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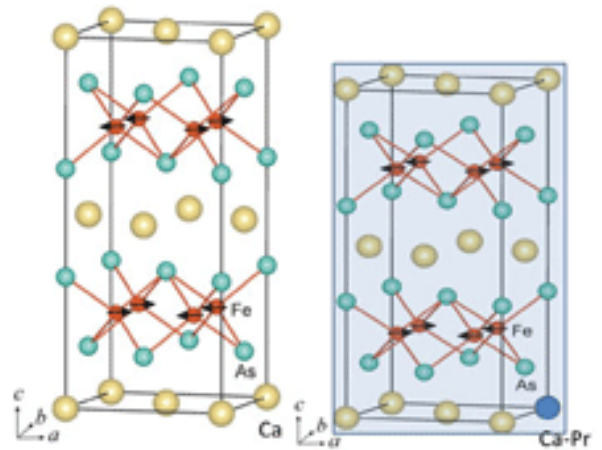
Unusual 'Collapsing' Iron Superconductor Sets Record for Its Class

A team from the University of Maryland and the National Institute of Standards and Technology (NIST) has found an iron-based superconductor that operates at the highest known temperature for a material in its class.* The discovery inches iron-based superconductors—valued for their ease of manufacturability and other properties—closer to being useful in many practical applications.

Iron-based superconductors, which were discovered only about four years ago, are a hot research topic, in part because they are more amenable to commercial applications than copper-based superconductors, which are more difficult to make and are frequently brittle. Of the four broad classes of iron-based superconductors, the 1:2:2 class—so named because their crystals are built around a hub of one atom of calcium, two of iron and two of arsenic—is particularly promising because these superconductors' properties can be custom-tailored by substituting other atoms for these basic elements.

Magnets made with low-temperature superconductors have already found use in hospital MRI machines, but less expensive MRI machines and other applications, such as superconducting cables for resistance-free power transmission over long distances, become closer to reality the more choices manufacturers have among superconductors.

Working at University of Maryland's Center for Nanophysics and Advanced Materials and the NIST Center for Neutron Research (NCNR), the team, led by Prof. John-pierre Paglione, found that a particular type of 1:2:2 superconductor possesses some unexpected properties. Of perhaps greatest value to manufacturers is that its threshold temperature of superconductivity is 47 degrees Kelvin, the highest yet for the 1:2:2 class, whose previous record was 38K.



Credit: NIST

When calcium atoms (yellow spheres) in these iron-based crystals (left) are replaced on some occasions with praseodymium (blue sphere in right image), the crystals are able to superconduct at up to 47K - but the crystals can also collapse, shrinking by about 10 percent in size. Adding a sufficient amount of praseodymium is necessary to avoid the collapse, which compromises the materials usability in electronics applications.

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But the crystal also has a highly curious property: It can superconduct at this record temperature when a smaller atom is substituted for the crystal's original calcium in some of its hubs, adding extra electrons that the researchers believe is the key to stabilizing superconductivity. "It's amazing that these crystals become superconductors when we replace only a small fraction of the calcium with rare earth atoms," says Prof. Paglione. "We had a hunch this might happen, but not at such high temperatures as compared to other materials." When this substitution is performed with the right elements, another intriguing transition occurs: the overall crystal instantaneously shrinks by about 10 percent, a dramatic size change that is literally called a "structural collapse". Dr. Saha, the lead scientist on the project, says that such a large change in crystal

structure would normally be catastrophic for technological applications. But the group's research has determined how to make the substitution while eluding the collapsed state altogether, resulting in another record - this time in the material's unprecedented thermal expansion property - that may prove extremely useful for technologies utilizing both superconductivity and thermal expansion applications.

* S.R. Saha, N.P. Butch, T. Drye, J. Magill, S. Ziemak, K. Kirshenbaum, P.Y. Zavalij, J.W. Lynn and J. Paglione. Structural collapse and superconductivity in rare-earth-doped CaFe₂As₂. *Physical Review B*. Published Jan. 13, 2012. DOI: 10.1103/PhysRevB.85.024525.

NEWS

The Japanese magazine, *Parity*, has published the Japanese translation of the *Physics Today* article by **Rabi Mohapatra** entitled "Neutrino Mass and Origin Matter."

Steve Rolston gave a talk about Quantum Physics, entitled "Quantum Mechanics: Embrace the Weirdness" at the DC Science Café on February 21.

Victor Yakovenko gave a seminar at the American Center for Physics, on February 22, entitled "Statistical Mechanics of Money, Income, Debt and Energy Consumption." The seminar was sponsored by the APS Mid-Atlantic Senior Physicists Group.

Jim Gates appeared in one of 10 segments by NBC called "Science of N.H.L. Hockey." The educational segments aired during the NBC Sports Network's coverage of the All-Star festivities on the weekend of January 25.

Ellen Williams was interviewed by Jeremy N. A. Matthews in the January 2012 issue of *Physics Today*. After spending three decades in academia conducting nanotechnology research, she is now tackling the energy problem in the faster-paced industrial environment. She is currently on leave from the University of Maryland to serve as British Petroleum's Chief Scientist.

www.physicstoday.org/resource/1/phtoad/v65/i1/p18_s1

In Memoriam:

Daniel Fivel

Dan Fivel passed away on Tuesday, February 7. He was 79 years old. Fivel received his PhD from Johns Hopkins and joined the University of Maryland in 1963. He retired in 2000. An obituary can be found in the Burlington Free Press at,

<http://www.legacy.com/obituaries/burlingtonfreepress/obituary.aspx?n=daniel-isaac-fivel&pid=15579734>

Ralph Vendemia Jr.

Ralph Vendemia Jr., who welcomed and assisted innumerable Terps in the Slawsky Clinic for over 11 years, succumbed on January 17. He was 84 years old. The following is a link to his obituary in *The Washington Post*,

<http://www.legacy.com/obituaries/washingtonpost/obituary.aspx?n=ralph-j-vendemia&pid=155550794>

EVENTS

On February 15, the Women in Physics group hosted a Career Panel, featuring guests whose graduate studies in physics led them to careers outside academia:

Joey Thompson - Partner at Alara Capital, a technology investment firm

Jelena Stajic - Associate Editor, Physics, for Science Magazine

Rolf Danner - Senior Scientist in the Science and Weather Systems section at Northrop Grumman Aerospace Systems

Crystal Bailey - Education and Careers Program Manager at APS

Richard Scheper - Founder and President of Jovian Concepts, Inc., a consulting firm

Marcos Huerta - Special Assistant, Office of Science at U.S. Department of Energy

Jason Hamm - Deputy Director for Cooperative Threat Reduction in the Countering Weapons of Mass Destruction Policy Office of the Office of the Secretary of Defense

More information and expanded bios available at <http://www.physics.umd.edu/wip/panel.html>



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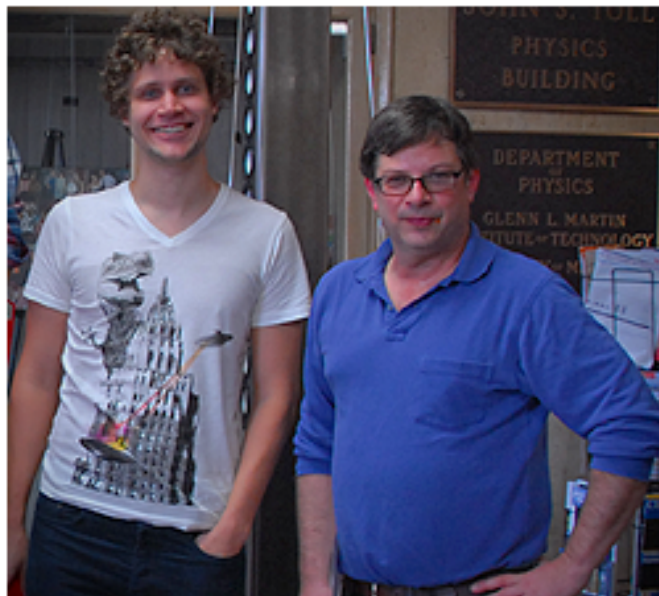
2011 Thomas Mason Fellowship Recipient

By Joshua Parker

Last summer, I was gratefully the recipient of the Thomas Mason Interdisciplinary Fellowship, which is administered by the Department of Physics here at the University of Maryland. A Maryland physics and electrical engineering alumnus, Thomas Mason is currently a professor at UCLA, bridging both the departments of Chemistry & Biochemistry and Physics & Astronomy. His interdisciplinary background and current working environment led him to start the fellowship, with the goal of encouraging physics students to benefit from conducting research in collaboration with non-physics faculty.

As a fellow, I worked with Dr. Jon Fourkas' chemistry lab to design devices to simulate how cancer cells move through the human body. Cancer cells have been seen to regulate their internal structures in response to forces felt by external environmental rigidity and topographies. We wanted to see this up close and personal, using model devices. Floyd Bates, a graduate student in Dr. Fourkas' lab, is an expert in using two-photon lithography techniques to design micro-fluidic devices with nano-scale features. Over the summer, with input from Dr. Wolfgang Losert, from the Physics Department, and Dr. Carole Parent, a cell biologist at the National Cancer Institute, we finished with a proof-of-concept design and device, ready for real-cell experiments.

The experiment is still ongoing, and will likely be so for a while (isn't that always the case in science?) We are also in the process of developing computer simulations of cells moving in the device, which will direct future device designs. Thanks to the support of the Thomas Mason Fellowship, the forthcoming results from both the experiment and simulations will dramatically aid in understanding how cancer cells find their way through the complex environment of a human body.



Joshua Parker, left, received the Thomas Mason Fellowship certificate, from Associate Chair Tom Cohen, at the 2011 Physics TA Awards



CONTACT US:

The Photon is an online newsletter from the University of Maryland Department of Physics. For questions, comments or to submit information, please contact Carole Cuaresma Kiger, ccuaresm@umd.edu.

