FAST BREAKING PAPERS - 2008

August 2008

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Ali Yazdani talks with *ScienceWatch.com* and answers a few questions about this month's Fast Breaking Paper in the field of Physics. The author has also sent along images of their work.

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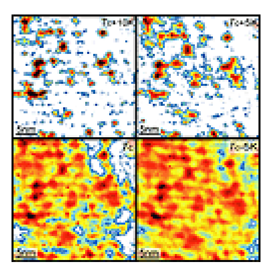
Article Title: Visualizing pair formation on the atomic scale in the high-T-c superconductor Bi2Sr2CaCu2O8+delta
Authors: Gomes, KK;Pasupathy, AN;Pushp, A;Ono, S;Ando, Y;Yazdani, A
Journal: NATURE
Volume: 447
Issue: 7144
Page: 569-572
Year: MAY 31 2007
* Princeton Univ, Joseph Henry Labs, Dept Phys, Princeton, NJ 08544 USA.
(addresses have been truncated)

SW: Why do you think your paper is highly cited?

This paper describes the use of newly developed experimental techniques to watch superconductivity—the phenomena of flow of electricity without resistance—develop on the atomic scale in a superconducting material.

The material system we studied is a ceramic superconductor, the mechanism for which has been the subject of intense debate for the last 20 years within the physics community. Perhaps the combination of a newly developed technique together with unraveling new microscopic information on the enigmatic ceramic superconductors has contributed to the paper's high citation rate.

Figure 1: + details



SW: Does it describe a new discovery, methodology, or synthesis of knowledge?

The paper described both a new methodology for studying superconductivity and an important new finding. Specifically, the paper shows how the superconducting state forms, starting with small nanoscale patches with superconducting-like properties in the material, at temperatures far higher than had been anticipated before.

It has often been assumed that the transition temperature where samples exhibit zero resistance is when superconducting behavior first occurs. This paper shows that, at temperatures well above the bulk transition temperature, if one looks carefully using specialized tools and techniques, we can identify nanoscale puddles of superconducting behavior up to very high temperatures. There had been hints of superconducting "fluctuations" above the transition temperature but "seeing" them with our technique has been a significant advance and an example of more direct evidence for this behavior.

SW: Would you summarize the significance of your paper in layman's terms?

Superconductivity, the ability to carry electricity without resistance, can have a significant impact on the future distribution of electrical energy. It can play a role both in making power transmission lines more efficient, yet also provide the technology which can make them more immune to the failure that causes power outages.

However, any realistic application requires the development of superconductors with higher transition temperatures and better current-carrying properties than are available today. Understanding the mechanism of superconductivity in the highest temperature superconductors is hence significant in achieving advances in this area. Our finding that the nanoscale region of a ceramic material can exhibit superconducting behavior at temperatures higher than anticipated can perhaps be used to develop new materials with higher superconducting transition temperatures.

"...the paper shows how the superconducting state forms, starting with small nanoscale patches with superconducting-like properties in the material, at temperatures far higher than had been anticipated before. "

SW: How did you become involved in this research, and were there any problems along the way?

I have been fascinated by superconductors for the past 20 years, and I have been very interested in the last 10 years in developing the tools to study superconductors on the atomic scale. This research was made possible with the development of a new generation of scanning tunneling microscope (STM), which can be used to study evolution of electronic phenomena while varying temperature. The most significant challenge we had to overcome was to develop an STM that can track the same atom on the sample, while the temperature was being varied and the sample was undergoing thermal expansion and contraction.

SW: Where do you see your research leading in the future?

Our ability to correlate atomic scale properties together with superconducting properties will be quite useful in understanding the mechanism of pairing in high-temperature superconductors as well as in the design of new superconductors to be discovered at some point in the future. In addition, the experimental tool we have developed can be used to examine a variety of other phase transition phenomena in materials—such as magnetic transition—with atomic scale resolution. We are currently busy working on these two fronts.

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Keywords: high-T-c superconductor, high-temperature superconductors, superconductivity, atomic scale, superconducting material, ceramic superconductor, bulk transition temperature, power transmission lines, scanning tunneling microscope, STM, magnetic transition.

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2008 : August - Fast Breaking Papers : Ali Yazdani - Figures & Descriptions

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Figures and descriptions:

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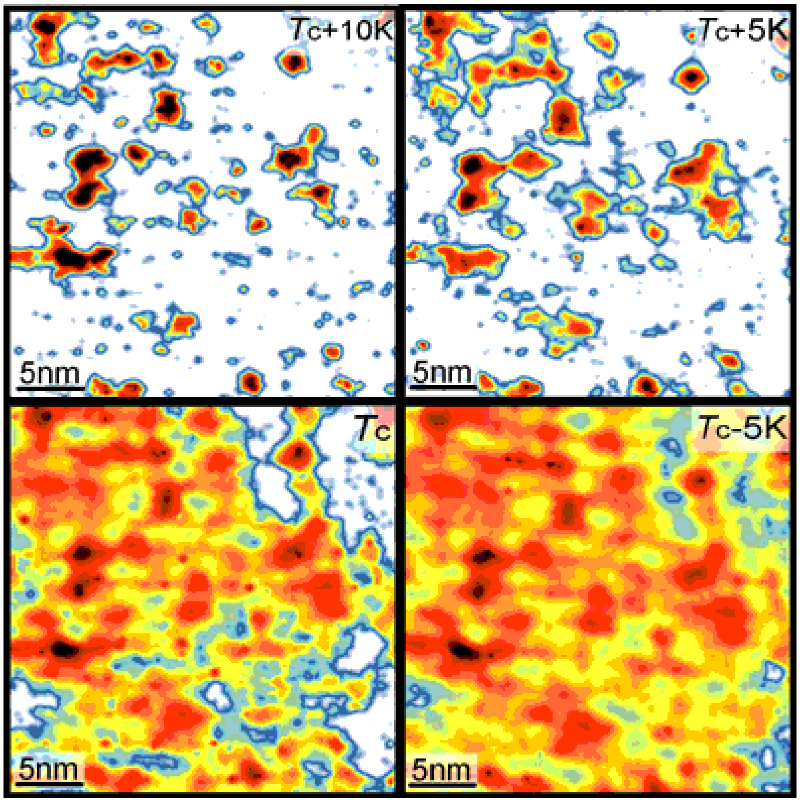

Figure 1:

Using a customized microscope, Princeton scientists have mapped the strength of current-carrying electron pairs as they form in a ceramic superconductor. The images show the same 30-nanometer square region of the ceramic at successively cooler temperatures. Red areas indicate the presence of superconducting pairs. Even at 10 degrees Celsius above Tc, the temperature at which the entire sample exhibits superconductivity, the electron pairs still exist in localized regions (top image). Image courtesy of the Yazdani Group.

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