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New study explains why superconductivity takes place in graphene

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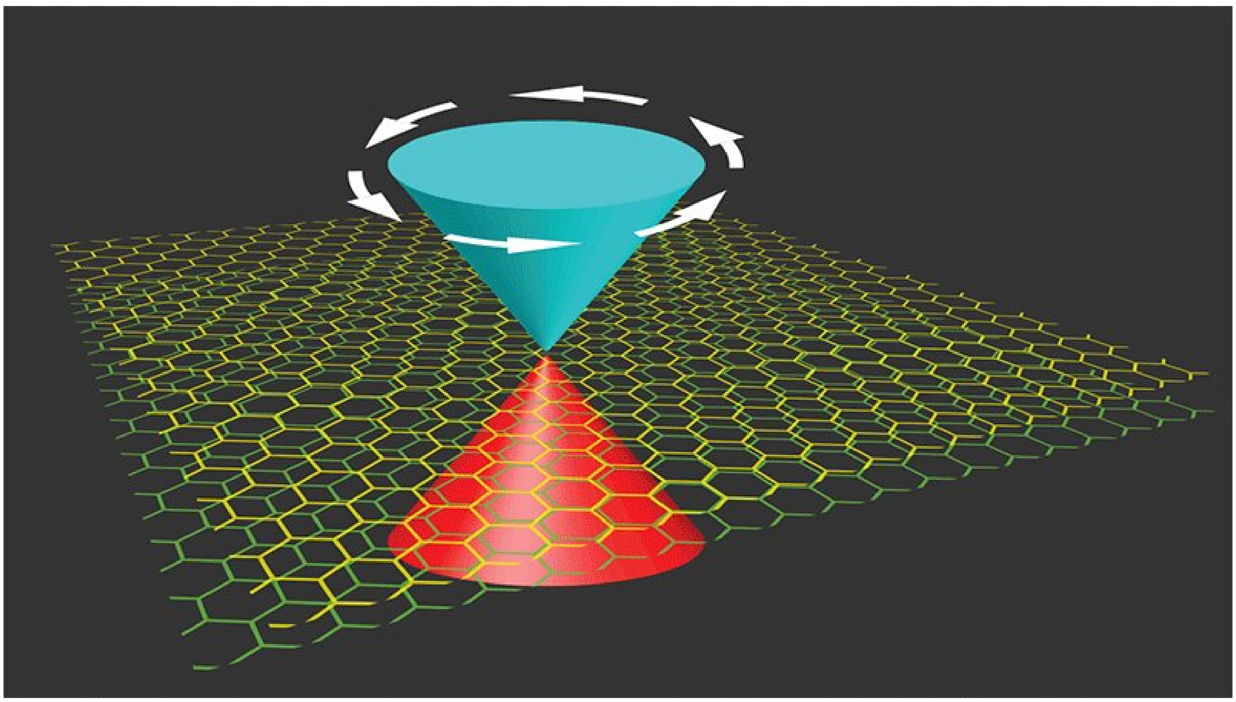

Figure 1: Electrons moving through the sheets of twisted bilayer graphene (TBG) have special points in their band structure where two cone-shaped bands meet. The inherent "curvature" of the states in these bands turns out to contribute to the magnitude of TBG's superconducting transition temperature. *Physics* (2020). DOI: 10.1103/Physics.13.23

Graphene, a single sheet of carbon atoms, has many extreme electrical and mechanical properties. Two years ago, researchers showed how two sheets laid on top of each other and twisted at just the right angle can become superconducting, so that the material loses its electrical resistivity. New work explains why this superconductivity happens in a surprisingly high temperature.

Researchers at Aalto University and the University of Jyväskylä showed that graphene can be a superconductor at a much higher temperature than expected, due to a subtle quantum mechanics effect of graphene's electrons. The results were published in *Physical Review B*. The findings were highlighted in *Physics* viewpoint by the American Physical Society, and looks set to spark lively discussion in the physics community.

The discovery of the superconducting state in twisted bilayer graphene was selected as the Physics breakthrough of the year 2018 by the Physics World magazine, and it spurred an intense debate among physicist about the origin of superconductivity in graphene. Although superconductivity was found only at a few degrees above the absolute zero of temperature, uncovering its origin could help understanding high-temperature superconductors and allow us to produce superconductors that operate near room temperature. Such a discovery has been considered one of the "holy grails" of physics, as it would allow operating computers with radically smaller energy consumption than today.

The new work came from a collaboration between Päivi Törmä's group at Aalto University and Tero Heikkilä's group at the University of Jyväskylä. Both have studied the types of unusual superconductivity most likely found in graphene for several years.

"The geometric effect of the wave functions on superconductivity was discovered and studied in my group in several model systems. In this project it was exciting to see how these studies link to real materials," says the main author of the work, Aleksi Julku from Aalto University. "Besides showing the relevance of the geometric effect of the wave functions, our theory also predicts a number of observations that the experimentalists can check," explains Teemu Peltonen from the University of Jyväskylä.

More information: A. Julku et al. Superfluid weight and Berezinskii-Kosterlitz-Thouless transition temperature of twisted bilayer graphene, *Physical Review B* (2020). DOI: 10.1103/PhysRevB.101.060505

Laura Classen. Geometry Rescues Superconductivity in Twisted Graphene, *Physics* (2020). DOI: 10.1103/Physics.13.23

Provided by Aalto University