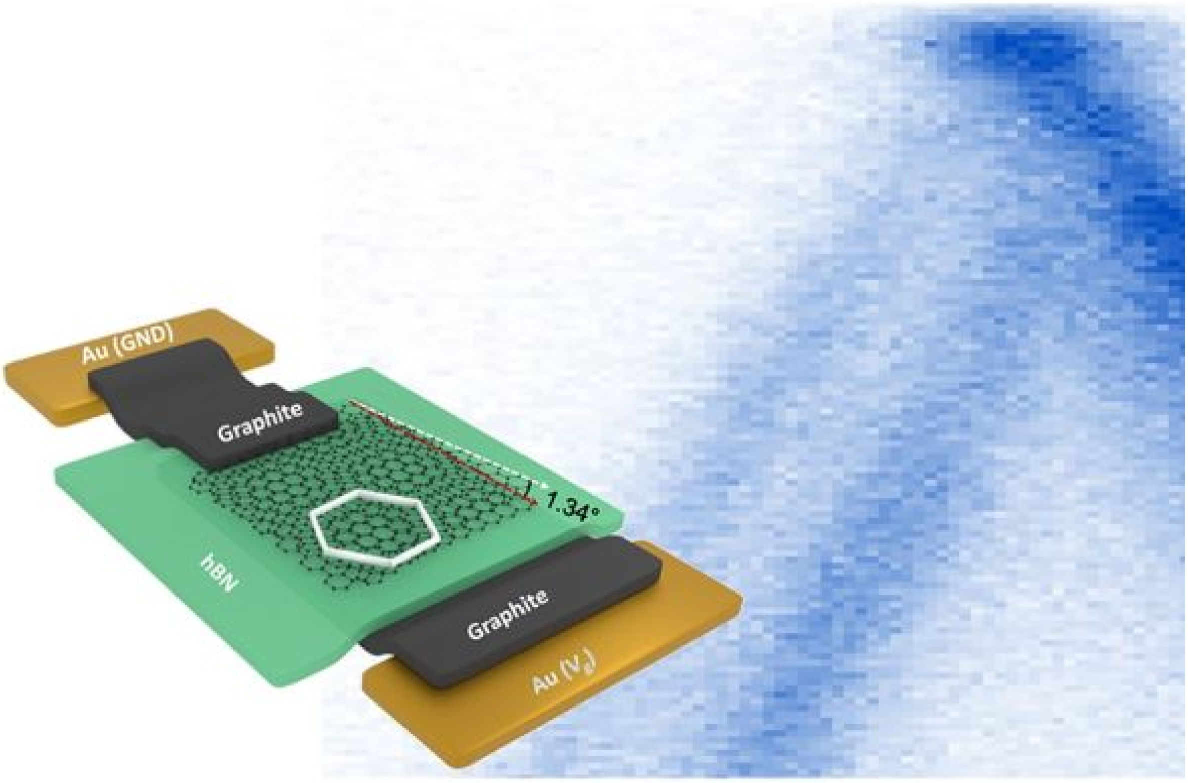

Superconductivity with a twist explained

Physicists have revealed what makes magic angle graphene so special. This is a key step elucidating the mystery behind superconductivity in this recently discovered material with potential for technological breakthroughs.

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Magic-angle materials represent a surprising recent physics discovery in double layers of graphene, the two-dimensional material made of carbon atoms in a hexagonal pattern.

When the upper layer of two stacked layers of graphene is rotated by about 1 degree, the material suddenly turns into a superconductor. At a temperature of 3 Kelvin, this so-called twisted bilayer graphene (tbg) conducts electricity without resistance.

Now, an international team of scientists from Geneva, Barcelona, and Leiden have finally confirmed the mechanism behind this new type of superconductors. In Nature Physics, they show that the slight twist causes the electrons in the material to slow down enough to sense each other. This enables them to form the electron pairs which are necessary for superconductivity.

How can such a small twist make such a big difference? This is connected with moire patterns, a phenomenon also seen in the everyday world. When two patterned fences are in front of another, one observes additional dark and bright spots, caused by the varying overlap between the patterns. Such moire patterns (derived from the the French name of textile patterns made in a similar way) generally appear where periodical structures overlap imperfectly.

Twisted bilayer graphene is exactly such a situation: the interplay between the two hexagonal carbon lattices, slightly twisted, causes a much larger hexagonal moire pattern to emerge.

By creating this new periodicity, the interaction between the electrons is predicted to change, slowing down the electrons. In previous research, clear signs of the superconductivity have been measured, but evidence that this is indeed due to ?slow electrons' had not been found so far.

A key to this work has been excellent sample quality, as mastered at ICFO- The Institute of Photonic Sciences in Barcelona. However, even in a good sample, the correct twist angle is only achieved in small patches of double layer graphene. Using advanced microscopy techniques, the Leiden groups imaged and characterized the samples, such that the magic-angle areas were pinpointed exactly. Then, the Geneva group used nano-ARPES, a local spectroscopy technique based on the photo-electric effect, to demonstrate the existence of these slow electrons.

Elucidating and then optimizing this type of superconductivity could lead to numerous technological applications, ranging from lossless energy transport to hypersensitive light detectors.

This news item was written by Bruno van Wayenburg

IMAGE: Schematic illustration of the experimental setup