PRESS RELEASE

ICMAB-CSIC
Communication department
Tel.: +34 93 580 18 53
communication@icmab.es
icmab.es

ICMAB Researchers Identify Atomic Vibrations at the Boundary Between Two Materials That Could Explain a Form of Superconductivity

- **The vibrations are localized at the interface between two materials and could be involved in the mechanism that allows electricity to flow without losses**

Cerdanyola del Vallès, 15 September 2026 – Superconductivity is one of the major areas of materials research today because of its great potential for the energy transition. Despite decades of research, it is still not completely clear why some interfaces between materials develop this property. Now, an international team involving researchers from the Institute of Materials Science of Barcelona of the Spanish National Research Council (CSIC) has identified, for the first time, a set of atomic vibrations that appear only at these interfaces and could play an important role in this phenomenon. The results of the study have been published in *Nature Materials*.

This research was carried out in collaboration with the University of Chinese Academy of Sciences, the Nanomaterials and Nanotechnology Research Center (a center involving the University of Oviedo), the Catalan Institute of Nanoscience and Nanotechnology, the École Supérieure de Physique et de Chimie de Paris, and Chalmers University of Technology.

A New Piece of a Scientific Puzzle

Superconductivity is a phenomenon in which some materials can conduct electric current without resistance and, therefore, without energy losses. Although it has been known for more than a century, the scientific community still debates the mechanisms that cause it in some materials. One of the most intriguing examples is the phenomenon that appears at the boundary between certain oxides: a layer only a few atoms thick in which properties emerge that do not exist in either of the materials individually.

The authors of this study investigated two oxides that are insulating on their own but have long been known to generate, when joined together, an interface just a few atoms wide that becomes superconducting. “They are two boring rocks that are insulating on their own, but when they come into contact with each other, they generate an interface that is conductive and, at very low temperatures, even superconducting,” says Jaume Gázquez, one of the authors of the study.

It has long been known that vibrations of the atomic lattice can play an important role in the emergence of superconductivity. Now, the results of this work show that the atomic lattice vibrates differently precisely where the two materials come into contact. This vibration is confined to the same region of the interface where superconductivity emerges. This correlation suggests that these vibrations could be related to the phenomenon.

This finding does not, by itself, demonstrate the origin of superconductivity, but it provides an important piece of information for understanding it. Materials researchers have long known that atomic vibrations can influence the behavior of electrons. “The atoms vibrate in a special

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way at the interface, but they do not do so away from it. This had never been identified before; it is something new and highly relevant," adds researcher Gervasi Herranz.

Another Step Toward Understanding Superconductivity

Despite the significance of the discovery, the researchers emphasize that the work does not, by itself, solve the mystery of these conducting interfaces. Instead, it provides information that was previously unavailable and that could help clarify the mechanisms involved in the formation of so-called Cooper pairs—pairs of electrons that form in some materials under special conditions and make it possible for electricity to be transported without losses.

For Cooper pairs to emerge, some mechanism must promote the pairing of electrons. One hypothesis is that atomic vibrations may be involved. The new observation strengthens this possibility, although it does not conclusively demonstrate it: "We cannot unequivocally establish that superconductivity in this case is caused by this interface mode," explains Gervasi Herranz. "But what is very important is that this had never been identified before."

The researchers believe that this observation provides a new clue for understanding how this behavior emerges in systems such as these, where electrons are confined to extremely thin layers. In addition, the authors are continuing to study this phenomenon in other materials, and it may not be exclusive to the combination investigated here. "It is one piece of a puzzle that is still incomplete," summarizes Jaume Gázquez.

Seeing Atoms Move: A Challenge That Was Until Recently Impossible

An important aspect of the significance of this work is methodological. To observe these vibrations, the authors used advanced electron microscopy with sufficient resolution to study the behavior of individual atoms and, in particular, their local vibrational modes. This made it possible to observe local differences that conventional techniques could detect only on a global scale.

Shortly before this publication, a team made up of almost the same researchers had presented a methodology capable of observing the electronic structure atom by atom. Now, this same commitment to atomic-scale resolution also makes it possible to study atomic vibrations with an unprecedented level of detail.

The researchers hope to apply this approach to other superconducting systems to determine whether these interface vibrational modes are a general phenomenon or a particular feature of this type of material.

Reference Article

Electron–phonon coupling and symmetry breaking in superconducting oxide interfaces near ferroelectric quantum criticality
Guzman, R., Pruneda, M., Nery, J. P., Xu, M., Li, A., Wittemeier, N., Li, A., Singh, G., Bergeal, N., Kalaboukhov, A., Herranz, G., Gazquez, J., & Zhou, W.
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