Meeting Report: Low Energy Electrodynamics in Solids (LEES '02)

October 13 - 18, 2002

The 5th International Meeting on the Low Energy Electrodynamics in Solids (LEES) was held in Montauk, NY (USA) during the week of October 13-18, 2002. Nearly 100 scientists from the U.S., Canada, Europe and Asia traveled to the eastern end of Long Island to participate in the meeting. Historically, the LEES meetings have provided a forum for infrared (especially the far-infrared) spectroscopy of solids. During the dozen years since the inception of the LEES meeting series, the use of infrared synchrotron radiation for spectroscopy has flourished. At the same time, the energy resolution for angle-resolved photoemission spectroscopy and x-ray inelastic scattering has increased to the point that they are now powerful tools for the study of low energy phenomena. Consequently, it was no surprise that 20% of the presentations directly involved the use of synchrotron facilities.

K. Alex Muller (Zurich), the Nobelist for the discovery of the high T_c superconductors, delivered opening remarks and chaired a session addressing both spectroscopy in high magnetic fields and electron spin resonance (ESR). In this session, Laszlo Mihaly (Stony Brook) described how ESR is enhanced when coupled with very far-infrared synchrotron radiation and a high-resolution spectrometer. Jack Crow (NHMFL) surveyed the capabilities at the National High Magnetic Field Laboratory in Florida and New Mexico, including infrared and microwave spectroscopy, and also described plans for new European facilities. Many of the meeting attendees agreed that the addition of high-field magnets at synchrotron radiation beamlines would significantly advance the study of electronic and magnetic properties of materials.

Several sessions addressed electronic band structure, superconducting energy gaps and quasiparticle lifetimes in correlated electron systems. Walter Hardy (British Columbia) presented microwave spectroscopy results on the low energy electronic scattering in the high-T_c superconductor $YBa_2Cu_3O_{7-\delta}$ (YBCO) that agrees with a d-wave energy gap. High-resolution photoemission was the subject of presentations by Jim Allen (Michigan) and Tony Valla (Brookhaven), who each studied quasiparticle lineshapes in systems having reduced dimensionality. Juan Campuzano (Argonne) and Alessandra Lanzarra (Berkeley) discussed photoemission results for high-T_c superconductors, including electron-phonon interactions. Phonons and their interaction with electrons were also the focus of presentations by the Brookhaven infrared group (Chris Homes and Jiufeng Tu), and a

Some of the LEES 02 conference attendees enjoying a crisp October day in Montauk.

generalized theory for extracting electron self energies from infrared and optical reflectance data was described by Frank Marsiglio (Alberta).

Charge inhomogeneity was another recurring theme of the meeting. Sophie DeBrion (Grenoble) described a study of phase separation in manganites using ESR as a probe. S. Sridhar (Northeastern) explained his group's microwave measurement results for a variety of high-T_c cuprates in terms of charge/stripe ordering and inhomogeneity. Setsuko Tajima (ISTEC-Tokyo) used far-infrared spectroscopy to study the low frequency absorption in $La_{2-x}Sr_xCuO_4$, and suggested that charge inhomogeneity may explain the excess absorption observed at low frequencies in the superconducting state. This excess absorption has consequences for optical sum rules and calculations of the condensate energy for superconductors. Dirk Van der Marel (Groningen) discussed the shift in spectral weight observed in the optical conductivity of systems undergoing a phase transition. The energy scale over which the spectral weight shifts is expected to be a measure of the energetics driving the phase transition itself. Andy Millis (Columbia) presented a more detailed theoretical discussion of the f-sum rule and its application to perovskites. Optical sum rules are also being used by Dimitri Basov (San Diego) to understand ferromagnetism in $Ga_{1-x}Mn_xAs$ and other magnetic III-V semiconductors. In all cases, accurately tracking spectral weight was dependent on precise spectroscopic data to very low frequencies.

John Hill (Brookhaven) and George Sawatzky (British Columbia) each described synchrotron x-ray studies of low-dimensional, correlated electron systems. John Hill used resonant inelastic x-ray scattering to study electronic excitations, achieving 0.3 eV energy resolution, sufficient to observe cross-gap excitations and excitons. In contrast to infrared, the larger momentum of x-rays allows one to probe k-space away from the zone center and track the dispersion of various excitations. George Sawatzky discussed x-ray absorption spectroscopy, using the facilities at the X1B beamline of the NSLS, to probe charge order in highly correlated electron systems. The ideas of stripe order, reduced dimensionality, and high-T_c superconductivity were nicely tied together in a theory presentation by Steve Kivelson (UCLA).

Superconductivity in MgB_2 continues to attract interest, with increasing evidence for multiple energy gaps. Leo Degiorgi (ETH-Zurich) used infrared reflectivity measurements on a mosaic of MgB_2 crystals, and detected a rather small energy gap. Ferenc Simon (Budapest) used ESR and microwave absorption to study electronic scattering and the critical field for MgB_2 powders. Conventional metallic behavior was observed in the normal state, but the magnetic field dependence in the superconducting state suggests a significant field-induced normal component, evidence for critical field anisotropy. Other presentations by Jure Demsar (Los Alamos) and Larry Carr (NSLS - Brookhaven) described time-resolved studies of non-equilibrium dynamics in MgB_2. Photoexcitation drives the electronic system away from equilibrium, and the relaxation process is probed by synchrotron THz spectroscopy. Whether the system was strongly perturbed (Demsar) or weakly perturbed (Carr), the relaxation process pointed to at least two energy gaps.

The main conference room at the Montauk Yacht Club was just sufficient for the nearly 100 participants.

Time-resolved spectroscopy was also discussed in the final session of the meeting. Joe Orenstein (Berkeley) has studied the relaxation of photoexcited excess quasiparticles inYBCO and BiSrCaCuO high-T_c superconductors using 100 fs laser pulses and THz pulses. In contrast to s-wave (isotropic) superconductors, the excess quasiparticles do not experience a phonon bottleneck that typically masks the intrinsic quasiparticle recombination rates. Rick Averitt (Los Alamos) presented a time-resolved study of collosal magneto-resistance manganites using laser-produced THz pulses. Optical excitation leads to a decrease in the far-IR conductivity, corresponding to a shift in spectral weight into the near-IR. The relaxation mechanism was found to depend on the magnetic state of the material (via spins below T_c and phonons above T_c). Time-resolved spectroscopy using pulsed infrared synchrotron radiation was described by David Tanner (Florida), and results for both electron-hole recombination (semiconductors) and excess quasiparticle recombination (superconductors) were presented.

Efforts are underway at many synchrotron facilities to produce shorter duration pulses of light for time-resolved spectroscopy. When the electron bunches are very short, coherent synchrotron radiation (CSR) at THz frequencies results. Gwyn Williams (Jefferson Lab) described measurements of high power THz produced as CSR in their energy recovery linac. A combination of relativitistic effects, plus the high average current of their accelerator, led to an average output power of 20 watts. Gwyn described a variety of applications in solid state physics as well as THz imaging. CSR has been observed in storage rings too, but the average beam current must be kept quite low to avoid bunch-shape instabilities. Still, the resulting sub-THz radiation may prove useful for some experiments, including time-resolved spectroscopy. Mike Martin (ALS) described an idea for a new storage ring dedicated to infrared spectroscopy, including a "coherent mode" for producing sub-picosecond duration pulsed THz radiation.

Despite the stormy weather on Wednesday, many of the conferees attended a winery tour where they were introduced to some local wines and pleasant scenery. Following the conference banquet that evening, the participants were treated to a concert by Zurab Ninua (Baritone) and Natia Astakhishvili (pianist), who performed musical selectrions from the works of Mozart, Tchaikovsky, Verdi and others. The meeting concluded with a Friday afternoon tour of the infrared and photoemission beamlines on the VUV-IR ring at the NSLS, and discussions on spectroscopy instrumentation and techniques. The solid state physics community looks forward to the next LEES meeting which is planned for the summer of 2004 in Germany.

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-G. Lawrence Carr