Team develops method for trapping elusive electrons

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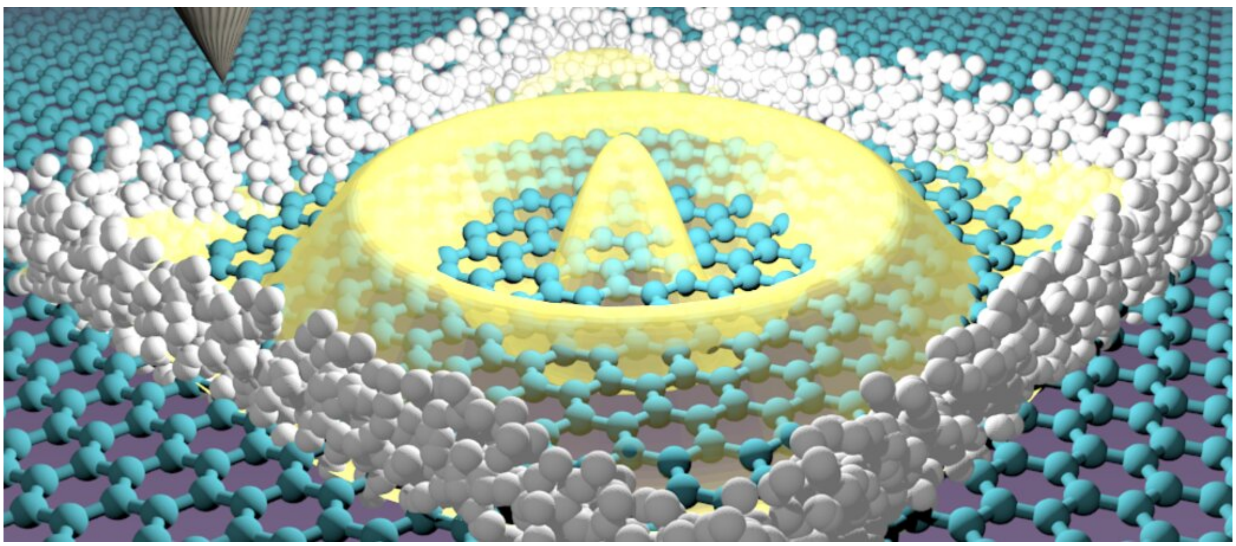

Credit: Aalto University

Graphene's unique 2-D structure means that electrons travel through it differently than in most other materials. One consequence of this unique transport is that applying a voltage doesn't stop the electrons like it does in most other materials. This is a problem, because to make useful applications out of graphene and its unique electrons, such as quantum computers, it is necessary to be able to stop and control graphene electrons.

An interdisciplinary team of scientists from the Universidad Autonoma de Madrid (Spain), Université Grenoble Alpes (France), International Iberian Nanotechnology Laboratory (Portugal) and Aalto University has solved this long-standing problem. The team included experimental researchers Eva Cortés del Río, Pierre Mallet, Héctor González-Herrero, José María Gómez-Rodríguez, Jean-Yves Veuillen and Iván Brihuega and theorists including Joaquín Fernández-Rossier and Jose Lado, assistant professor in the department of Applied Physics at Aalto.

The experimental team used atomic bricks to build walls capable of stopping the graphene electrons. This was achieved by creating atomic walls that confined the electrons, leading to structures whose spectrum was then compared with theoretical predictions, demonstrating that electrons were confined. In particular, it was obtained that the engineered structures gave rise to nearly perfect confinement of electrons, as demonstrated from the emergence of sharp quantum well resonances with a remarkably long lifetime.

The work, published this week in *Advanced Materials*, demonstrates that impenetrable walls for graphene electrons can be created by collective manipulation of a large number of hydrogen atoms. In the experiments, a scanning tunneling microscope was used to construct artificial walls with sub nanometric precision. This led to graphene nanostructures of arbitrarily complex shapes, with dimensions ranging from two nanometres to one micron.

Importantly, the method is non-destructive, allowing researchers to erase and rebuild the nanostructures at will, providing an unprecedented degree of control to create artificial graphene devices. The experiments demonstrate that the engineered nanostructures are capable of perfectly confining the graphene electrons in these artificially designed structures, overcoming the critical challenge imposed by Klein tunneling. Ultimately, this opens up many exciting new possibilities, as the nanostructures realize graphene quantum dots that can be selectively coupled, opening possibilities for artificially designed quantum matter.

More information: Eva Cortés-del Río et al. Quantum Confinement of Dirac Quasiparticles in Graphene Patterned with Sub-Nanometer Precision, *Advanced Materials* (2020). DOI: 10.1002/adma.202001119

Provided by Aalto University