Buckyballs on gold are less exotic than graphene
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Artificial graphene with buckyballs?

A recent study suggested that it is infinitely easier to make artificial graphene using C\textsubscript{60} molecules called buckyballs. Only a uniform layer of these needs to be vapor-deposited onto gold for the gold electrons to take on the special graphene properties. Measurements of photoemission spectra appeared to show a kind of Dirac cone.

Analysis of band structures at BESSY II

"That would be really quite amazing," says Dr. Andrei Varykhalov, of HZB, who heads a photoemission and scanning tunneling microscopy group. "Because the C\textsubscript{60} molecule is absolutely nonpolar, it was hard for us to imagine how such molecules would exert a strong influence on the electrons in the gold." So Varykhalov and his team launched a series of measurements to test this hypothesis.

In tricky and detailed analyses, the Berlin team was able to study C\textsubscript{60} layers on gold over a much larger energy range and for different measurement parameters. They used angle-resolved ARPES spectroscopy at BESSY II, which enables particularly precise measurements, and also analyzed electron spin for some measurements.

Variants in graphene architecture

Artificial variants of graphene architecture are a hot topic in materials research right now. Instead of carbon atoms, quantum dots of silicon have been placed, ultracold atoms have been trapped in the honeycomb lattice with strong laser fields, or carbon monoxide molecules have been pushed into place on a copper surface piece by piece with a scanning tunneling microscope, where they could impart the characteristic graphene properties to the electrons of the copper.
Measurement data from BESSY II before and after deposition of C$_{60}$ molecules demonstrate the replication of the band structure and the emergence of cone-like band crossings. A scanning electron microscopy of the buckyballs on gold is superimposed in the center. Credit: HZB

**Normal behavior**

"We see a parabolic relationship between momentum and energy in our measured data, so it's a very normal behavior. These signals come from the electrons deep in the substrate (gold or copper) and not the layer, which could be affected by the buckyballs," explains Dr. Maxim Krivenkov, lead author of the study. The team was also able to explain the linear measurement curves from the previous study. "These measurement curves merely mimic the Dirac cones; they are an artifact, so to speak, of a deflection of the photoelectrons as they leave the gold and pass through the C$_{60}$ layer," Varykhalov explains. Therefore, the buckyball layer on gold cannot be considered an artificial graphene.

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