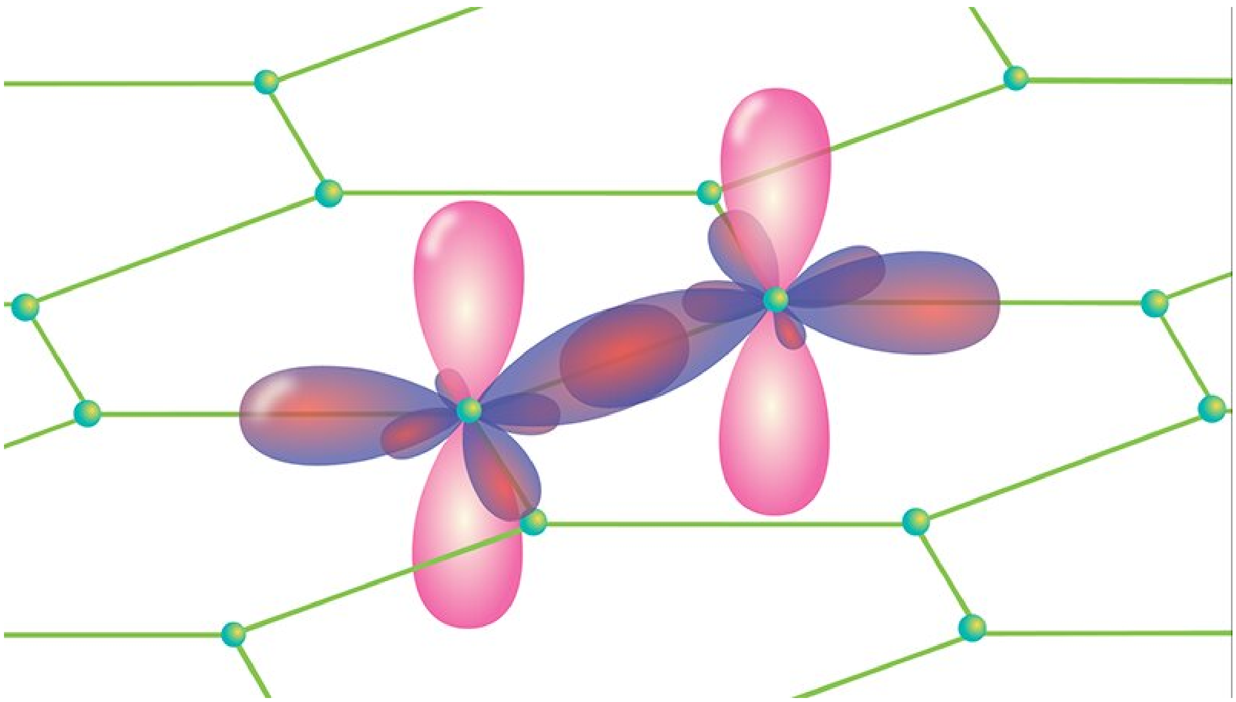
Graphene's mechanical properties found to have similarities to graphite

September 27 2019, by Bob Yirka



Graphene is only one carbon atom thick and looks 2D. But it has electronic orbitals that extend perpendicularly to the atomic plane, such as the $2p_z$ orbitals (light pink). These orbitals resist compression in the direction perpendicular to graphene's lattice, a characteristic of 3D materials. Credit: APS/Carin Cain

A team of researchers from the U.K., China and Spain has found that graphene exhibits mechanical properties that are similar to those of graphite. In their paper published in the journal *Physical Review Letters*, the group describes testing flakes of graphene in a unique way, and what they found.

Graphene is a sheet of carbon atoms just a single atom thick, sometimes called a two-dimensional material. In this new effort, the researchers questioned whether it truly is a two-dimensional material by testing it to see if it has 3-D mechanical properties.

Prior research has shown that graphene does behave as a 2-D material when looking at its electronic properties. It also behaves like a 2-D material when testing its thermal properties. But until now, its mechanical properties had not been tested. The reason fis that graphene falls apart nearly instantly when not supported by a substrate, presenting difficulties in testing its mechanical properties without also including those of the substrate. To get around this problem, the researchers tested one of graphene's mechanical properties by suspending graphene flakes in a viscous liquid, thereby preventing phonons from shaking it apart. The liquid also prevented the flakes from bonding and forming graphite. The team then carried out a common 3-D test—applying high pressure, in this case, using a diamond anvil cell. Doing so showed (via Raman spectroscopy) that the energy shift that resulted from its phonons was closer to that exhibited by a 3-D material (graphite) than a 2-D material.

The researchers note that even if a material such as graphene is just one atom thick, it is still not truly flat. This is because it has electronic orbitals that extend above and below the plane that makes up its surface. Such orbitals resist compression, a characteristic of 3-D materials. They note that their work suggests that graphene could be used as the basis of a strain sensor—and it could have implications for how Raman spectroscopy is used as a diagnostic tool when using graphene as a composite with other materials.

More information: Y. W. Sun et al. 3D Strain in 2D Materials: To

What Extent is Monolayer Graphene Graphite?, *Physical Review Letters* (2019). DOI: 10.1103/PhysRevLett.123.135501