Physicists explore superconductivity at the two-dimensional limit

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Researchers at the University of Valencia show that the superconducting state can be maintained even when the material is reduced from three to two dimensions, making the efficiency gains needed for technologies like frictionless trains possible.

An international research team led by Eugenio Coronado, of the Univeristy of Valencia's Institute of Molecular Science (ICMol) has shown that it is possible to maintain superconductivity at the two-dimensional limit, currently one of the most hotly debated issues in solid state physics. This finding allows us to advance our understanding of superconductivity and paves the way for the miniaturisation of ultrasensitive magnetic field detectors. The work was published in *Nature Communications*.

Superconductivity is one of the most fascinating quantum phenomena in physics. In the superconducting state, materials conduct electricity without energy loss, which makes them very efficient for many applications including the manufacture of the strongest known magnets, ultrasensitive magnetic field detectors, efficient energy conduction and frictionless transportation (levitating trains).

Since its discovery in 1911, one of the issues that has most intrigued scientists is whether it is possible to maintain the superconducting state even when the material is reduced from three to two dimensions. Intuitively we expect that it would be more difficult to stabilise the superconducting state when the dimensionality is reduced. With the isolation of graphene, the first two-dimensional material, made up of a single layer of carbon atoms, the issue been pushed resolutely to the fore. However, despite graphene's extraordinary mechanical, electrical and magnetic properties, superconductivity has so far remained an elusive property.

Based at the UV's Science Park, ICMol researchers have shown that superconductivity can indeed be maintained at this two-dimensional limit. The researchers have studied layered materials similar to graphene, but which become superconductors when cooled to low temperatures. Specifically, they have studied the electrical properties of a large family of layered materals known as metal dichalcogenides.

As with graphene, these materials are made up of individual atom layers that can be easily exfoliated, which makes it possible to obtain sheets of different thicknesses, made up of a specific number of layers. In one of the compounds from this family, tantalum disulphide (TaS_2), the researchers found that, contrary to expectations, the temperature at which the layered material becomes superconducting increases as the number of layers is reduced, meaning that this property is indeed maintained at the two-dimensional limit.

This discovery deepens our understanding of the superconducting properties of materials, many of which have so far eluded the scientific community. It also paves the way for the development of smaller and more efficient ultrasensitive magnetic field detectors.

More information: Efrén Navarro-Moratalla et al. Enhanced superconductivity in atomically thin TaS_2, *Nature Communications* (2016). DOI: 10.1038/ncomms11043

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