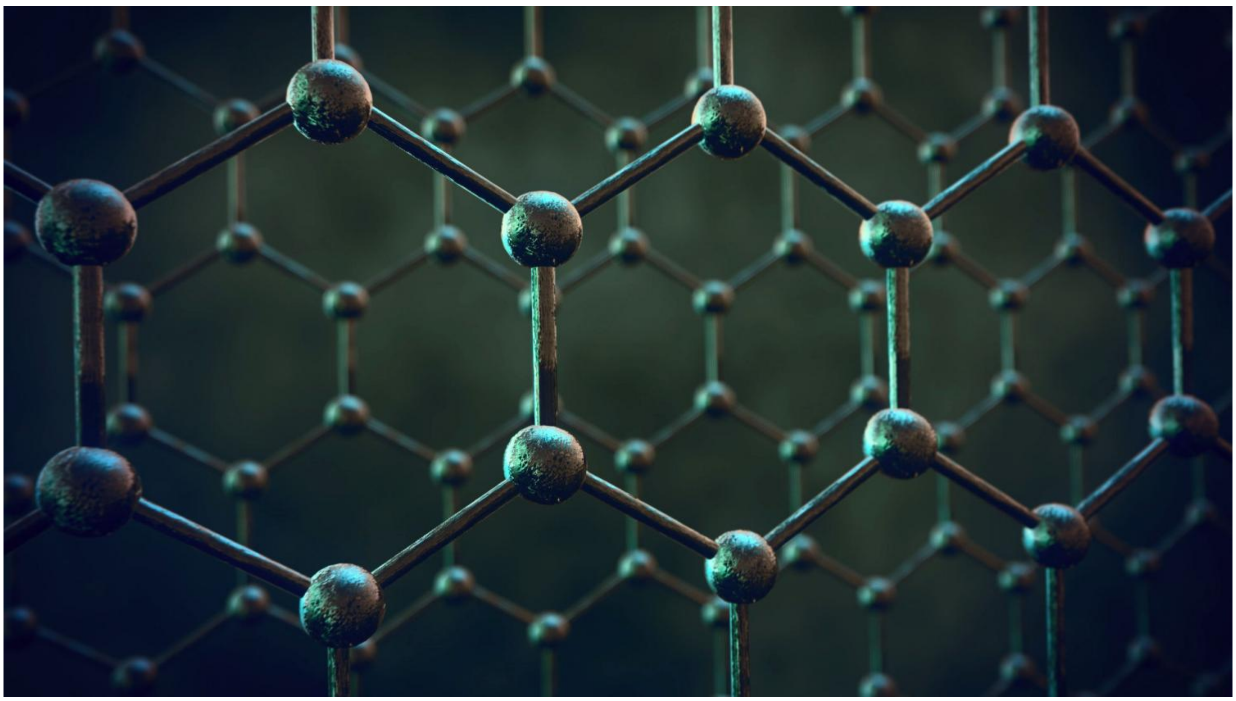
Physicists shed light on the properties of plasmons in nanostructured graphene

September 12 2018



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

A group of scientists from Russia and Austria has demonstrated that the interaction between plasmon oscillations in nanostructured graphene causes a significant shift in the far IR light absorption spectrum. Plasmons, collective excitations of electrons in solids, were demonstrated to change their properties under the influence of the electric field in low-dimensional materials, such as graphene, thus breaking new ground for a plethora of optoelectronic applications, including sensors, detectors, radiation sources and many others. The findings will enable modeling plasmon spectra and using the modeling results in optoelectronics. The results of the study were published in *ACS Photonics*.

Plasmon spectra in isolated graphene nanostrips is a thoroughly researched area. But for actual optoelectronic devices to operate efficiently, the biggest possible number of nanostrips are required per unit length so that graphene covers as much of the substrate area as possible. Until recently, the optical spectra of such systems were described in approximate manner and regarded as an assembly of non-interacting plasmons within an individual nanostrip – an approach that calculates the dominant oscillation mode frequency in an isolated nanostrip with an error of over 10 percent and is unable to capture subtler effects in graphene, such as radiation broadening of the absorption spectra.

The scientists discovered that the electrical interactions between plasmons result in a substantial shift in the far IR absorption spectrum with reference to the plasmon spectrum in an isolated nanostrip. The study also revealed a significant broadening of the nanostrips' absorption spectra resulting from back re-radiation of the absorbed energy. If properly taken into account, this effect ensures very high accuracy in determining the parameters of the nanostrip graphene, such as the Fermi level and electron collision frequency. The absorption spectrum analysis method put forward by the authors can be used to study the subtle factors that influence the conductivity of graphene and other two-dimensional materials.

The graphene samples used in the study were supplied by Graphenea (Spain).

"Due to the interactions between plasmons, the graphene absorption spectra cover the far IR spectrum (photon energies ranging from 10 meV to 200 meV), which matches the oscillation spectra of most biological molecules. This opens up new vistas for designing and manufacturing graphene-based biosensors," says the study lead and Skoltech employee Vyacheslav Semenenko.

More information: Vyacheslav Semenenko et al. Plasmon–Plasmon Interactions and Radiative Damping of Graphene Plasmons, *ACS Photonics* (2018). DOI: 10.1021/acsphotonics.8b00544

Provided by Skolkovo Institute of Science and Technology