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Finding a nano puzzle piece

BY SEAN MOORE

Photo by Sean Moore

David Abergel (left), and Tapash Chakraborty, from Physics and Astronomy

Take a carbon nanotube, snip it open, lay it flat, and you have graphene, one of the most rigid materials known, and one full of strange properties that were first predicted in 1947 by Canadian physicist Philip Wallace.

Judging by the thousands of papers written about graphene since 2005 (when Wallace's predictions about electrons behaving relativistically in graphene were verified experimentally), it's safe to say that this puzzle has plenty of pieces – and two University of Manitoba researchers have just found a big one hiding, as they sometimes do, in an advanced theory.

Their findings will be published in the prestigious journal *Physical Review Letters*.

Tapash Chakraborty, Canada Research Chair in Nanoscale Physics, and his post-doctoral researcher David Abergel, have developed a theory which explains why bilayer graphene displays strange properties when placed in a magnetic field. Their explanation has implications for industries hoping to make the next generation of computer chips.

But let's take a step back for a moment.

Monolayer graphene is one atom thick and looks, as other have written, like molecular chicken wire. Stack two monolayers and you get bilayer graphene.

Recently, researchers at Columbia University put this material in a magnetic field and shone specific wavelengths of light at it to see what was absorbed – measuring what's called the cyclotron resonance.

By doping graphene so that it has an overall positive charge in one experiment, and an overall negative charge in another, the researchers observed how much energy the cyclotron resonance absorbed.

Imagine an elevator in a building. It should take the same amount of energy to move it from the basement (negatively doped) to the main floor (no doping) as it does to go from the main floor to the first floor (positively doped). At least, that is what you would expect if you used the simple theory.

What the Columbia team found, however, was that it took less energy to move from the basement to the main floor than it did to move from the main to the first floor.

Simple theory ignores the interactions between electrons because when you account for these, the equations become very difficult to solve. But interacting theory does take them into account.

"Interacting theory is usually a very difficult thing to handle so people first try the simple approach to see if it fits the experimental result," Chakraborty said.

"So, what we've done in the more complicated theory is to take the fact that electrons repel each other into account and model the system in this much more complete way," Abergel said.

"And when you include these interactions, it does predict this difference in the energy that the experimentalists found. It's a fundamental addition to the whole jigsaw puzzle of knowledge about this material, and you have to include these interactions if you want an accurate theoretical description of graphene," he said.

It was, in short, an important discovery.

"I was telling David how lucky he is," Chakraborty said. "There are so many groups around the world studying the same thing, and that makes it all very exciting, although it makes it a challenge too. But we hit the right thing. We found the explanation."