Scientists create atomic scale, 2-D electronic kagome lattice

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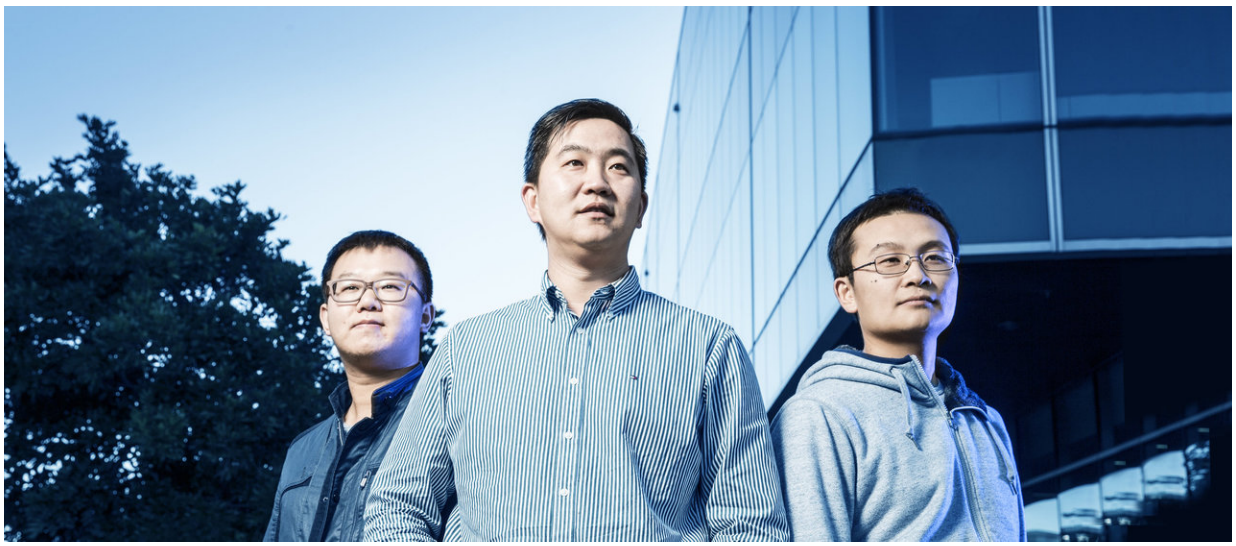

(Left to right) Dr Jincheng Zhuang, Dr Yi Du and Dr Zhi Li from the University of Wollongong's Institute for Superconducting and Electronic Materials. Credit: Paul Jones

Scientists from the University of Wollongong (UOW), working with colleagues at China's Beihang University, Nankai University, and Institute of Physics at Chinese Academy of Sciences, have successfully created an atomic scale, two-dimensional electronic kagome lattice with potential applications in electronics and quantum computing.

The research paper is published in the November issue of *Science*

Advances.

A kagome lattice is named after a traditional Japanese woven bamboo pattern composed of interlaced triangles and hexagons.

The research team created the kagome lattice by layering and twisting two nanosheets of silicene. Silicene is a silicon-based, one-atom thick, Dirac fermion material with a hexagonal honeycomb structure, which electrons can speed across at close to the speed of light.

When silicene is twisted into a kagome lattice, however, electrons become "trapped", circling around in the hexagons of the lattice.

Dr. Yi Du, who leads the Scanning Tunneling Microscopy (STM) group at UOW's Institute for Superconducting and Electronic Materials (ISEM) and Beihang-UOW Joint Research Centre, is the paper's corresponding author.

He said scientists have long been interested in making a 2-D kagome lattice because of the useful theoretical electronic properties such a structure would have.

"Theorists predicted a long time ago that if you put electrons into an electronic kagome lattice, destructive interferences would mean the electrons, instead of flowing through would instead turn around in a vortex and would become locked in the lattice. It is equivalent to someone losing their way in a maze and never getting out," Dr. Du said.

"The interesting point is that the electrons will be free only when the lattice is broken, when you create an edge. When an edge forms, electrons will move along with it without any electric resistance—it has very low resistance, so very low energy and electrons can move very fast, at the speed of light. This is of great importance for designing and developing low-energy-cost devices.

"Meanwhile, with a strong so-called spin-orbital coupling effect, novel quantum phenomena, such as frictional quantum Hall effect, are expected to happen at room temperature. This will pave a way for quantum devices in the future."

While the theoretical properties of an electronic kagome lattice made it of great interest to scientists, creating such a material has proved extremely challenging.

"For it to work as predicted, you have to make sure the lattice is constant, and that lengths of the lattice are comparable to the wavelengths of the electron, which rules a lot of materials out," Dr. Du said.

"It has to be a type of material on which the electron can only move on the surface. And you have to find something that is conductive, and also has a very strong spin-orbital coupling effect.

"There are not many elements in the world that have these properties."

One element that does is silicene. Dr. Du and his colleagues created their 2-D electronic kagome lattice by twisting together two layers of silicene. At a rotation angle of 21.8 degrees they formed a kagome lattice.

And when the researchers put electrons into it, it behaved as predicted.

"We observed all the quantum phenomena predicted theoretically in our artificial kagome lattice in silicene," Dr. Du said.

The expected benefits of this breakthrough will be much more energy efficient electronic devices and faster, more powerful computers.

More information: Zhi Li et al. Realization of flat band with possible nontrivial topology in electronic Kagome lattice, *Science Advances* (2018). DOI: 10.1126/sciadv.aau4511

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