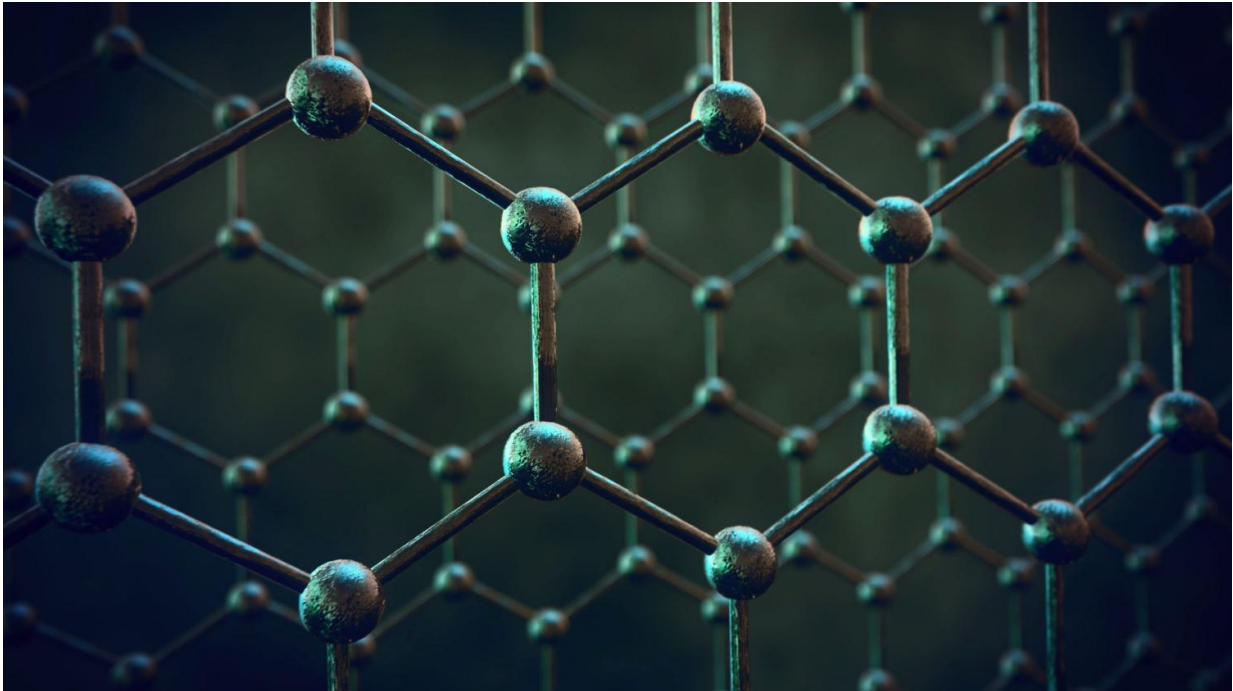


The fastest light-driven current source

September 26 2017



This visualisation shows layers of graphene used for membranes. Credit: University of Manchester

Controlling electronic current is essential to modern electronics, as data and signals are transferred by streams of electrons controlled at high speed. Demands on transmission speeds are also increasing as technology develops. Physicists at Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU) have succeeded in switching on a current with a desired direction in graphene using a single laser pulse within a femtosecond—a

femtosecond corresponds to the millionth part of a billionth of a second. This is more than a thousand times faster than the most efficient transistors today.

Scientists have already shown that it is possible to steer electrons with light waves in gases, insulating materials and semiconductors. Thus, in principle, it is possible to control current. However, this concept has not yet been applied to metals as light cannot usually penetrate the material to control the electrons. To avoid this effect, physicists in the working groups of Prof. Dr. Peter Hommelhoff and Prof. Dr. Heiko Weber used graphene, a semimetal consisting of only a single layer of carbon atoms. Even though graphene is an excellent conductor, it is thin enough to let some light penetrate the material and move the electrons.

For their experiments, the scientists fired extremely short laser pulses with specially engineered waveforms onto graphene. When these [light](#) waves hit the graphene, the electrons inside were hurled in one direction, like a whiplash. "Under intense optical fields, a current was generated within a fraction of an optical cycle—a half-femtosecond. It was surprising that despite these enormous forces, quantum mechanics still plays a key role," explains Dr. Takuya Higuchi from the Chair of Laser Physics, the first author of the publication.

The researchers discovered that the current generation process in the [graphene](#) follows complicated quantum mechanics. The electrons travel from their initial state to the excited state by two paths rather than one—similar to a forked road leading to the same destination. Like a wave, the electrons can split at the fork and flow on both roads simultaneously. Depending on the relative phase between the split electron waves, when they meet again, the current can be very large, or not present at all. "This is like a water wave. Imagine a wave that breaks against a building wall and flows to the left and the right of the building at the same time. At the end of the building, both parts meet again. If the

partial waves meet at their peak, a very large wave results and current flows. If one wave is at its peak, the other at its lowest point, the two cancel one another out, and there is no current," says Prof. Dr. Peter Hommelhoff from the Chair of Laser Physics. "We can use the [light waves](#) to regulate how the [electrons](#) move and how much electricity is generated."

The results are another important step in uniting electronics and optics. In the future, the method could open a door for realizing ultrafast electronics operating at optical frequencies.

More information: Takuya Higuchi et al, Light-field-driven currents in graphene, *Nature* (2017). [DOI: 10.1038/nature23900](https://doi.org/10.1038/nature23900)

Provided by University of Erlangen-Nuremberg

Citation: The fastest light-driven current source (2017, September 26) retrieved 27 April 2024 from <https://phys.org/news/2017-09-fastest-light-driven-current-source.html>

This document is subject to copyright. Apart from any fair dealing for the purpose of private study or research, no part may be reproduced without the written permission. The content is provided for information purposes only.