Highlights From the March 2002 American Physical Society Meeting

March 18 - 22, 2002

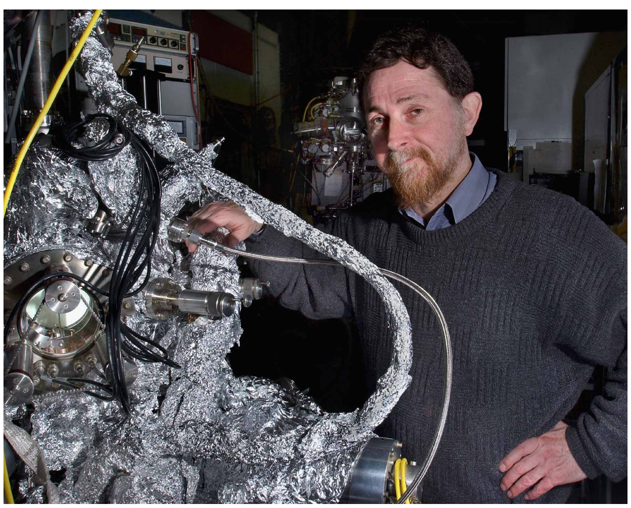
The stories below describe five of the more than 50 scientific presentations given by BNL scientists at the American Physical Society (APS) March meeting in Indianapolis, Indiana.

New Spin on High-Temperature Superconductors

Understanding what holds electron pairs together in high-temperature (high-T_c) superconductors is one of the biggest problems in condensed matter physics, says BNL physicist Peter Johnson, who is searching for the explanation.

Like traditional superconductors, high-T_c superconductors can carry electrical current with no resistance, or loss. But high-T_c superconductors operate at temperatures where liquid nitrogen, rather than expensive liquid helium, can do the cooling. This difference would decrease the cost of and increase potential applications for superconducting materials. But the first step is to understand the mechanism.

Johnson's National Synchrotron Light Source (NSLS) research indicates that electron "spin" plays an important role. Rather than exchanging vibrations with the crystal lattice (the mechanism for electron pairing in traditional superconductors), electron pairs in

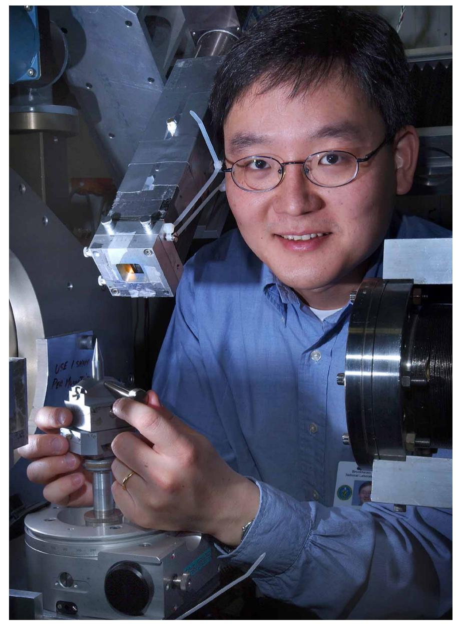


Peter Johnson

high-T_c materials interact by affecting the spin of atoms in the lattice. Understanding the role of spin has the potential to revolutionize our thinking about the transfer of electrical current, Johnson says.

Electron Excitations in High-Temperature Superconductors

BNL physicist Young-June Kim is studying the collective behavior of electrons in materials closely related to high-T_c superconductors. He uses resonant inelas-



Young-June Kim

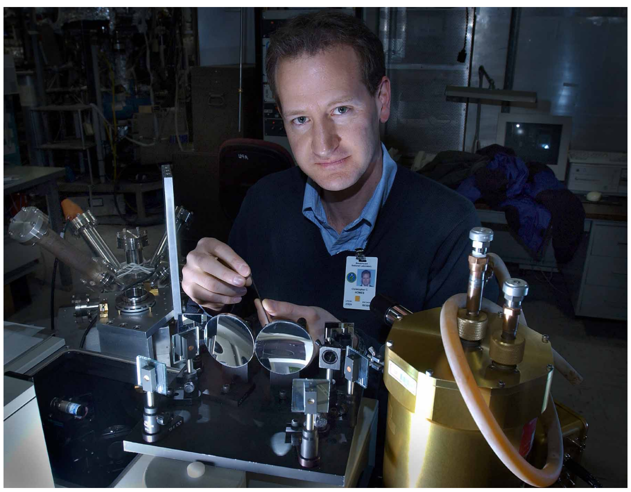
tic x-ray scattering (RIXS), a technique developed at the NSLS, to understand how electrons are moving around in the system. By comparing the energy of x-rays beamed into a sample and those coming out, this sensitive technique measures how much energy is transferred to the electrons in the material.

The absorbed energy can result in a variety of excitations, which can be distinguished by RIXS. Kim is using the technique to study lanthanium copper oxide, an insulating material, and looking at how the excitations change as the material is transformed to a high-T_c superconductor by gradually substituting strontium atoms for lanthanum atoms. With improved sensitivity, the technique may help reveal the mechanisms behind high-T_c superconductivity.

Material with Unusual Electrical Properties Holds Up to Scrutiny

An unusual material with an extremely high dielectric constant, which may have applications in high-performance capacitors and miniaturized electronics, first described last July by BNL physicist Christopher Homes has stood up to further scrutiny. The material's enormous dielectric constant - a property that determines it's ability to separate positive and negative electrical charges, or become polarized - is apparent even in thin films of the material, which are the form necessary for applications in microelectronics.

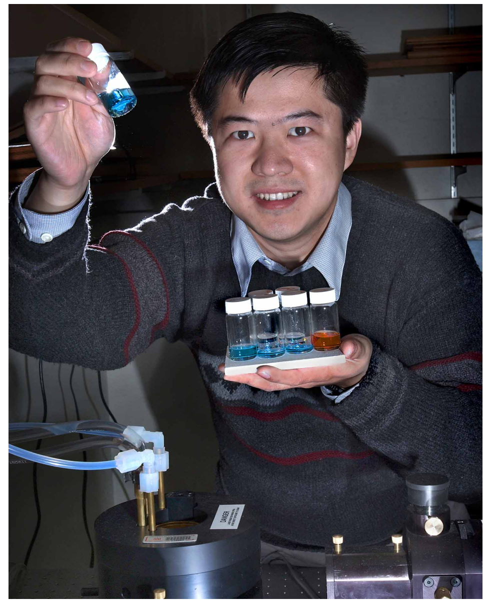
The scientists are now studying how the material changes as the chemical composition is altered. This will allow them to separate intrinsic from extrinsic effects and to zero in on the mechanism responsible for the large dielectric constant, Homes says.



Christopher Homes

Giant Nanomolecule Discovered by Accident

"Giant nanomolecules" may sound like an oxymoron, but these relatively large inorganic structures may provide big benefits for nanoscience, says BNL physicist Tianbo Liu. Measuring 5.1 billionths of a meter in diameter and covered with large pores, the spherical, cagelike molecules may be useful as "containers" for studying chemical reactions at the nanoscale. The molecules are themselves magnetically active, and can be used to create even stronger magnetic materials by loading other compounds inside. One possible application: contrast agents in magnetic resonance imaging (MRI).

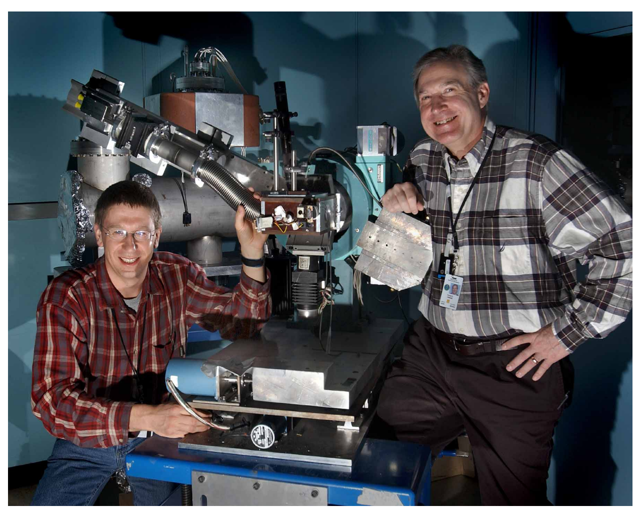


Tianbo Liu

Liu and his collaborators discovered the giant nanomolecules at the NSLS and using transmission electron microscopy. The particles' orderly arrangement tipped the scientists off that they were seeing something unique: nanoparticles with a uniform size. Ordinary nanoparticles vary in size. But these particles are molecules, with a definite molecular structure, so they are made the exact same way every time. Having one-size particles is an advantage when studying and finding applications for nanoscale properties, which are generally dependent on particle size.

Seeing Hidden Structure in Liquid Crystals

Liquid crystals, the materials used in laptop computer screen displays, optical networking devices, and other applications, are composed of rod-shaped mol-



Wolfgang Caliebe and Ron Pindak

ecules with the ability to change their orientation (the direction in which they "point") in response to an electric field. In many cases, these oriented molecules also form layers. The arrangements of these layers and orientations of molecules within them determine the materials' optical properties, says BNL physicist Ron Pindak.

Until now, some of the structural details of liquid crystals have been "hidden," because conventional x-ray scattering can detect the layers, but not the orientation of individual molecules within the layers. Moreover, often the orientation changes over very short distances, making it invisible to an optical microscope. But Pindak's "resonant polarized x-ray diffraction" experiments at the NSLS are starting to reveal these hidden structural details. Understanding these details will allow scientists to improve the design of liquid crystal materials, possibly leading to higher-definition video displays or faster optical conditioning devices.

- Karen McNulty Walsh

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