Physicists explore properties of electrons in graphene

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Scientists from Georgia State University and the Georgia Institute of Technology have found a new way to examine certain properties of electrons in graphene – a very thin material that may hold the key to new technologies in computing and other fields.

Ramesh Mani, associate professor of physics at GSU, working in collaboration with Walter de Heer, Regents' Professor of physics at Georgia Tech, measured the spin properties of the electrons in graphene, a material made of carbon atoms that is only one atom thick.

The research was published this week in the online-only journal *Nature Communications*.

Electrons, which follow orbits around the nucleus in atoms, have two important characteristics – charge and spin.

The electric charge is the basis of most electronic devices, but spin – which Mani and co-workers examined using a new technique – forms the basis of new "spintronic" devices, and can serve as a building block for new computers in a field called quantum computing, as well as other technologies.

Graphene is thought to be a key material for spintronic devices, but it is so new that scientists must perform a lot of research on it to understand its capability. The GSU and Georgia Tech study propels this research forward.

"We tried to use the electrical resistance to detect spin resonance. When you shine microwaves on the device, and the microwave energy equals the spin-splitting energy," Mani explained.

"The device absorbs the microwave energy, and that changes the resistance of the device. But this is usually such a small effect that one hardly expects to see it. Fortunately, this material allowed us to see the effect. Measuring spin resonance electrically is especially useful for nanoscale devices."

"By doing such a measurement, we can measure properties like the spin splitting energy, and the spin relaxation time directly," he continued. "There have been other measurements, but those have been a little more indirect."

With the advance in measuring the properties of an electron's spin in graphene, it will allow scientists to carry out further studies of this novel material – giving researchers ways to optimize graphene for spintronic applications.

Mani noted that that the experiments which were conducted at GSU, were very labor intensive. Simply creating graphene – which de Heer's laboratory accomplished – is very time consuming and requires enormous experience.

Measurements use very sophisticated equipment, requiring the researchers to immerse samples in liquid Helium at temperatures close to absolute zero – about 460 degrees Fahrenheit below zero.

Atlanta has become a center for graphene research, Mani said.

"The confluence of available experimental capability in Atlanta, a hotbed for graphene science and technology, made possible this important advance in the world of spintronics physics," he explained.

More information: The journal article is "Observation of Resistively Detected Hole Spin Resonance and Zero-field Pseudo-spin Splitting in Epitaxial Graphene," Mani, R.G., Hankinson, J., Berger, C. and de Heer, W.A., DOI:10.1038/ncomms1986

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