Creating a pure spin current in graphene

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(PhysOrg.com) -- Graphene is a material that has the potential for a number of future applications. Scientists are interested in using graphene for quantum computing and also as a replacement for electronics. However, in order to realize these graphene applications, a solid understanding of how spin current works in graphene is important.

One of the goals is to achieve pure spin current in graphene. "Pure spin current is a spin current with zero charge current, which means electrons with different spins travel toward opposite directions," K S Chan tells *PhysOrg.com* via email. Chan is a professor at the City University of Hong Kong. Working with Zijing Lin, a professor at the University of Science and Technology of China in Hefei, and, Qingtian Zhang, a student of the CityU-USTC joint Ph.D. program, Chan studied adiabatic pumping in graphene as a way to generate spin current. Their work is published in *Applied Physics Letters*: "Spin current generation by adiabatic pumping in monolayer graphene."

"Spin current is an important tool of studying spins in graphene," Chan explains. "With spin current, you can create polarization in a particular region, and you can study the behavior of the spin in that particular region." Chan points out that spin current is important in the development of a graphene quantum computer. Additionally, he points out that graphene is the material of choice for spintronics, which some hope will be able to replace electronics.

"Spintronic devices are believed to be faster and consume less power than electronic devices," Chan continues. Understanding how spin works in graphene could be an important part of making a breakthrough in spintronics. Chan and his colleagues use a method called adiabatic quantum pumping to generate spin current for study.

Chan describes the technique: “[Adiabatic pumping] is a quantum phenomenon in which a DC current is generated without a DC voltage. Two AC voltages are applied to the graphene and a DC charge current can be generated through adiabatic quantum pumping. Adiabatic means the rates of change of the voltages are very slow in comparison with the speed at which the electrons travel through the graphene structure.”

On top of that, the team created asymmetry between electrons with different spin using the ferromagnetic proximity effect. “A ferromagnetic thin film is deposited on graphene. Electrons with different spins under the ferromagnetic layer will have different energies and therefore respond differently to adiabatic pumping,” Chan says. As a result of these different responses, pure spin current is generated, with different spins traveling in opposite directions. “What is so special about the present method is that a pure spin current can be generated at some Fermi energy without an external magnetic field, which is important for making nanosized devices.”

Fundamentally, the work done by Chan and his colleagues show that it is possible to generate pure spin current in graphene without magnetic field. This could lead to more practical applications in quantum computing and perhaps, later, spintronics. The next step, though, is to learn how spin current can be detected.

“Spin current is difficult to detect,” Chan explains. “It’s not like the charge current which can be easily measured by a voltmeter.” He admits that there are other important issues that need to be studied regarding spin in graphene, but Chan points this out: “To develop graphene spintronic devices, we need to know how to measure the spin current in graphene."

More information: Qingtian Zhang, K S Chan, and Zijing Lin, "Spin current generation by adiabatic pumping in monolayer graphene," *Applied Physics Letters* (2011). Available online: link.aip.org/link/APPLAB/v98/i3/p032106/s1