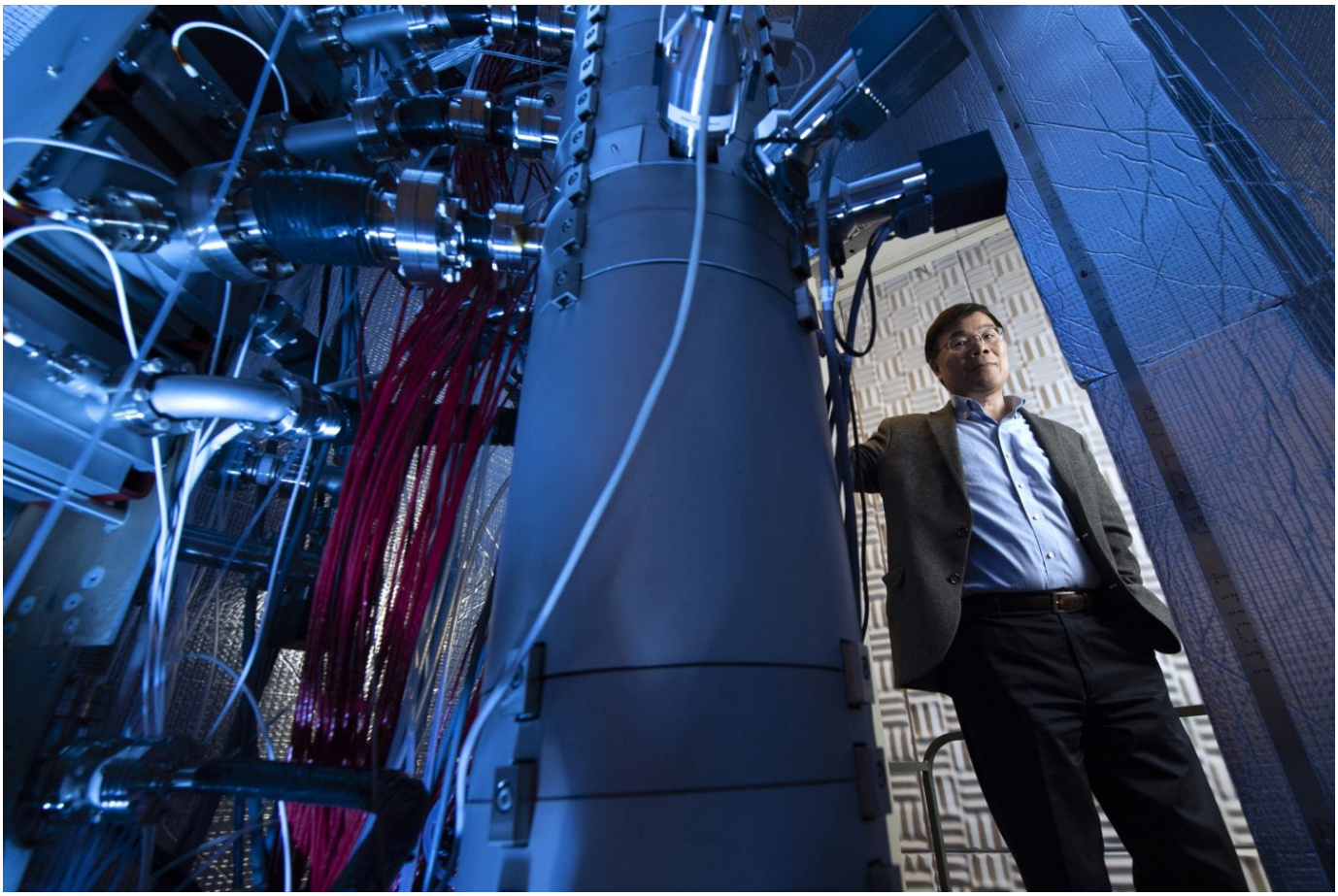
UC Irvine researchers reveal superconductivity secrets of an iron-based material

Findings could spur advancements in quantum computing and electronics.
Friday, December 06, 2024
Brian Bell
UC Irvine News



Xiaoqing Pan, UC Irvine Distinguished Professor of materials science and engineering as well as physics and astronomy, Henry Samueli Endowed Chair in Engineering, and director of the Irvine Materials Research Institute, displays IMRI equipment that allowed his team to image atom vibrations at the interface between a superconductor and a substrate. The research, published recently in Nature, provides an atomic-scale understanding of what enhances superconductivity in

advanced materials.

Picture Credit:
Steve Zylius / UC Irvine

Irvine, Calif., Dec. 5, 2024 — Scientists at the University of California, Irvine have uncovered the atomic-scale mechanics that enhance superconductivity in an iron-based material, a finding published recently in *Nature*.

Using advanced spectroscopy instruments housed in the UC Irvine Materials Research Institute, the researchers were able to image atom vibrations and thereby observe new phonons –quasiparticles that carry thermal energy –at the interface of an iron selenide (FeSe) ultrathin film layered on a strontium titanate (STO) substrate.

“Primarily emerging from the out-of-plane vibrations of oxygen atoms at the interface and in apical oxygens in STO, these phonons couple with electrons due to the spatial overlap of electron and phonon wave functions at the interface,” said lead author Xiaoqing Pan, UC Irvine Distinguished Professor of materials science and engineering, Henry Samueli Endowed Chair in Engineering and IMRI director. “This strong electron-phonon coupling provides a mechanism for the enhancement of superconductivity transition temperature in ultrathin FeSe.”

The scientists found that FeSe has a transition-to-superconductivity temperature of 65 Kelvin, roughly minus 340 degrees Fahrenheit, making it the highest-temperature superconductor in its class. They witnessed a close relationship between electron-phonon coupling and the uniformity of the FeSe/STO interface; greater homogeneity means a higher temperature at which superconductivity occurs.

“Our vibrational spectroscopy approach enabled us to achieve highly detailed imaging of the vibrations at the superconducting material’s interface with its substrate,” said Pan, who holds a joint appointment in the UC Irvine Department of Physics & Astronomy. “The observed variation in the interlayer spacing correlates with the superconducting gap, which demonstrates the crucial role of spacing in electron-phonon coupling strength and superconductivity.”

Co-author Ruqian Wu, UC Irvine Distinguished Professor of physics and astronomy, said: “The ultrahigh spatial and energy resolutions of state-of-the-art instruments at IRMI provide exceptional experimental data for theoretical analysis. This collaboration between theoretical simulations and experimental observations allows

for precise identification of individual atomic contributions to the enhancement of the superconducting transition temperature, deepening our understanding of superconductivity at heterogeneous interfaces."

Pan said that his team's results are an important step toward achieving scalable fabrication and utilization of superconductors in a range of applications, including quantum computers, mass transportation through magnetic levitation, and advanced medical diagnostic and treatment devices.

In addition to working with UC Irvine colleagues, Pan collaborated with researchers from Sweden's Uppsala University, Princeton University, the Beijing National Laboratory for Condensed Matter Physics and the Institute of Physics at the Chinese Academy of Sciences. The project received support from the U.S. Department of Energy's Office of Basic Energy Sciences, Division of Materials Sciences and Engineering.

About UC Irvine's Brilliant Future campaign: Publicly launched on Oct. 4, 2019, the Brilliant Future campaign aims to raise awareness and support for UC Irvine. By engaging 75,000 alumni and garnering $2 billion in philanthropic investment, UC Irvine seeks to reach new heights of excellence in student success, health and wellness, research and more. The Henry Samueli School of Engineering plays a vital role in the success of the campaign. Learn more by visiting https://brilliantfuture.uci.edu/the-henry-samueli-school-of-engineering.

About the University of California, Irvine: Founded in 1965, UC Irvine is a member of the prestigious Association of American Universities and is ranked among the nation's top 10 public universities by *U.S. News & World Report*. The campus has produced five Nobel laureates and is known for its academic achievement, premier research, innovation and anteater mascot. Led by Chancellor Howard Gillman, UC Irvine has more than 36,000 students and offers 224 degree programs. It's located in one of the world's safest and most economically vibrant communities and is Orange County's second-largest employer, contributing $7 billion annually to the local economy and $8 billion statewide. For more on UC Irvine, visit www.uci.edu.

Media access: Radio programs/stations may, for a fee, use an on-campus studio with a Comrex IP audio codec to interview UC Irvine faculty and experts, subject to availability and university approval. For more UC Irvine news, visit news.uci.edu. Additional resources for journalists may be found at https://news.uci.edu/media-resources.