PHYSICS

Einstein tile inspires a weird material

The theoretical quasicrystal shares properties with graphene

BY EMILY CONOVER

"The hat" wowed mathematicians. Now the shape is shaking up physics.

In 2023, mathematicians reported that the 13-sided tile was the first known "einstein" (SN: 4/22/23, p. 7). That's a shape that can perfectly cover an infinite plane — no gaps or overlaps — but only without forming a repeating pattern.

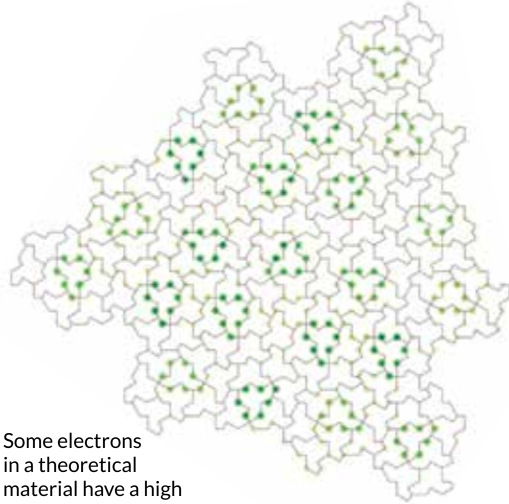
Scientists have now predicted the properties for a two-dimensional material based on the hat. It's a quasicrystal, a material that is orderly like a crystal but the arrangements of atoms don't repeat. Intriguingly, this hat-based material shares properties with graphene, a crystalline material, the researchers report in a study to appear in *Physical Review Letters*.

"It's got lots of properties that we associate with quasicrystals, but then it acts strangely like crystals," says physicist Sinéad Griffin of Lawrence Berkeley National Laboratory in California. "It's a really fun study."

Previously, mathematicians needed more than one shape to cover an infinite plane with an aperiodic tiling, the mathematical term for this type of nonrepeating pattern. Some earlier aperiodic tilings have connections to real-world materials. Penrose tilings, based on sets of two tiles discovered in the 1970s by mathematician Roger Penrose, look like a 2-D slice through a quasicrystal. Such quasicrystals have been found in meteorites and atomic bomb test debris, in addition to being made in the lab (SN: 6/19/21, p. 12).

Scientists wanted to know what a material based on the hat tiling might be like. Physicist Adolfo Grushin of Institut Néel of CNRS in Grenoble, France and colleagues calculated the properties of electrons in a 2-D material in which atoms sit at vertices of the hat tiles.

To characterize a material, scientists can look at the relationship between the energies of its electrons and their wavelengths. (According to quantum physics,



Some electrons in a theoretical material have a high probability (dark green) of encircling mirrored tiles.

electrons travel through materials as waves; the wavelength denotes the size of those waves.) In this energy–wavelength relationship, the team found striking similarities between the hat quasicrystal and graphene, a 2-D crystal of carbon.

That's because many of the vertices of the hat tiling fall along a hexagonal grid like that of graphene, Grushin says.

The fact that the hat tiling is made up of a single tile shape, rather than multiple shapes, also helps explain how it straddles the worlds of crystals and quasicrystals.

At a particle accelerator in Germany, scientists used highly charged uranium ions to test the theory of quantum electrodynamics.

QUANTUM PHYSICS

In an extreme test, QED still stands

Pivotal quantum theory works even in strong electric fields

BY EMILY CONOVER

To put one of physics' most important theories to the test, scientists go to extremes. Extremely strong electromagnetic fields, that is.

The theory of quantum electrodynamics, which describes interactions of electrically charged particles and light, has been checked to painstaking precision (SN: 3/11/23, p. 10). The theory correctly predicts properties of simple atoms, like hydrogen or helium. But it has been less carefully tested in strong electromagnetic fields, like those of large atomic nuclei.

The theory's predictions hold up even in those conditions, physicist Robert Lötzsch of Friedrich Schiller University Jena in Germany and colleagues report in the Jan. 25 *Nature*.

Quantum electrodynamics, or QED, is an integral part of the standard model of particle physics, the theory of fundamental particles and their interactions. So testing it in all possible scenarios is key.

To probe QED's prowess, the scientists turned to uranium, which has a whopping 92 protons in its nucleus and a mighty electric field. The tests used uranium that had been stripped of all but two electrons to form an ion, or electrically charged atom. This type of uranium ion is called helium-like uranium because helium atoms normally have just two electrons.

Field strengths around such ions are much stronger than any field produced by humankind, Lötzsch says.

At the GSI Helmholtz Centre for Heavy Ion Research in Darmstadt, Germany, the team accelerated slightly charged uranium and sent it through copper foil, peeling all but one electron from each ion. When sent through nitrogen gas, the ions grabbed an electron to make helium-like uranium. The process left each ion with one of its two electrons in a high-energy state.

Those electrons quickly jumped to lower energy levels. By measuring X-rays released from a given jump, the team determined the energy of that transition.

FROM TOP: A. GRUSHIN/INSTITUT NÉEL/CNRS; J. MAI/GSI HELMHOLTZ CENTRE FOR HEAVY ION RESEARCH GMBH

Excerpt from the February 23, 1974 issue of *Science News*

50 YEARS AGO

Cancer drugs by computer

Chemists often need to sort a large number of compounds according to whether or not they possess a given property.... [Researchers] have been working on a technique of getting computers to teach themselves how to solve such problems. The most recent experiments indicate that the technique [based on pattern recognition] may be useful in finding cancer drugs.

UPDATE: Modern computers can do more than sift through known compounds. With advanced artificial intelligence, computers are helping scientists design novel molecules and predict how those compounds will react with proteins in the body, possibly leading to new cancer treatments. The technology is promising but still in its early days. Ultimately, most drug candidates will still falter in people, some scientists caution. In 2021, the international biotech company Exscientia launched the first trial of an AI-developed cancer drug. But the company shelved the drug in 2023 after it proved to be ineffective. Other AI cancer drugs are in various stages of testing.

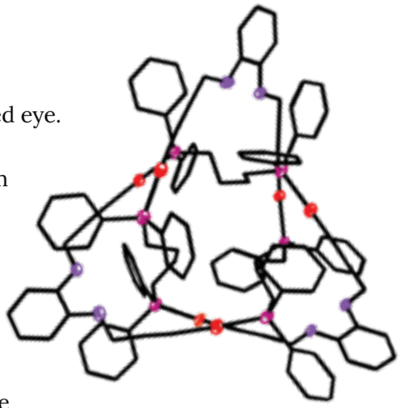
IT'S ALIVE

Snails that give live birth seem to leave labor up to the babies

The rough periwinkle snail's brood pouch contains embryos at various stages of maturity (shown). When young hatch, they may have to crawl out of mom's body on their own.

THE –EST

The smallest molecular knot yet



Imagine a knot so small that it can't be seen with the naked eye. Then think even smaller.

Chemists have tied together a chain of 54 atoms to form the smallest molecular knot yet. Described January 2 in *Nature Communications*, the pretzel-shaped knot (illustrated), called a trefoil, has a backbone made of gold (red), phosphorus (purple), oxygen (magenta) and carbon atoms (black nodes). The previous smallest molecular knot, reported in 2020, contained 69 atoms.

Chemist Richard Puddephatt and colleagues created the new knot while attempting to build complex structures of interlocked ring molecules, or catenanes. Someday catenanes could be used in molecular machines — think switches and motors at the molecular scale — but for now scientists are still figuring out how to build them. In this case, that effort resulted in something else by mistake.

"It was just serendipity really, one of those lucky moments in research that balances out all the hard knocks that you take," says Puddephatt, of the University of Western Ontario in London, Canada.

The new knot is also the tightest molecular trefoil knot. Researchers calculate a molecular knot's tightness by dividing the number of atoms in the chain by the number of chain crossings to get what's called the backbone crossing ratio, or BCR. The smaller the BCR, the tighter the knot. The new knot has a BCR of 18. The previous smallest molecular knot was also the previous tightest, with a BCR of 23.

Studying small molecular knots could someday lead to new materials (SN: 9/15/18, p. 32). But for now, the team is still trying to determine why this combination of atoms results in a knot at all. — *Anna Gibbs*

FROM TOP: FREDRIK PLEIJEL; Z. LI *ET AL*/*NATURE COMMUNICATIONS* 2024