HIGH T_c UPDATE

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NOTA BENE:

Vortices

An extensive theoretical study of the effect of critical fluctuations on the B-T phase diagram in clean, extreme type-II superconductors ($\kappa >> 1$) in zero and finite magnetic fields has been carried out by A. K. Nguyen (Trondheim) and A. Sudbø (Trondheim and Caltech). In zero field, the authors show that the superconducting to normal-metal transition is described by the unbinding of thermally induced vortex loops. In other words, superconductivity is destroyed by fluctuations in the phase of the order parameter; amplitude fluctuations are far from critical at T_c. The authors also find that as T_c is approached from below, the vortex line tension $\varepsilon(T)$ vanishes as a power law, $\varepsilon(T) \propto |T-T_c|^{\gamma}$, where $\gamma = 1.45 \pm 0.05$, and there is a diverging length in the problem, $L_0(T) \rightarrow \infty$ as $T \rightarrow T_c^-$. The authors also relate these results to the dual field ϕ, and in conjunction with the Fisher scaling law $\gamma = \nu(2-\eta_\phi)$ the authors extract the value $\eta_\phi = -0.18 \pm 0.07$.

In finite field, Nguyen and Sudbø find that the vortex-line lattice melts in a first-order phase transition along the line $T_m(B)$ into a completely incoherent vortex liquid characterized by zero global phase coherence in all directions. The authors find a crossover from mean-field scaling at high fields to 3D XY scaling at low fields. In addition, the authors find that a change in the vortex-tangle connectivity O_L signals the presence of another transition line $T_L(B)$, which lies above the melting line. $T_L(B)$ is the finite-field extension of the zero-field vortex-loop unbinding point, and thus has an endpoint at the zero-field critical temperature, $T_L(0) = T_c$. Below T_L, connectivity of the vortex system is determined exclusively by the field-induced vortex lines, but above T_L, there exist thermally generated vortex lines that thread across the entire system perpendicular to the magnetic field. The authors find that the vortex system in the clean limit exhibits three distinct phases in the B-T phase diagram, characterized by the average values of the Ginzburg-Landau order parameter $\langle\psi\rangle$ and its dual order parameter $\langle\phi\rangle$. In region I below $T_m(B)$, $\langle\psi\rangle \neq 0$ and $\langle\phi\rangle = 0$; in region II between $T_m(B)$ and $T_L(B)$, $\langle\psi\rangle = 0$ and $\langle\phi\rangle = 0$; and in region III above $T_L(B)$, $\langle\psi\rangle = 0$ and $\langle\phi\rangle \neq 0$.

The resistivity of clean *$YBa_2Cu_3O_{7-\delta}$ (Y-123* or *YBCO)* in the vortex-liquid state has been measured by S. N. Gordeev (Southampton) et al. Using scaling analysis, the authors find two distinct regimes. While at high temperatures the vortex liquid is unpinned and the resistivity assumes its free-flux-flow state, at lower temperatures the vortex dynamics can be described in terms of the model of a very viscous liquid, in which the vortex motion is controlled by thermally activated processes with high energy barriers $U_{pl} >> k_BT$. The authors found that the ratio of the activation energy to the melting temperature has a constant value $U_{pl}(T_m)/k_BT_m \approx 12$, independent of the degree of underlying disorder. This is in agreement with recent theoretical predictions for vortex-line-cutting energies and implies that the vortex liquid is highly entangled.

Measurements of the nonlinear susceptibility of *$YBa_2Cu_4O_8$ (Y-124), $Bi_2Sr_2CaCu_2O_{8+\delta}$ (Bi-2212),* and untwinned *$YBa_2Cu_3O_{7-\delta}$ (Y-123)* crystals near the superconducting critical temperature T_c have been carried out by F. Mrowka (Leipzig) et al. to determine the lower critical field $H_{c1}(T)$. The ac-field-amplitude dependence of the susceptibility for homogeneous *Y-124* and *Bi-2212* crystals is in agreement with the geometrical-barrier model, allowing the authors to determine the penetration field $H_p(T) \propto H_{c1}(T)$. The authors also found that the previously reported breakdown of H_{c1} near T_c coincides with the low-temperature ac-field-independent onset of the superconducting transition and that this anomalous behavior of $H_{c1}(T)$ is not an intrinsic property but rather is due to the influence of inhomogeneities.

A preprint by S. Okayasu and H. Asaoka (JAERI) reports the experimental observation of a new vortex phase in a detwinned *YBCO* single crystal. Using dc magnetization (M vs H) hysteresis measurements at fixed temperatures above 55 K but below the vortex-lattice melting line $T_m(B)$, the authors found an apparently reversible region (region IV) between the irreversibility line $B_{irr}(T)$ and a reentrance line $B_{on2p}(T)$, which marks the onset of a second peak in the magnetization hysteresis. While the irreversibility line $B_{irr}(T)$ decreases with increasing temperature, the authors found that

the reentrance line $B_{on2p}(T)$ increases with temperature. Using ac susceptibility measurements, the authors found the magnitude of the third-harmonic signals to be large only in region IV between the irreversibility line and the reentrance line.

A method based on partial magnetization loops has been used by S. Kokkaliaris (Southampton) et al. to study memory effects in detwinned *$YBa_2Cu_3O_{7-\delta}$* single crystals. The measurements have revealed the transition from a dislocation-free Bragg glass to a disordered vortex phase. On the B-T phase diagram, this transition occurs along a boundary that is close to the onset of the second magnetization peak. For fields above the transition line, metastable topological disorder invades the vortex system, leading to a pronounced dependence of the critical current on the formation history of the vortex lattice.

The quasiparticle density of states in d-wave superconductors containing a vortex lattice has been calculated by K. Yasui and T. Kita (Hokkaido), who self-consistently solved the Bogoliubov-de Gennes equations. For a pure $d_{x^2-y^2}$ state, the authors found that (a) low-energy quasiparticle bands in the magnetic Brillouin zone have large dispersion even in low magnetic fields, indicating the absence of bound states for an isolated vortex, and (b) in finite fields with small $k_F\xi_0$, the calculated tunneling conductance at the vortex core shows a double-peak structure near zero bias, qualitatively consistent with the STM experiment by I. Maggio-Aprile et al., Phys. Rev. Lett. **75**, 1754 (1995). The authors also found that mixing of a d_{xy}- or an s-wave component, if any, develops gradually without transitions as the field is increased, having little effect on the tunneling spectra.

Using London theory, E. Sardella (Bauru) et al. have calculated the reversible magnetization curve of a superconducting ($\kappa = 100$) film of width $a = 7\lambda$ and thickness $b < \lambda$ in a parallel magnetic field. Multiple peaks in M(H) occur, corresponding to different numbers N of vortices in the film ($N \leq 30$). For $b = 0.5\ \lambda$, the Gibbs free energy minimum corresponds to only a single row of vortices along the midline of the film, while for $b = 0.75\ \lambda$, there are two staggered rows of vortices straddling the midline.

The nucleation of superconductivity in a uniform perpendicular magnetic field H in *Al* 2.0 μm × 2.0 μm microsquares containing two or four submicron holes (antidots) has been studied experimentally and theoretically by V. Bruyndoncx et al. (Leuven). In low magnetic fields, the normal-superconducting phase boundary shows oscillations in $T_c(H)$ arising from fluxoid quantization around each antidot, similar to the behavior in a network. In high magnetic fields, the $T_c(H)$ boundaries of the perforated microsquare and a reference nonperforated microsquare have cusps at the same values of Φ/ϕ_0 (Φ = applied flux threading the total square area, ϕ_0 = superconducting flux quantum), while the background on $T_c(H)$ becomes quasilinear, indicating that a giant vortex state is established.

$RBa_2Cu_3O_{7-\delta}$

The flux-pinning behavior of ternary melt-processed *(Nd-Eu-Gd)$Ba_2Cu_3O_{7-\delta}$ [(NEG)-123]* superconductors with varying defect concentrations has been studied by A. K. Pradhan et al. (SRL-ISTEC). The authors interpret the maximum in $J_c(B)$ at 2-3 T in terms of pinning-induced vortex entanglement in the vortex-liquid phase.

As noted in a preprint by I. M. Fita (Donetsk) et al., it has been found that pressure-induced superconductivity ($T_c \rightarrow 30$ K) can occur in normally nonsuperconducting *$NdBa_2Cu_3O_{6.67}$ (Nd-123).* The authors have found that when the pressure is released, oxygen disordering gradually occurs. Over a few hours, the unit-cell volume V_{cell} increases with time, the hole density decreases, and T_c decreases to zero. Oxygen disordering upon pressure release was found to occur five times faster than oxygen ordering under pressure.

Bi Cuprates

A preprint by R. S. Gonnelli (Torino) et al. reports solutions of the real-axis d-wave Eliashberg equations for *$Bi_2Sr_2CaCu_2O_{8+\delta}$ (Bi-2212)* to satisfactorily fit break-junction tunneling experiments, and an $\alpha^2F(\omega)$ was obtained. However, the same procedure was unable to fit the differential conductance curves from recent STM experiments.

Three preprints listed in this issue report enhancements of the critical current density J_c in *Bi-2212* samples grown in a high magnetic field. H. B. Liu et al. (MIT) report experiments on *Bi-2212* films of thickness 25-125 μm melt-grown in fields up to 10 T; H. B. Liu (MIT) et al. report results for *Bi-2212/Ag* tapes melt-grown in magnetic fields up to 10 T; and S. Pavard et al. (Grenoble) report on J_c enhancements in bulk *Bi-2212* superconductors with *MgO* additions, where the samples were hot-forged in a magnetic field of 5.7 T.

Nondestructive measurements by P. Usak (Bratislava) have been used to determine the transport current distribution across the width of a superconducting wire-in-tube (WIT) *(Bi,Pb)-2223/Ag* tape. The author measured the spatial dependence of the magnetic self-field just above the tape and used the Biot-Savart law to invert the results and obtain the current distribution. The measurements showed that at the critical current, the current capacity in the central section was higher than at the edges of the tape.

Measurements of the ac susceptibility of a well-textured *(Bi,Pb)-2223/Ag* tape have been carried out by G. C. Han and C. K. Ong (Singapore) as a function of temperature, externally applied dc magnetic field, and angle θ between the field and the tape plane. The authors found that the results could be scaled using the three-dimensional anisotropic effective-mass model, but with a $\gamma \sim 4$ most likely reflecting the misalignment of the grains, rather than indicating the anisotropy of perfectly aligned *Bi-2223*.

Other Cuprates

The mixed-state Hall resistivity ρ_{xy} and the longitudinal resistivity ρ_{xx} in $HgBa_2CaCu_2O_{6+\delta}$ *(Hg-1212),* $HgBa_2Ca_2Cu_3O_{8+\delta}$ *(Hg-1223),* and $Tl_2Ba_2CaCu_2O_{8+\delta}$ *(Tl-2212)* thin films have been investigated by W. N. Kang (POSTECH) as functions of the magnetic field H up to 18 T. The scaling exponent β in $\rho_{xy} = A\,\rho_{xx}^{\beta}$ was found to be 1.9±0.1 in the clean limit at high H and low temperature T. In the moderately clean limit at low H and high T, $\beta = 1.0 \pm 0.1$, consistent with a theory based on midgap states in the vortex core.

Infrared studies of the c-axis electrodynamics of $Tl_2Ba_2CuO_{6+\delta}$ *(Tl-2201)* crystals have been carried out by A. S. Katz (US-San Diego) et al. A sum-rule analysis reveals spectral weight shifts that can be interpreted as a kinetic-energy change at the superconducting transition. In optimally doped crystals showing an incoherent normal-state response, the kinetic energy is lowered at $T < T_c$, but no significant change is found in overdoped samples, which have more coherent conductivity at $T > T_c$.

As reported by S. Yu et al. (NIRIM), critical current densities J_c and irreversibility fields B_{irr} of the high-T_c superconductors $(Cu,Cr)Sr_2Ca_{n-1}Cu_nO_{2n+3}$ [*(Cu,Cr)-12(n-1)n,* n = 2 (T_c = 81 K) and n = 3 (T_c = 103 K)] prepared under high pressure have been determined from dc magnetization hysteresis. Plotted as a function of T/T_c, the values of $J_c(B=0)$ and $J_c(B=1T)$ are higher than those of other high-T_c superconductors, including $YBa_2Cu_3O_{7-\delta}$, for almost the entire range of temperatures. The B_{irr} values are also very high; at 77 K, for example, $B_{irr} > 5$ T for *(Cu,Cr)-1223.* The authors suggest that the good J_c properties of *(Cu,Cr)-1212* and *(Cu,Cr)-1223* are caused by their less anisotropic electronic structures and high density of pinning centers due to random arrangement of *Cu* and *Cr* in the blocking layer.

Films

The influence of a driving force and vortex-lattice motion on the vortex-depinning and dissipation in vibrating $YBa_2Cu_3O_{7-\delta}$ superconducting films has been investigated by A. V. Pan et al. (Leipzig). The authors observed a motional narrowing of the depinning transition.

Thermomagnetic instabilities (flux jumps or vortex avalanches) have been observed by P. Esquinazi (Leipzig) et al. in *Nb* thin films. The field $H_{SMP}(T)$ at the second magnetization peak separates the region of flux jumps, $H < H_{SMP}(T)$, from smooth behavior at $H > H_{SMP}(T)$. Using local magnetization measurements, the authors also found dome-like flux profiles at low fields.

A preprint by X. Cui et al. (Oak Ridge) reports that a reel-to-reel electron-beam-evaporation system has been developed to continuously deposit epitaxial CeO_2 and other oxide buffer layers on meter-long lengths of rolled *Ni* tapes. J_cs as high as 5×10^5 A/cm^2 at 77 K in self-field have been achieved for *YBCO* films deposited on short segments of these substrates.

According to a preprint by F. Zygalsky et al. (TU-Berlin), it is possible to produce high-T_c thin films from polymer metal precursors by a simple spin-coating technique. The authors show how this method can be used to manufacture $YBa_2Cu_3O_{7-\delta}$ *(Y-123)* and $(Bi,Pb)_2Sr_2Ca_2Cu_3O_{10+\delta}$ *[(Bi,Pb)-2223]* thin films and to produce microbridges without etching using photolithography on the precursor film.

Large-area crack-free thick $YBa_2Cu_3O_{7-\delta}$ films have been prepared by R. Wördenweber (Jülich) et al. on CeO_2-buffered r-cut sapphire (two-inch diameter) with thickness up to 700 nm, smooth surfaces (peak-to-valley roughness less than 10 nm), high critical currents ($J_c > 2$ MA/cm^2 at 77 K and 0 T), and low microwave surface resistance [$R_S(77K) = 1.4$ mΩ and $R_S(4.2K) \approx 110$ $\mu\Omega$ at 19 GHz], comparable with the best values reported for *YBCO* films on structurally better-matched substrates.

Low-power nonlinear effects in high-temperature superconducting microwave devices have been studied by J. C. Booth et al. (NIST-Boulder), who measured third-harmonic generation at 76 K in coplanar waveguide transmission lines of different geometries fabricated from *YBCO* thin films with $J_c(76K,0T) = 3.0 \times 10^6$ A/cm^2. The authors were able to analyze their results using a simple transmission-line model with a nonlinear inductance arising from a current-dependent superconducting penetration depth, characterized by a scaling current density $J_0 = 3.0 \times 10^7$ A/cm^2 at 76 K.

A related preprint by J. H. Claassen (NRL) et al. describes another method to determine the dependence of the penetration depth $\lambda(J)$ on the current density J. The technique involves a pair of small coaxial coils positioned on opposite sides of the film. Using this method and the model $\lambda^2(T,J) = \lambda^2(T,0)[1+(J/J_0)^2]$, the author obtained values of J_0 in good agreement with those measured by third-harmonic generation in coplanar waveguide transmission lines at 5 GHz. This nondestructive technique could be used to screen films before incorporating them into circuits sensitive to nonlinear effects.

Applications

Contained in this issue are a number of preprints from Forschungszentrum Jülich related to applications of high-temperature superconducting $YBa_2Cu_3O_{7-\delta}$ rf SQUIDs and gradiometers. P. Selders et al. (Jülich) report that the low-frequency 1/f noise can be strongly reduced when the vortex lattice in the body of a SQUID is geometrically matched to an antidot (hole) lattice. Y. Zhang et al. (Jülich) reports on the performance of a planar multiturn flux transformer integrated with a superconducting labyrinth resonator serving as the planar tank circuit for an rf SQUID magnetometer. H. R. Yi et al. (Jülich) report numerical calculations of the coupling coefficient k^2 between a superconducting coplanar resonator and a flip-chip-coupled washer rf SQUID. M. Bick (Jülich) et al. report on a highly sensitive rf SQUID vector (x,y,z) magnetometer system which operates at 77 K and is suitable for electromagnetic geophysical exploration. D. F. He et al. (Jülich) report on the magnetically unshielded operation of a device consisting of three magnetometer SQUIDs oriented in the x, y, and z directions. R. Hohmann et al. (Jülich) report on the development of an automated inspection system using an HTS SQUID gradiometer sensor for eddy-current detection of deep-lying flaws in large aircraft wheels. Y. Tavrin (Jülich) et al. report on the development of a highly sensitive second-order gradiometer using three HTS SQUIDs as magnetic sensors for nondestructive testing of small ferrous inclusions in aircraft engine disks.

A preprint by Y. Zhang (Jülich) et al. reports the development of a radio-frequency bias-current scheme with reversal frequency up to 50 MHz for dc SQUIDs. The SQUID and the readout electronics were connected via a quarter-wavelength transmission line, which also served as the resonant matching circuit.

Two more papers from Jülich describe the performance of high-T_c Josephson mixers. O. Harnack (Jülich) et al. report on experimental studies of noise properties and conversion efficiency of *YBCO* Josephson mixers and hot-electron-bolometric (HEB) mixers at frequencies between 90 GHz and 550 GHz. S. Beuven et al. (Jülich) report on the experimental realization of a sub-mm wavelength oscillator based on *YBCO* Josephson junctions integrated on-chip with a detector Josephson-junction mixer. The oscillator was a 2D array of 20 step-edge junctions biased in parallel, such that all junctions of the network were oscillating with the same frequency.

The design and fabrication of a low-noise HTS magnetometer consisting of a low-inductance (<16 pH) *YBCO* dc SQUID coupled to a 28 nH *YBCO* pickup loop flux transformer fabricated on the same 1 cm^2 substrate is described by N. J. Exon et al. (DERA-Malvern). Efficient coupling was achieved by using a flip-chip intermediate flux transformer, resulting in a magnetometer with a high sensitivity per unit area. The measured white noise, which was higher than the design value, was due largely to Johnson noise from the $PrBa_2Cu_3O_{7-\delta}$ in the flux-transformer crossovers.

A method for the determination of the critical current density J_c from measurements of the levitation force on a permanent magnet is described in a paper by A. A. Kordyuk (Kiev) et al. The calculated first and second levitation-force hysteresis loops calculated with these J_c values are in good agreement with experimental data on melt-processed *YBCO* samples.

Theory

A preprint by L. P. Pryadko (Princeton) et al. analyzes the properties of a general Ginzburg-Landau free energy with competing order parameters, long-range interactions, and global constraints (e.g., a fixed value of total charge) to address the physics of stripe phases in underdoped high-T_c and related materials. For a local free energy limited to quadratic terms of the gradient expansion, only uniform or phase-separated configurations are found to be thermodynamically stable. Stripe or other nonuniform phases can be stabilized by long-range forces, but they can have nontopological (in-phase) domain walls only where the components of the antiferromagnetic order parameter never change sign, and the periods of charge and spin density waves coincide. The authors discuss the implications for the phase diagram of underdoped cuprates.

Considering both large-U and small-U orbitals, J. Ashkenazi (Miami) finds that the high-T_c cuprates are characterized by a striped structure and three types of carriers: polaron-like stripons carrying charge, quasielectrons carrying charge and spin, and svivons carrying spin and lattice distortion. The author shows that this electronic structure leads to the anomalous physical properties of the cuprates, and specifically the systematic behavior of the resistivity, Hall constant, and thermoelectric power. In this theory, high-T_c pairing results from transitions between pair states of quasi-electrons and stripons through the exchange of svivons. A pseudogap phase occurs when pairing takes place above the temperature where stripons become coherent, and this temperature determines the Uemura limit.

As noted in a preprint by B. Normand (Basel) et al., $LaCuO_{2.5}$ is a system of coupled two-chain cuprate spin ladders, which may be doped systematically by *Sr* substitution. Motivated by the recent synthesis of single crystals, the authors used a model of spin-fluctuation-mediated superconductivity, where the pairing potential is strongly peaked at π in the ladder direction, to investigate the possibility of superconductivity in this compound. The authors solved the coupled gap equations on the bonding and antibonding ladder bands to find superconducting

solutions across the range of doping. They predict that sufficiently clean single crystals of $La_{0.9}Sr_{0.1}CuO_{2.5}$ should be superconducting with a transition temperature around 25 K.

A preprint by G. A. Ummarino and R. S. Gonnelli (Torino) considers consequences of the breakdown of Migdal's theory in high-T_c superconductors. They find that the experimental coupling constant λ, gap parameter Δ, and transition temperature T_c are all enhanced, and that the enhancement is greater for Δ than for T_c, leading to an increased value of the experimental ratio $2\Delta/k_BT_c$. The authors conclude that the renormalized values of λ and $2\Delta/k_BT_c$ are compatible with a conventional strong-coupling electron-boson origin of superconductivity.

The effect of impurity scattering in superconductors usually has been calculated theoretically assuming s-wave impurity scattering, which leads to results depending only upon the mean free path and the impurity cross section. M. L. Kulic (Bayreuth) and O. V. Dolgov (Tübingen) have investigated corrections coming from anisotropy in the scattering cross section. They find both quantitative and qualitative deviations from the s-wave isotropic pair-breaking theory in the transition temperature, density of states, quasiparticle bound states at impurities, and pinning of vortices by impurities.

Using a multi-Josephson-junction model, S. Sakamoto (Seikei) et al. have investigated voltage-biased I-V characteristics of high-T_c superconductors. The I-V characteristics show a complicated behavior due to interlayer couplings among the superconducting phase differences mediated by the charging effect.

In analyzing the current-voltage characteristics of polycrystalline $RBa_2Cu_3O_{7-\delta}$ *(R = Y* or *Gd)* samples, M. Prester (Zagreb) concludes that the current-carrying medium is an object of fractal geometry.

Overviews

As noted in a review by A. Gilabert (Nice) et al., persistent photoconductivity is an unusual property of the high-temperature superconductors. Illumination of these compounds can lead to a change in doping that persists at low temperatures but relaxes back to its initial value at elevated temperatures. Photoinduced effects also can be used to probe or modify the properties of grain boundaries in grain-boundary Josephson junctions. The authors review the experimental data and the proposed models for persistent photoconductivity (128 refs.).

In-situ high-temperature optical microscopic observations of the nucleation, growth, and morphology of $RBa_2Cu_3O_{7-\delta}$ *(R-123, R = Nd,Y)* are reviewed in a book chapter by D. K. Aswal (Shizuoka) et al. By observing the crystallization of *Nd-123* from high-temperature solutions, the authors found that the growth mechanism changes from 3D growth, via 2D layer-by-layer growth, to continuous dendritic growth with increasing supersaturation, suggesting that interface kinetics is the rate-limiting factor (111 refs.).

A review by J. F. Annett (Bristol) summarizes the evidence for or against conventional s-wave and unconventional p-wave or d-wave pairing in various anomalous superconductors including the cuprates, ruthenates, organics, borocarbides, bismuthates, fullerenes, and C15s. The author notes that there is now strong evidence for p-wave pairing in Sr_2RuO_4 (104 refs.).

An overview on the deposition of high-T_c superconducting thin films has been prepared by R. Wördenweber (Jülich). The author discusses and compares the major technologies, and describes the advantages and disadvantages of various substrate materials. Film nucleation, growth modes, and the consequences of lattice mismatch also are discussed (90 refs.).

The physics of Raman spectroscopy and its application to study phonons, interband and intraband electronic excitations, the electron-phonon interaction, and crystal-field transitions between f-electron levels in high-T_c superconductors are the subject of a review by M. Cardona (MPI-Stuttgart). The author notes that Raman experiments reveal a remarkably large electron-phonon interaction in $HgBa_2Ca_3Cu_4O_{10+\delta}$ (*Hg-1234,* T_c = 123 K) (81 refs.).

A review by J. R. Hull (Argonne) discusses the use of melt-textured bulk high-temperature superconductors in magnetic-levitation applications. The author discusses the behavior of the levitation force, stiffness, damping, and rotational losses. These materials are finding uses in superconducting bearings, flywheel energy storage, and other levitation applications (77 refs.).

The superconducting properties of quasi-two-dimensional organic metals have been reviewed by J. Wosnitza (Karlsruhe). The author also presents recent experimental results on the magnetic phase diagram, fluctuation effects, vortex dynamics, and specific heat. There is still no general consensus on the nature of the superconducting state in organic materials (52 refs.).

An overview of selected properties of quaternary intermetallic rare-earth transition metal borocarbides and related boronitride compounds has been prepared by S.-L. Drechsler (Dresden) et al. The authors also discuss theoretical calculations, the mechanism of superconductivity, and the interplay of superconductivity and magnetism for compounds with pure and mixed rare-earth components (47 refs.).

The fabrication of high-T_c superconducting Josephson-junction arrays and their application as voltage standards, microwave radiation sources, and mixers are discussed in a review by M. Darula (Jülich) (41 refs.).

A review of how neutron scattering can be used to search for mechanisms of superconductivity has been prepared by G. Aeppli (Risø and NEC-Princeton) et al. The authors report results from UPt_3, $La_{2-x}(Sr,Ba)_xCuO_4$, and $YBa_2Cu_3O_{6.67}$ (36 refs.).

A review by P. Wölfle (Karlsruhe) examines the properties of superfluid ^3He as a well-studied model of unconventional superfluidity, and includes a discussion of BCS theory extended to spin-triplet p-wave states, the nodal structure of the energy spectrum, and its implications for thermodynamic and transport properties. The author also considers charged superfluids (i.e., superconductors) and their coupling to the electromagnetic field (33 refs.).

Contributed by John R. Clem

Contents:

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TECHNOLOGY NEWS

(Also see Applications section of Nota Bene.)

This section describes progress in manufacturing, product development, and technology transfer in the high-T_c superconductivity field. Please send your contributions (product development information, news regarding technology transfer efforts, or any information you would like to share about your corporation or laboratory) to the editor.

A four-year cooperation agreement was signed recently by Pirelli Cables and Systems, ENEL, and Edison for the development, production, and testing of a high-temperature superconducting cable system. The objective of this partnership is to conduct a study to assess the commercial use of new systems based on this technology in existing electricity transmission networks, and to evaluate the impact and benefits on those networks. The development program will include the first field trial of an industrialized HTS cable system in Italy. Pirelli Cables and Systems, ENEL, and Edison, which have extensive experience in the field of superconductivity research, will combine their respective capabilities to develop a 132 kV 3-phase HTS cable system capable of transporting 3,000 A current continuously, more than double the load of a conventional system. Pirelli Cables and Systems will develop and manufacture a high-performance cold dielectric prototype cable, ENEL and Edison will contribute their systems expertise, operational know-how, and facilities to evaluate the advantages and applicability of HTS cable technology in transmission and distribution networks. In addition, the new system will be subjected to prolonged electrical and mechanical tests in the CISE Laboratories in Milan. For information, contact Sergio Zannella, Edison SpA, Foro Buonaparte 31, I-20121 Milano, Italy; telephone +39 02 62227295; telefax +39 02 62223074; e-mail zannellas@edison.it.

Dramatic range extension and performance improvements were reported by Illinois Superconductor Corporation recently, from the installation of ISC's SpectrumMaster® Classic filter in a Code Division Multiple Access (CDMA) commercial cell site in the United States. The operator is conducting additional testing which may lead to the widespread deployment of ISC's technology throughout its CDMA system. In the evaluation, the SpectrumMaster® Classic filter was installed in a rural site along a major interstate highway, and documented results show expanded cell site coverage by more than 25%. Other documented benefits of the test included decreased dropped and blocked calls and significantly lower handset transmit power (3-5 dB), which can increase cell capacity and extend cell phone talk time.

In other news, Illinois Superconductor Corporation announced the introduction of its new GSM (Global System for Mobile Communications) RangeMaster® filter system with ATP™, which will be field tested by one of the world's largest cellular system equipment providers (OEMs). The new product will be shipped within the next week for testing in a "live" cellular system located in Europe. The new system, which is expected to improve system sensitivity, combines high-performance superconducting filters with cooled low-noise amplifiers, and typically increases site coverage by as much as 70%, lowers dropped calls by up to 40%, and simplifies the location of new cell sites in comparison to conventional filters. With All Temperature Performance (ATP™), the GSM RangeMaster® filter uniquely provides excellent performance, whether the unit is in cold "superconducting" or warm "nonsuperconducting" mode. First operational in 1992, GSM is an international digital standard developed under the promotion of the Conférence des Administrations Européenes des Postes et Télécommunications (CEPT), the telecommunications industry administration of 26 European countries. With more than 160 million customers, GSM technology is deployed in approximately

160,000 cell sites in 133 countries and areas around the world. Because of the wide deployment of GSM technology, GSM customers can use their cellular telephones domestically and when traveling internationally.

More information about Illinois Superconductor Corporation is available on the Company's Web site at http://www.ilsc.com. Or contact Monique Showalter, telephone (847) 391-9426, e-mail showalter@ilsc.com.

PREPRINTS

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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.)*

June 21 - 25, 1999: The European Conference Physics of Magnetism 99, Science Centre of the Polish Academy of Sciences, Poznan, Poland. Ninth conference in the series. Conference is intended to be an international forum for the presentation and discussion of novel scientific ideas, in a field of broadly understood magnetic phenomena, experimental results, and new magnetic materials. Main objective is to bring together scientists from Western, Central, and Eastern European countries involved in research and application of new magnetic materials and high-temperature superconductors. Special emphasis on novel metallic oxides and anomalous magnetoresistive materials; low-dimensional quantum magnets; heavy fermions, fluctuating valence, and Kondo systems; quantum tunneling and magnetism in nanoscale; magnetic multilayers, surfaces, and nanostructures; high-temperature superconductors; and electronic structure. Plenary talks will be presented by invited distinguished scientists from all over the world. Twenty-five plenary talks and about 200 oral and poster contributions. Proceedings will be published as a special issue of *Acta Physica Polonica.* For information, contact Solid State Theory Division, Institute of Physics, Adam Mickiewicz University, Ul. Umultowska 85, 61-614 Poznan, Poland; telephone +48 61 8 273-041 or -052; telefax +48 61 8 257-758; e-mail rom@alpha.amu.edu.pl or mth@main.amu.edu.pl; Web site http://www.ifmpan.poznan.pl/zp2/main.htm.

Oct. 17 - 19, 1999: 12th International Symposium on Superconductivity (ISS'99), Hotel Metropolitan Morioka, Morioka, Japan. Organized to provide an opportunity for representatives from many countries to freely exchange information, thereby contributing to the advancement of superconductivity and strengthening international cooperation. Symposium will consist of oral and poster sessions, highlighted by a few dozen invited talks on the latest topics related to superconductivity. Will cover the latest findings and related themes in the following research fields of superconductivity: Physics and Chemistry – theory, physical properties, new measurement techniques, vortex physics and weak links, new materials and syntheses, substitution, solid-state chemistry and properties; Bulks – processing, critical current, flux-pinning mechanism, and standardization; Wires and Tapes – processing, critical current, and standardization; System Applications – power, transportation, magnet, magnetic shield, and others; Films and Junctions – processing, properties, lithography, junction fabrication, physics and standardization; Electronics – digital, analog, SQUID, and other electronics devices using HTS and LTS materials. **Abstract deadline, June 30, 1999.** Official language is English. For information, contact 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. Or contact Japan Convention Services, Inc., Nippon Press Center, Bldg. 4F, 2-2-1 Uchisaiwai-cho, Chiyoda-ku, Tokyo 100-0011, Japan; telephone +81 3 3508 1213; telefax +81 3 3508 0820.

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