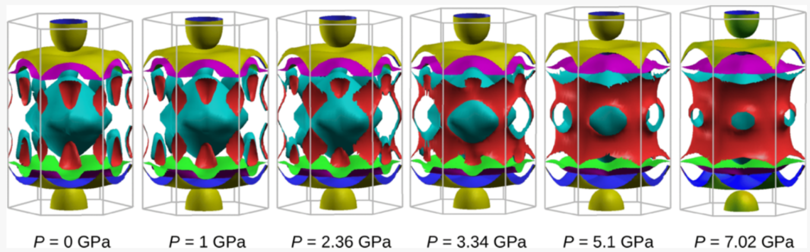
Scientists unveil breakthrough that could transform energy transmission

Scientists have identified materials capable of allowing electrical current to flow with almost perfect efficiency, wasting no energy as heat.



FS of BaFe2□Al9 at different pressures calculated using DFT taking the experimentally obtained lattice parameters (with the fractional coordinates of Al fixed to the ambient condition data). Credit: Physical Review Letters (2025). DOI: https://doi.org/10

SHARJAH, EMIRATE OF SHARJAH, UNITED ARAB EMIRATES, December 16, 2025 /EINPresswire.com/ -- Scientists have discovered a way to efficiently transfer electrical current through specific materials at room temperature, a finding that could revolutionize superconductivity and reshape energy preservation and generation.

The much-sought-after breakthrough hinges on applying high pressure to certain materials, forcing their electrons closer together and unlocking extraordinary electronic behaviors.

“Our research explores how electrons interact inside solid materials—interactions that give rise to remarkable phenomena such as high-temperature superconductivity and charge-density waves (CDWs),” said Dr. Mahmoud Abdel-Hafiez, Associate Professor of Physics at the University of Sharjah. “These effects are important because they influence how efficiently electricity can move through a material, and they have the potential to transform future technologies.”

In most materials, electrons move independently. However, in select materials, they interact collectively, producing powerful new behaviors. “We wanted to understand how these interactions change when the material is placed under high pressure—when electrons are forced closer together,” explained Dr. Abdel-Hafiez, the study’s lead author.

Published in the journal Physical Review Letters, the study reveals that CDWs behavior not only strengthens under extreme pressure but can also emerge at room temperature, a rare and exciting discovery, according to the authors. This finding contrasts sharply with what is typically observed in other two-dimensional materials, where CDWs weaken under pressure.

“Our finding opens the door to new possibilities in materials science. The key takeaway is that electrons inside certain materials can behave in surprising and powerful ways when the material is placed under high pressure,” emphasized Dr. Abdel-Hafiez. “Instead of weakening, one important electronic pattern called a CDW becomes stronger and can even exist at room temperature. This is unusual because, in almost all similar materials, CDWs disappear when pressure is applied.”

Scientists from leading universities and scientific institutions across Germany, Sweden, India, Japan, Italy, Egypt, Qatar, Taiwan, and the United Arab Emirates contributed to the groundbreaking study that could pave the way for next-generation technologies, from ultra-efficient energy transmission to advanced quantum devices.

These findings are significant because strengthening these electron interactions brings society closer to transformative breakthroughs, including room-temperature superconductors and ultra-efficient electronic systems. The research demonstrates that pushing materials to extreme conditions can uncover hidden behaviors that may refine the technologies of tomorrow.

“This discovery will attract considerable scientific interest,” said Prof. Olle Eriksson, Professor of Materials Theory at Sweden’s Uppsala University and Chair of the Nobel Prize Committee for Physics. “Techniques such as muon resonance spectroscopy, neutron scattering, and ARPES will be essential to fully understand why the charge-density wave becomes so robust—even at room temperature.”

Strengthening electronic behavior under pressure suggests new possibilities for future technologies. If science controls these material interactions – a breakthrough this study proves to be attainable—the world will move closer to developing materials that conduct electricity with little or no energy loss, and devices that operate faster and more efficiently than ever before.

Overall, the research shows that by pushing materials to extreme conditions, scientists can reveal entirely new behaviors that were previously hidden – discoveries that may play a role in the next generation of electronic and energy technologies.

"This result is remarkable because it challenges our current understanding of how electronic order behaves under pressure,” said Prof. Rüdiger Klingeler of Germany’s University of Heidelberg. “Observing a charge-density wave that not only survives but strengthens up to room temperature opens entirely new pathways for exploring correlated electron systems. It is a discovery that will undoubtedly motivate further experimental and theoretical studies across the field."

The findings could have far-reaching implications for both industry and society, pointing toward materials that can handle electricity more efficiently.

“If electronic behaviors like charge-density waves can exist at room temperature, as our study

suggests, this could lead to devices that use far less energy and generate less heat. That means longer-lasting electronics, lower electricity costs, and reduced environmental impact," Dr. Abdel-Hafiez said.
"The results also hint at progress toward future technologies such as highly efficient power systems or faster computing devices. Industries working on advanced electronics, communication technologies, and clean energy could benefit from materials that perform better under everyday conditions."

In the long run, understanding how to control these electronic behaviors could bring society closer to breakthroughs like room-temperature superconductors, which would transform everything from power grids to transportation.

The research demonstrates that charge-density waves can strengthen at room temperature under pressure, a discovery that points to creating materials that can work more efficiently without requiring extremely low temperatures, making advanced electronic technologies easier and more cost-effective to deploy.

"One real-world application is in designing faster and more energy-efficient electronic devices. If materials can naturally control the flow of electrons at room temperature, computers, sensors, and communication systems could operate with less power and produce less heat. This would help extend battery life and reduce energy consumption in everyday devices," Dr. Abdel-Hafiez explained.

"Another potential application lies in next-generation power systems. Understanding and controlling electron behavior could bring us closer to technologies like room-temperature superconductors, which could allow electricity to travel long distances without any energy loss. This would revolutionize power grids, lower costs, and support cleaner and more sustainable energy solutions."

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LEON BARKHO
University Of Sharjah
+971 501654376
email us here
