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NOTA BENE:

Because John Clem, our Science Editor, is on travel, Douglas K. Finnemore, Distinguished Professor of Physics, Iowa State University, has graciously agreed to write "Nota Bene" for this issue.

A Reminder: **This, readers, is the second-to-last issue of *High-T_C Update.* Our final issue will be the April 15, 2000, newsletter. We will continue to maintain our Web site for a few months beyond this date, and will list information on all preprints received after the deadline at our Web site. We will also continue to post new information on upcoming conferences and resources. Please contact the Editor if you have questions.**

Bi-2212

Scanning tunneling microscopy on *Bi-2212* surfaces has been used by B. W. Hoogenboom (Geneva) et al. to study both the shape of the vortex core and the motion of the core as it moves small distances. A very irregular distribution of the positions and shapes of the vortex cores imply strong pinning by defects and inhomogeneities. Some vortex cores seem to consist of two or more randomly distributed elements. Even more striking is the observation of vortex motion where the vortex cores are divided between two positions before totally moving from one position to the other. These effects can be explained by quantum tunneling of vortices between different pinning centers during the averaging time of the scanning tunneling microscopy measurement. This analysis would represent the first microscopic signature of the vortex quantum tunneling as derived from magnetic relaxation measurements, and it is also a further indication that objects of larger size and complexity than one or several atoms can appear as a superposition of different quantum states.

Inelastic neutron scattering studies by H. He (Stuttgart) et al. have revealed a resonant spin excitation in the superconducting state of *Bi-2212*. For an overdoped sample with T_C = 83 K, the mode energy is 38 meV, significantly lower than in optimally doped material with T_C = 91 K and a mode energy of 43 meV. The ratio of the mode energy to the transition temperature is found to be a constant of about 5.4 indicating that the mode energy scales with T_C. This observation helps resolve a long-standing controversy about the origin of the resonant spin excitation in high temperature superconductors. More detailed analysis of the experiment clearly favors the particle-hole over the particle-particle interpretation of the resonant spin excitation peak.

A report by A. D. Gromko (Boulder) et al. describes photoemission results at a photon energy of 33 eV that probe the electron-like and hole-like properties of the Fermi surface topology of *Bi-2212*. The goal here is to resolve the nature of the charge carriers near the zone boundary of the Fermi surface. At this energy, they clearly identify the existence of electron-like portions of Fermi surface near the M point. The hole-like topology cannot explain the details of the spectra, even with the ad-hoc inclusion of strong k-dependent matrix element effects. The energy dependence of the final state matrix elements is discussed in some detail.

The time evolution of the vortex structure in *Bi-2212* has been studied after a sudden application of a magnetic field by D. Giller (Bar-Ilan) et al. using a high temporal resolution magneto-optical system. Images reveal dynamic coexistence of two vortex phases: a quasi-ordered phase in the sample interior, and a transient disordered phase near the sample edges. The border between these two phases is marked by an abrupt change in the gradient of the local induction and changes its position with time. The rate at which this process evolves changes with the location in the field-temperature diagram.

An article by C. E. Gough et al. (Birmingham) reports the intrinsic c-axis tunneling in the superconducting state using mesa structures on the surface of *Bi-2212*. The temperature dependence of the zero-field critical current and quasi-particle conductance is related to microscopic d-wave models in the presence of impurity scattering. The strong field dependence of the c-axis critical current provides information on the correlation of flux pancakes across adjacent superconducting layers. An instability in the current-voltage characteristics is observed below 20 K which accounts for the apparent drop in critical current at low temperatures reported earlier.

Flux pinning enhancement by alkaline-earth cuprate defects as well as nanophase alumina and *Au* particles has been studied by T. Haugan (NIST-Gaithersburg) et al. for thick *Bi-2212* films. The addition of defect particles delayed and reduced the formation of c-axis texture during the growth of the film. Oxide defects were observed to rapidly coarsen in the melt, simultaneously with a beneficial increase of *2212* texture. The addition of nanophase alumina improved the critical current density and the addition of micron size *Au* completely suppressed the *2212* c-axis orientation of the film.

Y-123

As reported by F. Tafuri (Napoli) and J. R. Kirtley (IBM-Yorktown), evidence is found for broken time-reversal symmetry in *Y-123* thin films. They observe spontaneous magnetization with random sign in c-axis oriented thin films imaged with a scanning SQUID microscope. This magnetization arises when the samples become superconducting and appears to be associated with non-magnetic defects in the films. The flux is concentrated in "fractional'' vortices that apparently contain less than the superconducting quantum, a sign of broken time-reversal symmetry. In contrast with the granular high T_c samples, which also show spontaneous magnetization with random signs, these samples shield diamagnetically. These experiments raise the possibility of intentionally introducing time-reversal symmetry breaking effects by, for example, photolithographically patterning small defects in high-T_c samples. This could be applicable to the fabrication of elements of quantum computation opening new perspectives in the design of such devices without necessarily using Josephson junctions.

According to a reprint from R. Liang et al. (U. British Columbia), high purity, highly ordered and twin-free ortho-II phase $YBa_2Cu_3O_{6.5}$ crystals have been successfully prepared and their structural properties characterized by x-ray diffraction. Removal of the twin boundaries was found to be essential in order to obtain highly ordered ortho-II crystals. The ortho-II phase shows a sharp superconducting transition at 62 K, 5 K higher than the ortho-I phase of the same oxygen content. The ordering was found to be three dimensional with long correlation lengths. No doubling of the unit lattice along the c-direction was observed, indicating an attractive interaction between oxygen ions in adjacent basal planes.

Oxygen ordering and the 60 K plateau on the ortho-II phase of *Y-123* also was reported by F. Yakhou (Grenoble) et al. for oxygen contents between 6.48 and 6.62. The best sample exhibits correlation lengths up to 70 unit cells along the a-axis and 5 unit cells along the c-axis. The superstructure peaks are resolution limited in the k-direction.

Local structural changes in *Li*-doped *Y-123* have been studied by F. Maury (Ecole Polytechnique) et al. by neutron powder diffraction. When synthesized in oxygen, *Li* substitutes for *Cu* in the copper oxide planes. When synthesized in air, about 20% of the *Li* substitutes for *Cu* on the copper oxide chains. Best fits to the spectra are obtained assuming that each substitution of a *Li* for a *Cu* entails the loss of an apical oxygen.

Theory

A simple model has been developed by I. Martin and A. V. Balatsky (Los Alamos) to describe the scanning tunneling microscope experiments that probe impurity sites of a single *Ni* atom replacing the *Cu* atom in the copper oxide plane. They find that to explain the experimental data, they need to include both the non-magnetic scattering of carriers from the *Ni* site as well as spin interaction between the carriers and the impurity spin. The most striking feature observed in the experiment – the rotation of the "impurity cross" as a function of bias – appears to be a universal function of the theoretical model. This rotation is the manifestation of the quantum-mechanical nature of the quasiparticles in the superconducting state, and is a consequence of the unique dual particle-hole composition of the quasiparticles.

The connection between angle-resolved photoemission experiments and the theory of high-temperature superconductors is discussed by E. Abrahams (Rutgers) and C. M. Varma (Bell Labs). The data are found to be consistent with a phenomenological description of the normal state of these materials as marginal Fermi liquids. A connection is drawn between the experiments and various constraints on microscopic theories.

As reported by X. Hu and M. Tachiki (NRIM-Tsukuba), extensive Monte Carlo simulations show that there is a critical value of the product of the anisotropy parameter and the magnetic field in interlayer Josephson-vortex systems in high-T_c superconductors. Below a critical value, the thermodynamic phase transition between the normal and superconducting state is first order and above this critical value, it is second order. According to present results, the phase transition in Josephson-vortex systems in *Y-123* is first order up to 50 T, while it varies from first to second order in *Bi-2212* at about a field of 1.7 T.

An analysis of optical conductivity data by E. Schachinger (Graz) and J. P. Carbotte (McMaster) has provided evidence for coupling of charge carriers to the 41 meV spin resonance seen in the superconducting state for a number of high-temperature superconductors. Analysis originally done for optimally doped *Y-123* is extended to *Y-124, Tl-2201,* and *Bi-2212*. A more specific interpretation of the optical

data in terms of a spin fluctuation exchange mechanism of superconductivity gives an underlying effective spectral density which is strongly temperature dependent and which contains important feedback effects that further stabilize superconductivity as the temperature is reduced.

A manuscript by W. A. Atkinson (Gainesville) et al. reports a numerical study of disorder effects in a 2D d-wave BCS superconductor. They compare exact diagonalization calculations of the density-of-states with the standard perturbative T-matrix approximation. Local suppression of the order parameter near impurity sites which occurs in self-consistent solutions of the Bogoliubov-deGennes equations, leads to apparent asymptotic power law behavior $\rho(E) \sim |E|^{\alpha}$.

Conductivity due to classical phase fluctuations in a model for high-temperature superconductors is studied by S. Barabash (Ohio State) et al. They show that the integral of the real part of the conductivity over all frequencies is not zero below the superconducting transition temperature providing that there is some quenched disorder in the system. Furthermore, for a fixed amount of quenched disorder, this integral at low temperature is proportional to the zero-temperature superfluid density in agreement with experiment.

The distribution of magnetic induction in the Meissner state with finite London penetration depth is analyzed by R. Prozorov (Illinois) et al. for platelet samples of rectangular cross-section in a perpendicular magnetic field. The exact 2D numerical solution for the London equation is extended to the realistic 3D case and compared to real foils and single crystals.

Thin Films

Raman and x-ray measurements have been used by G. Gibson (Imperial College) et al. to study the cation disorder in epitaxial *Y-123* thin films grown at different temperatures to give different c parameters. The Raman intensity ratio (585)/(340) is found to correlate with the x-ray intensity ratio (005)/(006) which is known to measure the cation disorder. Raman has the advantage of a spatial resolution of about 1 μm and changes in oxygen content do not affect the Raman method. Because the x-ray method gives global information and Raman is a near surface measurement, the two techniques are complementary.

As reported by H.-W. Yu (National Taiwan U.) et al., atomic force microscopy has been used to investigate the correlation between the characteristics of grooved $SrTiO_3$ bicrystal line and grain boundary microstructure for junction preparation in *Y-123* films. When the underlying groove becomes deeper and steeper, the density-of-growth spirals along the boundary line increases and the meandering configuration of the grain-boundary disappears. From the measured signals of the dc-SQUID patterned on the films, they also conclude that the homogeneity of the grain-boundary is improved.

Pulsed-laser deposition of *Y-123* thin films and step-edge Josephson junctions has been studied by T. Schmauder et al. (Jena) in order to determine the influence of the angle between the target and the substrate orientation on the properties of the junction. By increasing the angle of growth, they find a shift of the optimal growth conditions toward higher laser pulse energy. Step-edge Josephson junctions prepared from *Y-123* films which were deposited at different angles show a maximum product of critical current and normal resistivity at an angle of 20° to 45°.

In a preprint by F. M. Granozio (Napoli) et al., the authors show that reducing the degree of symmetry of the surface, by choosing a suitable miscut angle between the substrate and the crystal plane, *Y-123* films showing a single or at least a preferential domain can be obtained. The driving force that determines the domain selection is discussed.

The response of *Y-123* bicrystal grain-boundary junctions to small dc magnetic fields has been probed by H. Xin (MIT) et al. with a low power microwave signal of 4.4 GHz. Peaks in the microwave loss at certain dc magnetic fields are observed that result from individual Josephson vortices penetrating into the grain-boundary junction under study. The system is modeled as a long Josephson junction described by the sine-Gordon equation with appropriate boundary conditions, and excellent agreement between data and the model is obtained.

Ion-beam sputtering has been used by T. Endo et al. (Mie University, Japan) to prepare films of *Y-123* at the low substrate temperatures of 450-650°C with a supply of oxygen molecules or plasma. The growth of the a-axis oriented phase was enhanced by the plasma and films could be grown with substrate temperatures as low as 450°C. Non-thermal energy from the kinetic energy of the ions and molecules provide the excitation energy required to form the a-axis structure at these temperatures.

A model has been developed by X. J. Chen (Hong Kong) et al. to describe the thickness dependence of the superconducting transition temperature of *La-214* thin films. Strain and the resulting lattice mismatch plays a key role in this model. Calculations show that the values of T_c of films on $SrLaAlO_4$ substrates under compressive strain are always higher than those on $SrTiO_3$ under tensile strain. As the thickness is reduced, the films grown on $SrTiO_3$ substrates exhibit a rapid reduction of T_c whereas T_c increases on the $SrLaAlO_4$ substrates. Theoretical results are in qualitative agreement with experiment.

Anisotropic arrays of antidots have been prepared on *Y-123* and *Nb* thin films by electron-beam-lithography by S. Kolesnik (Warsaw) et al. in order to study the flux pinning effects. Fast-Fourier-Transform analysis of the magnetization curves reveals their periodic character which corresponds to the matching effect of the vortex lattice. These observations strongly suggest the formation of anisotropic vortex lattices in the patterned thin films.

Applications

Texture development in pure *Ag* has been investigated by H. L. Suo (Geneva) et al. in order to produce a stable {110}<112> biaxially textured ribbon that can be used as a substrate for *Y-123* coated tapes without a buffer layer. The starting material was 99.95% pure commercial *Ag* foil. A 20% deformation reduction was used at each step of the cold-rolling process after which an optimal annealing was achieved at 800°C for 4 hours in a primary vacuum. This leads to large grain ribbons with {110}<112> orientation. X-ray pole figures show a full width at half maximum of 6°. A twinning mechanism is used to explain the texture. The texture is retained on further heating to 900°C which is a practical temperature for coated tape preparation.

A preprint by D. Liu et al. (Beijing) reports the fabrication of biaxially textured {110}<211> *Ag* tapes suitable for *Y-123* coated conductors. The annealing temperature of 550°C is optimal but 700°C also is satisfactory. Using a pulsed-laser deposition method, *Y-123* coatings were deposited on the tape that gave 5×10^5 A/cm^2 at 77 K and 0 T.

Contributed by D. K. Finnemore

Contents:

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

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.

Recently, Superconductor Technologies Inc. (STI) announced that it has signed a supply agreement with ALLTEL Communications Products under the terms of which ALLTEL will designate STI as their supplier of high-temperature-superconductor (HTS) base-station-receiver solutions for their analog and CDMA cellular and PCS networks. ALLTEL, a pioneer in the deployment of superconducting technology in a cellular network, completed extensive evaluations of several cryogenic filter systems in 1999 by reviewing product performance, network impact, cost of ownership, reliability, and vendor strength. Measurable improvements in coverage, minutes of use, and customer satisfaction have been noted deploying the SuperFilter(R) at several sites. For further information, contact Superconductor Technologies Inc., 460 Ward Drive, Suite F, Santa Barbara, CA 93111-2310; telephone (805) 683-7646; telefax (805) 683-8527; Web site at http://www.suptech.com.

Contributed by Sreeparna Mitra

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.)*

**May 22 - June 2, 2000:* NATO-ASI Modern Trends in Magnetostriction Study & Application, Kiev, Ukraine. Objectives: (1) to determine the state of the art of the basic and applied research of magnetostriction and related phenomena, (2) to define and prioritize directions of investigation for the future, (3) to consider new materials for common applications of magnetostriction-based devices, and (4) to formulate new perspectives on magnetostriction phenomena and applications, using advances in materials design and technology. For information, contact Institute for Low Temperature Physics & Engineering, 47 Lenin Avenue, 310164 Kharkov, Ukraine; telephone +380 572 321 223; telefax +380 572 322 370; e-mail ASI-2000@ilt.kharkov.ua.

**May 28 - June 2, 2000:* International Conference on Transport Processes in Inorganic Materials: Fundamentals to Devices, Venice (Jesolo Beach), Italy. Objective is to discuss recent developments in microscopic mechanisms of transport in different inorganic materials; assess the role of transport in materials reactivity, synthesis, and processing; explore the transport mechanisms which affect materials properties and behavior under operating conditions; and exploit the role of transport processes in a number of advanced technologies of current or emerging interest. Papers to be presented in several areas, including diffusion and transport in media of lower dimensionality, single-crystal growth, materials processing for HTS materials, and superconducting devices for high- and low-field applications. For information, contact CIMTEC-Transport Phenomena Conference, P.O. Box 174, I-48018 Faenza, Italy; telefax +39 0546 664138.

June 5 - 9, 2000: XVII Sitges Conference on Statistical Mechanics (SITGES Euroconference) – Coherent Structures in Classical Systems, Sitges, Barcelona, Spain. Conference will be centered in statistical and dynamical aspects of classical systems presenting coherent structures or patterns, with special emphasis on those appearing in the following fields: combustion, turbulence, patterns in fluids, crystal growth, granular flow, and biological systems. Number of participants limited to 100. Conference can provide financial support to selected young researchers from EC countries (age below 35). For further information contact Prof. Miguel Rubí, Dept. Física Fonamental, Universitat de Barcelona, Av. Diagonal, 647, E-08028 Barcelona, SPAIN; telephone +34 93 402 11 62; telefax +34 93 402 11 49; e-mail sitges17@precario.ffn.ub.es; Web site http://precario.ffn.ub.es/~sitges or http://www.ffn.ub.es/~sitges.

**June 20 - 22, 2000:* 11th International Cryocooler Conference (ICC11), Keystone Resort and Conference Center, Keystone, Colo. Technical program will consist of oral and poster sessions. Invited technical topics include Stirling and Pulse-Tube cryocoolers, J-T and G-M cryocoolers, new cryocooler concepts, cryocooler component developments, modeling and test techniques, performance and life test data, applications and integration issues, space flight cryocoolers, and low cost cryocoolers. Oral and poster sessions. For information, contact Rodney L. Oonk, ICC11, Ball Aerospace Systems Division, P.O. Box 1062, Boulder, CO 80306-1062; telephone (303) 939-4449; telefax (303) 939-6307; e-mail iccchair@cryocooler.org.

**July 1 - 6, 2000:* Future Perspectives of Superconducting Josephson Devices – EuroConference on Physics and Applications of Multi-Junction Superconducting Josephson Devices, Aquafredda di Maratea, Italy. The conference will be dedicated to an advanced discussion of the present state-of-the-art and future perspectives of superconducting Josephson electronic devices with particular attention to their impact in technological and industrial applications. Sessions will provisionally include physics of superconducting Josephson devices, flux-flow and high-frequency devices, low-frequency devices and SQUIDs, RSFQ devices, and unconventional applications. Maximum 100 participants. A number of grants available for young scientists from European Community countries and Associated States. To apply, contact Josip Hendekovic, 2 quai Lezay-Marnésia, F-67080 Strasbourg Cedex, France; telephone +33 388 76 71 35; telefax +33 388 36 69 87; e-mail euresco@esf.org; Web site http://www.esf.org/euresco/.

**July 1 - 9, 2000:* 6th Advanced Studies on Superconducting Engineering (ASSE2000), Eger, Hungary. Detailed studies on the newest results and their engineering aspects both in fundamental research and applications of high-temperature superconductors. The main frame is a series of lectures held by well-known scientists, researchers, engineers, and experts. After lectures, the unique "Club of Scientists" will be organized to provide time for free discussions. The last three days of the Studies will be devoted to a workshop for each participant willing to present the results of her/his work. The purpose of ASSE2000 is: to introduce a wide range of aspects of superconducting engineering to interested people; to get together researchers, engineers, students, lecturers, and scientists to discuss new results and ideas in the HTS field; and to make new friendships and create a partnership among participants. After ASSE2000, a special two-day (July 10-11, 2000) satellite workshop will be held on Superconducting Flywheels – all participants are invited to attend. Contact Dr. István Vajda,

Department of Electrical Machines and Drives, Technical University of Budapest, H-1111 Budapest, Egry József u. 18., Hungary; telephone +36 1 463-2961; telefax +36 1 463-3600, e-mail vajda@supertech.vgt.bme.hu.

July 3 - 28, 2000:* United States Summer School in Condensed Matter and Materials Physics, Boulder, Colo. New summer school for graduate students and postdocs in condensed-matter and materials physics has been established and will be held annually in Boulder. This first one is entitled *Introduction to Superconductivity: Fundamentals and Applications.* Main themes of the school will be basic principles of superconductivity, quantum dynamics of vortices and electrons, vortices in D > 2 and critical phenomena in superconductors, high-temperature and other unconventional superconductors, physics and applications of vortex dynamics, nonequilibrium superconductivity, mesoscopic and nanoscale superconducting systems, materials, applications, and devices. **Application deadline, May 1, 2000. Most local expenses will be covered by the summer school (supported by the National Science Foundation, University of Colorado at Boulder, NIST, and Lucent). For further information, contact Z. Tesanovic, Department of Physics and Astronomy, 315 Bloomberg Center, Johns Hopkins University, 3400 North Charles Street, Baltimore, MD 21218-2686; telephone (410) 516-5391; telefax (410) 516-7239; e-mail cmsummer@pha.jhu.edu or zbt@pha.jhu.edu. For details and application forms see Web site http://www.indiana.edu/~uscmpsc/.

Sept. 25 - 30, 2000:* Third International Conference on Stripes and High-T_c Superconductivity (STRIPES2000), University of Rome "La Sapienza," Rome, Italy. Follows previous conferences held during December 1996 and June 1998. Intends to bring together active researchers in the field of stripes and high-T_c superconductivity in order to discuss the latest experimental and theoretical developments, and implication of the stripe phenomena to the future technology. Main topics include stripes formation in perovskites, pairing and stripes, advanced experiments for probing stripe phases, and superconductivity in low dimensions. Meeting will cover various aspects of natural and artificial stripes and charge-ordering phenomena in the cuprates, manganites, nickelates, and other related materials. Topics include stripes in a doped antiferromagnetic lattice, stripes in a polarized electron gas, coexistence of stripes and superconductivity, polaron ordering and lattice-charge instabilities, stripes and Wigner metal-insulator transitions, pairing-mediated by spin fluctuations, pairing-mediated charge fluctuations, superconducting fluctuations in striped phases, superconductivity in mesoscopic metals, superlattice of quantum stripes, and mechanisms for T_c amplification. Various experimental techniques to probe the stripes will be discussed, which include neutron, electron, and x-ray scattering; NMR/NQR, μSR, and high-frequency probes; x-ray and optical spectroscopy; and photoemission. The scientific program of the conference will include invited and contributory talks and some poster presentations. **Abstract deadline, May 30, 2000; preregistration deadline, June 15, 2000. Conference chair: Antonio Bianconi. For information, contact Anna De Grossi, Conference Secretary, Piazzale Aldo Moro 2, I-00185 Rome, Italy; telephone +39 06 49914343; telefax +39 06 49914387; Web site http://www.bianconi.net.

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New Book: *Introduction to Unconventional Superconductivity,* by V. P. Mineev and K. Samokhin. Unconventional superconductivity (or superconductivity with a nontrivial Cooper pairing) is believed to exist in many heavy-fermion materials as well as in high-temperature superconductors, and is a subject of great theoretical and experimental interest. This book is intended to meet this information need and includes the authors' original results. Contents divided into two parts: Part I – Cooper pairing, spin states of pairs, superfluid helium-3 phases, superconducting states in crystals, energy of elementary excitations, energy gap and critical temperature, low-temperature behavior of thermodynamical values, manifestations of parity of electrons number, spin susceptibility and Knight shift, Landau expansion of free energy, multicomponent superconducting states, Ginzburg-Landau equations and the problem of upper critical field, boundary conditions and surface superconductivity, Meissner and mixed states in unconventional superconductors, magnetic superconductors, and Josephson effect. Part II: Gor'kov Equations, Ginzburg-Landau functional, upper critical field in p-wave superconductors, boundary conditions for the order parameter, influence of impurities, and thermal conductivity of unconventional superconductors. Readership: Researchers in theoretical physics, especially condensed matter and superconductivity. Publ. 1999; 200 pp.; price $68,; ISBN 90-5699-209-0. Contact Gordon and Breach Science Publishers, PTT, P.O. Box 566, Williston, VT 05495-0080; telephone (800) 326-8917; telefax (802) 864-7626; e-mail book.orders@aidcvt.com; Web site http://www.gbhap.com.

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