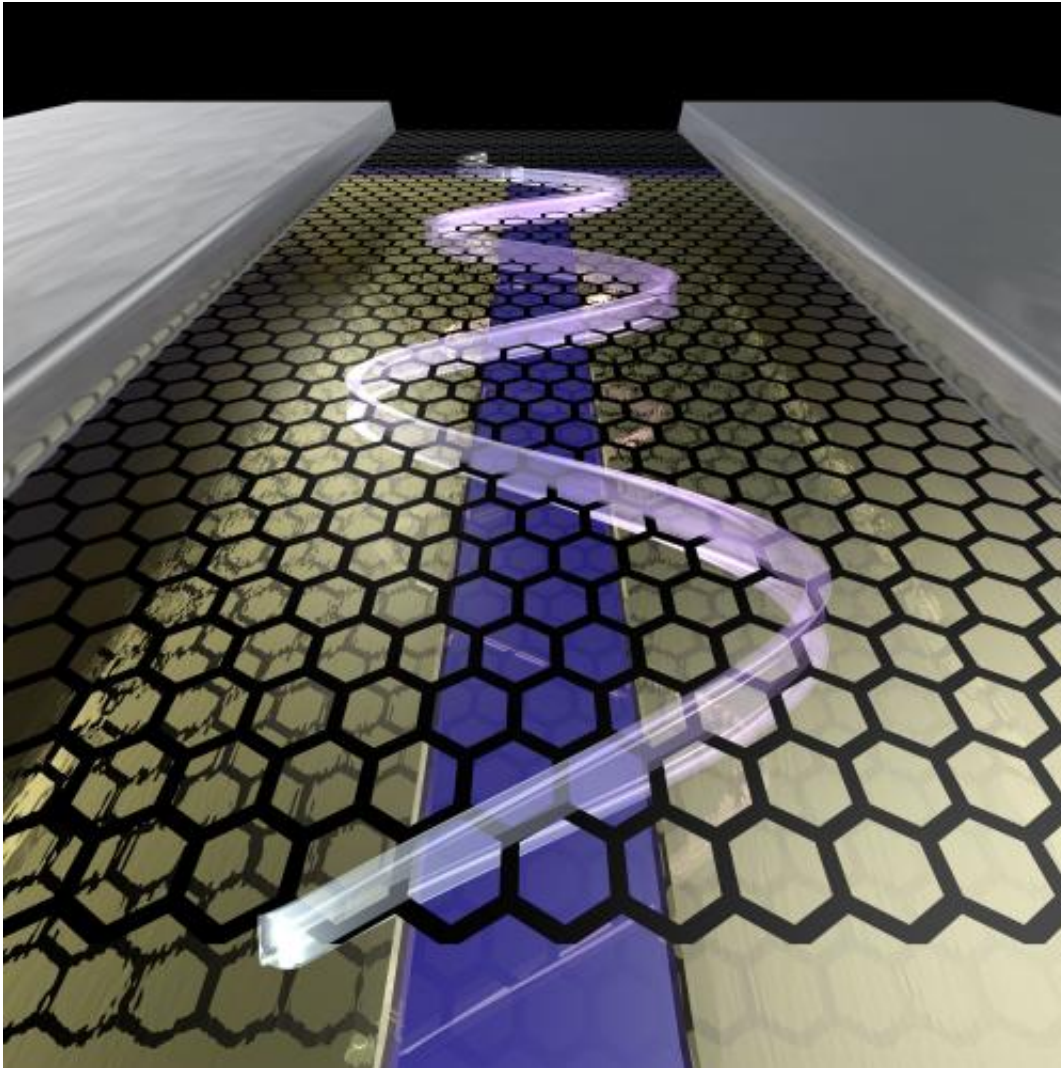


Electrons moving along defined snake states

March 3 2015



The principle of the experiment: The honeycomb grid provides an atomic graphene layer stretched between two electrical contacts (silver). The lower area contains two control electrodes (gold), which are used to generate an electrical field. A magnetic field is also applied vertically to the graphene level. Combining an electrical field and a magnetic field means that the electrons move along a snake state. Credit: Rickhaus et al., Nature Communications (2015).

Physicists at the University of Basel have shown for the first time that electrons in graphene can be moved along a predefined path. This movement occurs entirely without loss and could provide a basis for numerous applications in the field of electronics. The research group led by Professor Christian Schönenberger at the Swiss Nanoscience Institute and the Department of Physics at the University of Basel is publishing its results together with European colleagues in the renowned scientific journal *Nature Communications*.

For some years, the research group led by Professor Christian Schönenberger at the Swiss Nanoscience Institute and the Department of Physics has been looking at [graphene](#), the "miracle material". Scientists at the University of Basel have developed methods that allow them to stretch, examine and manipulate layers of pure graphene. In doing so, they discovered that electrons can move in this pure graphene practically undisturbed – similar to rays of light. To lead the electrons from one specific place to another, they planned to actively guide the electrons along a predefined path in the material.

Electrical and magnetic fields combined

For the first time, the scientists in Basel have succeeded in switching the guidance of the electrons on and off and guiding them without any loss. The mechanism applied is based on a property that occurs only in graphene. Combining an [electrical field](#) and a magnetic field means that the [electrons](#) move along a snake state. The line bends to the right, then to the left. This switch is due to the sequence of positive and negative mass – a phenomenon that can only be realized in graphene and could be used as a novel switch.

"A nano-switch of this type in graphene can be incorporated into a wide

variety of devices and operated simply by altering the [magnetic field](#) or the electrical field," comments Professor Christian Schönenberger on the latest results from his group. Teams of physicists from Regensburg, Budapest and Grenoble were also involved in the study published in "*Nature Communications*".

Material with special properties

Graphene is a very special material with promising properties. It is made up of a single layer of carbon atoms but is still very mechanically durable and resistant. Its excellent electrical conductivity in particular makes graphene the subject of research by numerous teams of scientists around the world.

The particular properties of this material were examined theoretically several decades ago. However, it was not until 2004 that physicists Andre Geim and Kostya Novoselov succeeded in producing graphene for experimental tests. The two researchers used scotch tape to peel away individual two-dimensional graphene layers from the original material, graphite. They received the 2010 Nobel Prize for Physics for this seemingly simple method, which enabled experimental graphene research for the first time. Since then, researchers worldwide have perfected the production process with tremendous speed.

More information: Peter Rickhaus, Peter Makk, Ming-Hao Liu, Endre Tovari, Markus Weiss, Romain Maurand, Klaus Richter, and Christian Schönenberger, "Snake trajectories in ultraclean graphene p–n junctions," *Nature Communications* 6:6470, published 3 March 2015, [DOI: 10.1038/ncomms7470](https://doi.org/10.1038/ncomms7470)

Provided by University of Basel

Citation: Electrons moving along defined snake states (2015, March 3) retrieved 4 November 2024 from <https://phys.org/news/2015-03-electrons-snake-states.html>

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