux gradient and vortex-free region near the edges of the twin boundary. For increasing drive, the authors found evidence for several distinct dynamical flow phases characterized by the density of defects in the vortex lattice, the microscopic vortex-flow patterns, and the orientation of the vortex lattice. The different dynamical phases can be directly related to microscopically measurable voltage-current (V-I) curves and voltage noise.

A related paper by F. Nori (Michigan) and C. Reichhardt (UC-Davis) reports a numerical investigation of the depinning and dynamics of vortex lattices in superconductors with square arrays of pinning sites. The authors considered vortex motion for varying angles of the driving force relative to the pinning lattice in incommensurate magnetic fields above the first matching field, such that interstitial vortices are present. The authors found that maximum pinning occurs for drives at an angle of 45° with respect to the pinning lattice.

The stochastic transport of vortices in superconductors by ac current rectification has been studied by J. F. Wambaugh (Michigan) et al. using numerical simulations. The simulated system acts as a vortex pump, lens, or rectifier because the applied electrical ac is transformed into a net dc motion of vortices. Thermal fluctuations and the asymmetry of the ratchet channel walls induce this diode effect.

More Vortices

The effects of weak point disorder on the vortex-matter phase diagram have been studied by T. Nishizaki (Tohoku) et al. The authors studied the effects of irradiation by 2.5 MeV electrons upon the magnetization curves of untwinned $YBa_2Cu_3O_{7-\delta}$ single crystals. The authors found that point disorder lowers the critical point H_{cp} of the first-order vortex-lattice melting line $H_m(T)$ and has an opposite effect on the vortex-glass phase boundary above and below H_{cp}. Below H_{cp}, the field-driven disordering transition line $H^*(T)$ between the Bragg glass and the vortex-glass phases shifts to lower fields, and the vortex-glass phase is expanded after irradiation.

The Bose-glass transition in the fully isotropic $(K,Ba)BiO_3$ superconductor with columnar defects produced by irradiation with 7.2 GeV *Ta* ions has been studied by T. Klein (Grenoble) et al. using transport and nonlinear susceptibility measurements. For fields below the dose-equivalent field B_ϕ, the Bose-glass transition line $H_{BG}(T)$ was found to shift progressively upwards with increasing dose: $dH_{BG}/dT \propto 1 + \alpha B_\phi^{1/2}$. The authors also deduced critical exponents from the scaling properties of the transport measurements: $z = 5.3 \pm 0.3$ and $\nu = 1.1 \pm 0.2$. For tilted magnetic fields, the transition temperature was found to behave as $T_{BG}(0) - T_{BG}(\theta) \propto |\sin\theta|^{1/\nu}$, as recently suggested by Lidmar and Wallin.

The supercurrent along the weakly conducting c-axis direction in layered superconductors has been studied by R. Hlubina et al. (Comenius). The authors considered the case of vortices pinned by screw dislocations with Burgers vectors parallel to the c axis, and they found that the critical current of small samples is enhanced with respect to the perfect crystal, since each dislocation is able to carry a supercurrent I_0.

Two preprints by M. R. Koblischka (SRL-ISTEC) et al. report observations of instabilities (macroturbulence) in the critical state of $NdBa_2Cu_3O_{7-\delta}$ single crystals. Signatures of such instabilities were found in both magneto-optical observations and SQUID magnetometry.

A numerical method for calculating zero-temperature equilibrium vortex-line configurations in bulk anisotropic type-II superconductors has been developed by W.A.M. Morgado and G. Carneiro (Rio de Janeiro). The method, which assumes that the vortex lines are straight and arranged in a periodic lattice, is designed to search for the minimum of the Gibbs free energy in the London approximation. The authors apply the method to two physical problems: (a) the magnetic induction vs applied field for an isotropic superconductor and (b) the zero-temperature phase diagram for a superconductor containing a square lattice of columnar defects.

General expressions are given in a paper by G. Carneiro (Rio de Janeiro) and E. H. Brandt (MPI-Stuttgart) for the magnetic field and energy of arbitrary arrangements of straight and curved vortices in an anisotropic superconducting film of finite thickness within anisotropic London theory. As examples, the authors consider the magnetic field and interaction of straight perpendicular vortex lines in films of finite thickness.

$YBa_2Cu_3O_{7-\delta}$

The effects of annealing treatments on T_c of *Ni*-substituted $YBa_2Cu_3O_{7-\delta}$ have been studied by S. Adachi et al. (SRL-ISTEC). Ceramic samples of $YBa_2Cu_{3-x}Ni_xO_{7-\delta}$ (x = 0.00, 0.02, 0.05, and 0.10) prepared in 1 atm oxygen atmosphere were annealed at 800-1000°C in various atmospheres with different oxygen partial pressures and were subsequently oxygenated below 550°C. The lower the oxygen partial pressure, the lower the T_c. For the samples with fixed x but different T_cs, no appreciable difference in lattice parameter and oxygen content was observed. The results indicate that the T_c of *Ni*-substituted $YBa_2Cu_3O_{7-\delta}$ can be controlled by changing the oxygen partial pressure during annealing, and that the distribution of *Ni* atoms between the chain and plane sites is probably altered by the annealing treatment.

Systematic measurements of the in-plane fluctuation magnetoconductivity in a $YBa_2Cu_3O_{7-\delta}$ single crystal have been made by R. M. Costa (Porto Alegre) et al. Fields up to 500 mT were applied parallel or perpendicular to the CuO_2 planes. Far from the transition, the data reveal a Gaussian-fluctuation regime, but closer to T_c, the results show a critical regime, where the exponent is consistent with predictions for the 3D XY universality class with model-E dynamics. Still closer to T_c, the authors find evidence for a fluctuation regime beyond 3D XY. The authors interpret this behavior as revealing the first-order character of the in-field superconducting transition in $YBa_2Cu_3O_{7-\delta}$.

Measurements of the first and third harmonics of the complex susceptibility ($\chi_i' + j\chi_i''$; i = 1 and 3) in *YBCO* single crystals with different oxygen content ($6.5 \le x \le 7$) are reported by A. J. Moreno and V. Bekeris (Buenos Aires). The amplitude of the ac field was varied in the presence of an external dc field, both fields being parallel to the c axis. The authors found evidence that deoxygenation leads to a reduction of bulk pinning strength and consequently to a stronger contribution of geometrical barriers. These results support recently reported investigations showing that deoxygenation makes the *YBCO* crystals more anisotropic, thus reducing the effective pinning barriers for quasi-two-dimensional vortices.

Bi Cuprates

Extensive first-principles angle-resolved photointensity (ARPES) simulations for $Bi_2Sr_2CaCu_2O_{8+\delta}$ *(Bi-2212)* have been carried out by A. Bansil (Northeastern) and M. Lindroos (Tampere), who modeled the photoemission process realistically by taking into account the full crystal wave functions of the initial and final states in the presence of the surface. The authors found that the spectral weight of the ARPES features associated with the CuO_2-plane bands undergoes large and systematic variations with $k_{||}$ as well as with the energy and polarization of the incident photons. The theoretical results are in good accord with the corresponding measurements, indicating that the remarkable observed changes in the spectral weights in *Bi-2212* are essentially a matrix-element effect and that the importance of matrix elements should be kept in mind when analyzing ARPES spectra in the high-T_c superconductors.

Measurements of the thermal conductivity of optimally doped *Bi-2212* at very low temperatures are reported by M. Chiao (McGill) et al. The authors observed a residual linear term and used it to extract the ratio of quasiparticle velocities v_F/v_2, a parameter in the low-energy d-wave spectrum that also governs the linear drop in superfluid density with temperature. A comparison with penetration-depth data reveals a sizable renormalization, due to quasiparticle interactions, which is of comparable magnitude in $Bi_2Sr_2CaCu_2O_{8+\delta}$ and $YBa_2Cu_3O_{7-\delta}$. The authors discuss their findings in the context of photoemission and specific-heat studies.

The resistivity and thermopower for a set of single crystals of $Bi_2Sr_2Ca_{1-x}R_xCu_2O_{8+\delta}$ *(R = Er* and *Pr)* have been measured by I. Terasaki et al. (Waseda). The authors found that (a) the resistivities of the parent insulators exhibit a confinement behavior above T_{max}, which is near the Néel temperature, and (b) the thermopower shows good scaling behavior with a scaling temperature T_{scale}, which is near the pseudogap temperature. The results show that there are strong similarities in the behavior of the antiferromagnetic insulators and the high-temperature superconductors.

Other Cuprates

Using Cu NQR in *Eu*-doped $La_{2-x}Sr_xCuO_4$, G. B. Teitel'baum (Kazan) et al. have found evidence for the pinned stripe phase at 1.3 K for $0.08 \le x \le 0.18$. The pinned fraction increases by one order of magnitude near hole doping x = 1/8. The NQR lineshape reveals three inequivalent *Cu* positions: (a) sites in the charge stripes, (b) nonmagnetic sites outside the stripes, and (c) sites with a magnetic moment of 0.29 μ_B in the antiferromagnetically correlated regions. A dramatic change of the NQR signal for $x > 0.18$, correlating with the onset of bulk superconductivity, corresponds to the depinning of the stripe phase.

Measurements of the resistivity, magnetoresistance, and penetration depth have been made by K. Karpinska (Warsaw) et al. on films of $La_{1.85}Sr_{0.15}CuO_4$ with up to 12 at% of *Zn* substituted for *Cu*. The results show that the quadratic temperature dependence of the inverse square of the penetration depth, indicative of d-wave superconductivity, is not affected by doping. The suppression of superconductivity leads to a metallic nonsuperconducting phase, as expected for a pairing mechanism related to spin fluctuations. The metal-insulator transition occurs in the vicinity of $k_F\ell \approx 1$ and appears to be disorder-driven, with the carrier concentration unaffected by doping.

A preprint by C. Panagopoulos (IRC-Cambridge) et al. reports measurements of the absolute values and temperature dependence of the c-axis penetration depth $\lambda_c(T)$ for two typical single-layer high-T_c cuprates, $La_{2-x}Sr_xCuO_4$ and $HgBa_2CuO_{4+\delta}$ *(Hg-1201),* as a function of doping. The authors observed a distinct change in the behavior of λ_c near 0.20 holes/*Cu,* which is related to the opening of the normal-state pseudogap. The variation of λ_c with doping is qualitatively similar to that of the in-plane component λ_{ab}, suggesting that both quantities are strongly affected by the presence of the normal-state pseudogap, as is the superconducting condensation energy. The strong doping dependence of $\lambda_c(0)$ for $p < 0.20$ provides an explanation for the discrepancies in the literature.

By analysis of the Raman spectra of superconducting $YBa_2Cu_4O_8$ *(Y-124),* J. Bäckström (Chalmers) et al. have observed a suppression of the low-energy density of states, which the authors link to changes in the linewidth of the *Ba*-phonon mode. These effects occur at a temperature below 150 K, where anomalies in the resistivity and other physical properties also take place. The authors argue that these changes in the Raman spectra of *Y-124* are associated with the opening of a pseudogap. Analogous anomalies in the resistivity and the *Ba*-phonon width in the nonsuperconducting homologue $PrBa_2Cu_4O_8$ *(Pr-124)* below 150 K suggest that similar pseudogap effects can occur without a transition to a superconducting state following at a lower temperature.

Samples of the $Hg_{1-x}Re_xBa_2Ca_2Cu_3O_{8+\delta}$ *[(Hg,Re)-1223]* superconductor with low *Re* content ($x = 0.05$) have been produced by M.T.D. Orlando (Rio de Janeiro and Vitória) et al. using a novel thermobaric analysis (TBA) that can monitor the total pressure inside the quartz tube during high-temperature synthesis. The authors found that reducing the oxygen content in the precursor $(Re_{0.05}Ba_2Ca_2Cu_3O_{8+\delta})$ and increasing the *Hg* partial pressure inside the quartz tube enhanced the yield of superconducting phase. Resistance measurements as a function of temperature under hydrostatic pressure (0-1.0 GPa) showed an increase in the superconducting transition temperature T_c, which can be fitted with a parabolic curve. The authors found that the reduction of the lattice volume induced by external hydrostatic pressure is similar to the one induced by chemical pressure due to *Re* doping ($0.00 < x < 0.10$). However, T_c was found not to depend on the chemical pressure. The authors explain the behavior on the basis of the pressure-induced charge-transfer model (PICTM), as modified by C. C. Almasan et al. [Phys. Rev. Lett. **69**, 680 (1992)].

Measurements of the microwave surface impedance $Z_S(T) = R_S(T) + iX_S(T)$ and the complex conductivity $\sigma_S(T)$ of high-quality high-T_c single crystals of $YBa_2Cu_3O_{7-\delta}$ *(Y-123),* $Bi_2Sr_2CaCu_2O_{8+\delta}$ *(Bi-2212),* $Tl_2Ba_2CaCu_2O_{8+\delta}$ *(Tl-2212),* and $Tl_2Ba_2CuO_{6+\delta}$ *(Tl-2201)* have been analyzed by M. R. Trunin (Chernogolovka) et al. The authors compare experimental data of $Z_S(T)$ and $\sigma_S(T)$ with calculations based on a modified two-fluid model that includes temperature-dependent quasiparticle scattering and a special temperature variation of the density of superconducting carriers. The authors compare the experimental data with their calculations and obtain generally good agreement, though some disagreements remain.

Films

Smooth and flat epitaxial $(Hg,Re)Ba_2CaCu_2O_{6+\delta}$ *[(Hg,Re)-1212]* thin films containing no appreciable pinholes or outgrowths have been fabricated by N. Inoue (SRL-ISTEC) et al. Films of thickness about 75 nm were prepared on (100) $SrTiO_3$ substrates using a two-step process: (a) preparation of thin (approximately 100 nm) $Re_{0.1}Ba_2CaCu_2O_z$ precursor films using a pulsed-laser-deposition (PLD) technique and (b) heat treatments in a *Hg*-vapor atmosphere. Homogeneous films with smooth surfaces were obtained by simply using precursor films thinner than those previously employed, which were thicker than 200 nm. The average roughness of the thin *(Hg,Re)-1212* films was about 3-4 nm and the maximum peak-to-bottom surface roughness was about 10 nm. The as-fabricated films exhibited T_cs typically in the range 109-117 K, substantially lower than that of the optimally doped bulk (127 K) and approximately 5 K lower than the values previous reported for thicker films. However, the self-field J_c values measured using bridges patterned in the film were reproducibly $(3\text{-}10) \times 10^6$ A/cm^2 at 77 K and as high as $(2\text{-}3) \times 10^6$ A/cm^2 at 100 K.

A preprint by Y.-Y. Xie (Kansas) et al. reports that the fabrication process for $HgBa_2CaCu_2O_{6+\delta}$ *(Hg-1212)* superconducting thin films can be greatly simplified when air-insensitive precursor films $(Tl_yBa_2CaCu_2O_x)$ are employed. Using such precursors, the authors were able to reproducibly fabricate high-quality *Hg-1212* films in air. Zero-resistance transition temperatures were typically

122-124 K. The self-field critical current densities J_C were up to 2.0×10^7 A/cm^2 at 5 K, remaining above 10^6 A/cm^2 at 100 K.

The synthesis by molecular beam epitaxy (MBE) and the structural characterization of a new superconducting barium cuprate $Ba_2CuO_{4-\delta}$ ($T_c \leq 90$ K) are described in a paper by H. Yamamoto et al. (NTT). Important factors are (a) the preparation of Ba_2CuO_3 in a CO_2/H_2O-free environment and (b) the structural transformation from insulating Ba_2CuO_3 with 1D *CuO* chains to superconducting $Ba_2CuO_{4-\delta}$ with 2D CuO_2 planes by strong ozone oxidation after growth.

Preprints by M. Naito and S. Karimoto (NTT) and by S. Karimoto and M. Naito (NTT) report the synthesis by MBE of a new superconducting lead cuprate $PbSr_2CuO_{5+\delta}$ *(Pb-1201),* which has $T_c \sim 40$ K and a pure *PbO* charge-reservoir block. The authors note that the keys to successful synthesis of *Pb-1201* are low-temperature growth and an appropriate choice of substrate materials. Synthesis of higher members in the *Pb-12(n-1)n* homologous series has not been straightforward because the growth temperature is limited by the volatility of *Pb* and PbO_x.

A preprint by Ö. Festin (Uppsala) et al. reports that the flux-noise spectrum and complex impedance for a 500 Å thick *YBCO* film have been measured and compared with predictions for two-dimensional vortex fluctuations. The authors verified that the complex impedance and the flux-noise spectra are proportional to each other, that the logarithm of the flux-noise spectra vs the logarithm of the frequency for different temperatures has a common tangent with slope ≈ -1, and that the amplitude of the noise decreases as d^{-3}, where d is the height above the film at which the magnetic flux is measured. The authors found what appears to be a crossover from normal to anomalous vortex diffusion, which they discuss in terms of a two-dimensional decoupling.

An array of miniature Hall sensors has been used by E. Sheriff et al. (Bar-Ilan) to measure the spatial distribution and time evolution of the local induction in a thin $YBa_2Cu_3O_{7-\delta}$ film in the remanent state before and after the application of a dc transport current. After the transport current is applied, the induction peak is shifted from the center of the sample, indicating an inhomogeneous current distribution. Transport current markedly changes the spatial distribution of the electric field and the relaxation rate, creating a dynamic neutral line where the electric field is maximum and the relaxation rate is zero.

A preprint by M. Naito et al. (NTT) stresses that the reason good tunnel junctions in high-T_c superconductors are so difficult to fabricate is that significant oxygen deficiencies readily occur near the interface with overlayers.

Applications

A spectrometer incorporating a high-T_c superconducting quantum interference device (SQUID) has been used by K. Schlenga et al. (UC-Berkeley and LBNL) to obtain nuclear magnetic resonance signals from protons in mineral oil at room temperature in fields up to 3 mT. The spatial separation between the SQUID magnetometer at 77 K and the sample at room temperature is less than 1 mm. At 2 mT, the signal is easily resolved in a single scan. The authors obtained two-dimensional images of samples consisting of pieces of lucite or glass immersed in mineral oil at 2 mT.

A preprint by E. J. Romans et al. (Strathclyde) reports theoretical and experimental studies of the low-frequency behavior of discrete HTS Josephson vortex-flow transistors. The devices were fabricated from $YBa_2Cu_3O_{7-\delta}$ thin films grown on 24° $SrTiO_3$ bicrystal substrates. They consist of an asymmetric array of 10 or 20 Josephson junctions, with a control current fed through an independent line that is inductively coupled to the array. The authors have measured current gains up to 40 at 77 K and substantially higher at lower temperatures. The authors discuss the results of simulations of the device behavior and consider the effects of junction critical current, number of junctions, and array loop inductance. The authors compare the measured device behavior at 77 K with simulations that include the effects of thermal noise.

The levitation force between *Nd-Fe-B* permanent magnets and *YBCO* bulk superconductors has been measured by K. Nagashima (SRL-ISTEC and Railway Technical Research Institute) et al. under varying magnet configurations. The authors varied the number of poles, the thickness of the magnets, and the shape of the bulk superconductors, and they added back iron yokes. The authors found the levitation force to be strongly dependent on the magnet configuration, and thus they concluded that for maximizing the levitation force of magnetic bearings in a superconducting flywheel system, it is important to optimize the arrangement of permanent magnets.

An analysis of the ac losses in a silver-sheathed *Bi-2223* multifilamentary tape has been carried out by M. Sugimoto (Furukawa Electric) et al. to show that twisting the filaments can reduce the losses. The authors find that the ac losses in external ac magnetic fields parallel to the tape surface consist mainly of the ac losses due to (a) macroscopic screening currents among the multiple filaments and (b) microscopic screening currents in the grains. The authors find that the former loss depends strongly on the filament pitch, while the latter does not. The authors' analytical model should be useful for optimizing the performance of *Bi-2223* tapes with respect to the cross-sectional dimensions, number of filaments, matrix resistivity, filament twist pitch, and critical current.

Theory

The effects of dilute nonmagnetic impurities on the frequency dependence of Imχ(**Q**,ω) have been studied by N. Bulut (Koç) within the framework of the 2D Hubbard model using the random-phase approximation. The calculations were motivated by neutron-scattering data on *Zn*-substituted $YBa_2Cu_3O_{7-\delta}$. The author discusses the origin of the peak and of the low-frequency spectral weight induced by the impurities.

A preprint by T. K. Ng (HKUST) proposes a duality relation between antiferromagnetism and d-wave superconductivity in the t-J model. The topological spin and charge excitations in one phase have the same dynamics as elementary excitations in the other phase, except for energy gaps. The author constructs a plausible phase diagram of the t-J model.

Zeeman and orbital effects of an in-plane magnetic field on high-T_c cuprate superconductors have been studied by K. Yang (NHMFL and Florida State) and S. L. Sondhi (Princeton). The authors find that the orbital effect is qualitatively different for in-plane and interlayer mechanisms of superconductivity. For in-plane mechanisms, interlayer couplings may be modeled via weak interlayer Josephson coupling, whose effects disappear as $H \rightarrow \infty$, in which case the Zeeman effect dominates. For the interlayer mechanism, in which the Josephson coupling is the driving force for superconductivity, the in-plane field suppresses superconductivity, yielding an upper bound for H_{c2}, which the authors estimate.

Using the linearized Eilenberger equations, W. Kim (TCSUH and Hsinchu) et al. have studied the upper critical field H_{c2} of mixed d- and s-wave superconductors, accounting for the competing effects of mass anisotropy and spin Zeeman coupling. The authors find that mass anisotropy always enhances H_{c2}, while the Zeeman interaction suppresses H_{c2}. As required by thermodynamics, H_{c2} saturates at zero temperature. The authors compare their theoretical calculations with recent experimental data on $YBa_2Cu_3O_{7-\delta}$.

A new method permitting the study of multiple coherent reflections or transmissions by partially transparent interfaces (e.g., in multilayer mesoscopic structures or grain boundaries in high-T_c superconductors) is proposed in a preprint by A. Shelankov and M. Ozana (Umeå), who use the framework of the quasiclassical theory of superconductivity. The authors apply their method to study the behavior of (a) a film separated from a bulk superconductor by a partially transparent interface and (b) a two-layer system with an arbitrary transparent interface.

A preprint by T. Dahm (MPI-Dresden and Tübingen) investigates the influence of a pseudogap upon the isotope-effect exponent. Within different approximations, the author finds that the pseudogap strongly increases the isotope exponent, in qualitative agreement with experiments on underdoped high-T_c superconductors. The author's result is stable against strong-coupling self-energy corrections and also holds for recently proposed spin-fluctuation-exchange models if a weak additional electron-phonon coupling is considered.

A unifying scenario for the critical behavior of $YBa_2Cu_3O_{7-\delta}$ *(Y-123)* and $Bi_2Sr_2CaCu_2O_{8+\delta}$ *(Bi-2212)* has been proposed by C. de Calan and F. S. Nogueira (Ecole Polytechnique). The authors find that both critical crossovers observed in these materials follow by considering two different scalings in the dual Ginzburg-Landau model. The first scaling leads to the critical exponents $\nu \approx 2/3$ for the correlation length, $\nu' \approx 1/3$ for the magnetic field penetration depth, and $\alpha \approx 0$ for the specific heat, in agreement with exponents obtained for *Y-123* single crystals. For the second scaling, the authors obtain $\nu = 1$ and $\alpha = -1$, which should be compared with the measured values $\nu \approx 1$ and $\alpha \approx -0.7$ for *Bi-2212.* The authors predict the value $\nu' = 1$ for the penetration-depth exponent in *Bi-2212.*

Other Activities

Puzzling results recently were published by V. I. Tsebro et al. in JETP Lett. **70**, 462 (1999). The authors found that the magnetization curves of samples of fragments of cathode carbon deposits with a high content of multiwalled nanotubes exhibited hysteretic magnetization, suggesting the induction of persistent currents in the samples and magnetic flux trapping, as in multiply connected superconducting structures. No decrease of the trapped flux with time was observed at helium temperatures over a measurement time of about 20 h. For intermediate (~30 K) and room temperatures, the trapped magnetic flux decayed slowly with characteristic relaxation times of the order of 150 h and 15 h, respectively.

The intergranular transport properties of polycrystalline samples of $Sm_{1.82}Ce_{0.18}CuO_{4-y}$ *(SCCO)* exhibiting a double resistive superconducting transition have been studied by M.J.R. Sandim (Lorena) and R. F. Jardim (São Paulo). The samples consisted of small islands that undergo a superconducting transition at $T_{ci} \sim 21$ K but for which long-range phase coherence is achieved through Josephson coupling only at a lower temperature $T_{cJ} \sim 10$ K. The authors concluded that magnetoresistance is associated with dissipation due to Josephson vortex motion (flux flow), and they obtained the field and temperature dependence of the corresponding intergranular activation energy.

Overview

A preprint by F. Sandiumenge (Barcelona) et al. summarizes the major factors constraining the development

of microstructures during melt processing in *Y-123* materials. The authors then discuss recent results on alternative processing routes that allow a selective modification of the dislocation substructure in melt-processed materials. Substantial increases of up to 180% in the critical current density J_C have been achieved. The authors also discuss the effect of rare-earth substitutions on the dimensionality of the dislocation substructure (34 refs.).

Ph.D. Thesis

Since their discovery in 1994, the quaternary borocarbides RN_2B_2C have generated intensive research activity because they are ideal systems for studying the interplay of magnetism and superconductivity, and they exhibit an interesting variety of commensurate and incommensurate magnetic structures. The ETH Zürich Ph.D. thesis of U. Gasser presents a study of the magnetic properties of the borocarbides containing heavy rare earths, with special emphasis on the compounds that display coexistence of antiferromagnetism and superconductivity *(R = Dy, Ho, Er,* and *Tm)*. The author performed both elastic and inelastic neutron scattering experiments to investigate both structure and excitations. In addition, the author combined the neutron-scattering results with information from specific-heat, susceptibility, Mössbauer, and μ^+SR experiments (126 refs.).

Contributed by John R. Clem

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PREPRINTS

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of Technology, Rotterdamseweg 137, Delft 2628 AL, THE NETHERLANDS; telephone +31 15 278 2266; telefax +31 15 278 6730; e-mail zandbergen@stm.tudelft.nl. Key words: $BaCu_3O_4$, $HoBa_2Cu_3O_7$, MOCVD.

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.)*

Feb. 17 - 22, 2000:

The 2000 AAAS Annual Meeting and Science Innovation Exposition – Science in an Uncertain Millenium, Washington Marriott Wardman Park and the Omni Shoreham, Washington, D.C. The 166th national meeting of AAAS will bring together more than 5,000 scientists, engineers, educators, policy-makers, and researchers in a multidisciplinary forum to share the latest research advances. Abstracts solicited for contributed poster presentations. The Meeting will feature more than 150 scientific symposia; specialized seminars; topical, plenary, and award lectures; poster sessions; an exhibition hall; field trips; career workshops; and a science career fair. Poster sessions are an important way for individuals to participate at the AAAS meeting. **Abstract deadline, January 7, 2000.** Symposia topics are: changing landscapes; communicating science; education and public understanding of science; environment, food, and natural resources; global change/earth systems science; human futures; industry and engineering; interconnectivity and life in cyberspace; life science and the science of life; looking back to forecast the future; looking beyond earth; mathematics and physical science; natural history in the new millennium; public health and medicine; science and society; science, engineering, and public policy; and science innovation. AAAS Meetings Office, 1200 New York Avenue NW, Washington DC 20005; telephone (202) 326-6450; telefax (202) 289-4021; e-mail confinfo@aaas.org.

March 12 - 16, 2000:

129th Annual Meeting & Exhibition of The Minerals, Metals & Materials Society,TMS Annual Meeting, Nashville, Tenn. More than 4,000 science and engineering professionals representing over 70 different countries will come together at this meeting. At least 200 sessions and 1,000 individual presentations. Technical areas of interest include precious metal extraction, aluminum processing, high-temperature superconductors, and many other materials fields and metallurgical disciplines. This year's meeting will feature programming by the Electronic, Magnetic & Photonic Materials Division, Extraction & Processing Division, Light Metals Division, Materials Processing & Manufacturing Division, Structural Materials Division, TMS Education Committee, TMS Young Leaders Committee, and Materials Science Critical Technologies Sector of ASM International. For information, contact TMS Meetings Services, 184 Thorn Hill Road, Warrendale, PA 15086; telephone (724) 776-9000, ext. 243; telefax (724) 776-3770; e-mail mtgserv@tms.org.

*March 20 - 24, 2000:

2000 March Meeting, Minneapolis Convention Center, Minneapolis, Minn. Sessions on superconductivity will include the following topics: synthesis, growth, and processing (bulk and films); thermodynamic and transport properties; mechanical and structural properties; electronic structure and spectroscopic properties; flux pinning and flux dynamics; spin properties (NMR, NQR, etc.); tunnel junctions, devices, and Josephson arrays; quantum computing; and other focused sessions. For further general information, contact Donna Baudrau, Manager, APS Meetings Department, telephone (301) 209-3285, e-mail baudrau@aps.org; more information on the March meeting is available at the Web site http://www.aps.org/meet/MAR00/.

*March 31 - April 10, 2000:

Conference on Major Trends in Superconductivity in the New Millennium (MTSC 2000) and Symposium on Itinerant and Localized States in HTSC (SILS), Klosters, Kanton Graubünden, Switzerland. Scope of MTSC 2000 is on recent developments and trends in new superconducting systems with emphasis on experiments and theories which are relevant to the pairing mechanism. Besides the superconducting cuprates, conventional superconductors, organic systems, borocarbides, ruthenates, nanostructures, and fullerenes will be addressed. In order to raise the awareness for novel ideas and results in this rapidly growing field, the physics and chemistry of related materials will be included. Special emphasis on phenomena related to nanoscale phase separation and charge modulation. Symposium on Itinerant and Localized States in HTSC (SILS) will focus on large and small polaron and bipolaron effects in high-T_c materials with special emphasis on their preparative properties. MTSC 2000 is organized in close analogy to the Gordon conferences. Total number of participants limited to 130 persons. Proceedings will be published in a special issue of *Journal of Superconductivity.* For more information, contact Annette Bussmann-Holder, Max-Planck-Institut für Festkörperforschung, Heisenbergstr. 1, D-70569 Stuttgart, Germany; telephone +49 711 689 1679; telefax +49 711 689 1091. Or contact Vladimir Z. Kresin, Lawrence Berkeley Laboratory, University of California, 1 Cyclotron Road, Berkeley CA 94720; telephone (510) 486-6951; telefax (510) 486-5401. Information also available at Web site http://www.mpi-stuttgart.mpg.de/CONF/mtsc2000.html.

June 19 - 22, 2000:

International Workshop on Superconductivity, Kunibiki Messe, Matsue, Shimane Prefecture, Japan. Workshop will focus on fundamental properties of high-temperature superconducting materials for actual applications. Theme of the workshop is "Structure and

Property Relationships for Applications of High-Temperature Superconducting Materials." No parallel sessions; significant amount of time to be allotted for the discussion of each paper. Topics of interest (including, but not restricted to): interfaces, grain boundaries, surfaces, thin films, bulks, wires and tapes, etc. Invited presentations, contributed papers, and contributed posters. **One-page summary deadline, January 15, 2000.** Contact Tetsuji Kobayashi, Director, International Affairs Department, ISTEC Eishin Kaihatsu Bldg., 6F, 34-3 Shimbashi 5-chome, Minato-ku, Tokyo 105-0004, Japan; telephone +81 3 3431 4002; telefax +81 3 3431 4044; e-mail t-kobayashi@istec.or.jp; Web page http://www.istec.or.jp/ISTEC_homepage/WORK/e-workshop.html.

June 21 - 23, 2000:* 4th European Workshop on Low Temperature Electronics (WOLTE-4), European Space Research and Technology Centre (ESTEC), Noordwijk, The Netherlands. Organized by the European Space Agency (ESA) and co-sponsored by IEEE/EDS. Objective of the workshop is to provide an international forum for discussing recent research and development in the area of low-temperature electronics including semiconductors, low- and high-temperature superconductors, devices, circuits, and systems. Emphasis on the application of these for space instrumentation. Both oral and poster presentations. Intent to exhibit or to organize a short course should be indicated to the Conference Secretariat with a preliminary description of requirements by October 15, 1999. Topics: device physics and fundamental aspects, fabrication technologies, device and circuit design, packaging and interconnections, front-end systems for cryogenic sensors, device simulation and modeling, cryogenic measurements and instrumentation, new materials and novel technologies, space-related applications, refrigeration, and interfacing for electronics. **Abstract deadline, December 15, 1999. Contact ESTEC Conference Bureau, P.O. Box 299, 2200 AG Noordwijk, The Netherlands; phone +31 71 5655005; fax +31 71 5655658; e-mail confburo@estec.esa.nl; Web site http://www.estec.esa.nl/CONFANNOUN/wolte4/.

July 23 - 25, 2000: International Symposium on Local Lattice Distortions (LLD2K), AIST Tsukuba Research Center, Ibaraki, Japan. Intensive discussions on physics related to local lattice distortions, with the aim of establishing its role in exotic properties of strongly correlated systems such as high-Tc superconductivity, colossal magnetoresistance, and related topics. Topics include local lattice distortions associated with stripes, charge and orbital ordering, lattice anomalies, phase transitions, excited states, and impurities. For further information, contact LLD2K Secretariat, Electrotechnical Laboratory, 1-1-4 Umezono, Tsukuba, Ibaraki, 305-8568, Japan; telephone +81 298 54 5072; telefax +81 298 54 5085; e-mail lld2k@etl.go.jp; Web site http://www.etl.go.jp/~lld2k/.

Sept. 13 - 16, 2000:* The Second International Conference on Inorganic Materials, University of California, Santa Barbara. Meeting will provide an opportunity to highlight recent developments and to identify emerging and future areas of growth in this field. Topics include electronic materials, structural materials and ceramics, biomaterials, intermetallics, catalytic and porous materials. Emphasis on oral presentations by invited speakers combined with extended poster sessions. **Abstract deadline, February 25, 2000. Official language is English. A tabletop exhibition will run for the duration of the conference. For information, contact Sarah Wilkinson, Second International Conference on Inorganic Materials, Elsevier Science Ltd., The Boulevard, Langford Lane, Kidlington, Oxford, OX5 1GB, United Kingdom; telephone +44 1865 843691; telefax +44 1865 843958; e-mail sm.wilkinson@elsevier.co.uk.

RESOURCES

Information

Proceedings: The European Conference on Energy Dispersive X-ray Spectrometry (EDXRS-98), Bologna, Italy, June 7-12, 1998, edited by J. E. Fernández and A. Tartari. A selection of the papers presented at EDXRS-98 has been arranged in ten topical sections which reflect the true distribution of the contributions and consequently the academic interest of the participants. Section I – Interaction of Photons and Particles with Matter and their Modeling; Section II – Energy Dispersive X-ray Detectors, is devoted to the rapidly changing field of photon detectors; Section III – X-ray Optics, TXRF, and Capillarity, shows the state-of-art of optical techniques for x-rays; Section IV – Instrumentation, is devoted to novel instrumental solutions in x-ray spectrometry; Section V – Microanalysis, is devoted to particle and photon microprobes; Section VI – Applications to Medicine, opens the applications part of the volume with the medical applications of x-ray spectrometry; Section VII – Applications to Biology, concerns primarily applications in botany; Section VIII – Applications in Environmental Research, is devoted to a sector where trace element techniques play an important role; Section IX – Applications to Archaeometry, groups the presentations in a field sensitive to the nondestructive capability of spectrometrical quantitation; and Section X – Applications to Industry, reveals the growing role of x-ray spectrometry in industrial technology. Publ. 1999; 366 pp.; price Lit. 170,000; ISBN 88-7794-195-2. For order information, contact Editrice Compositori, Via Stalingrado 97/2, 40128 Bologna, Italy; telefax +39 051 327877.

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