

ScienceNews

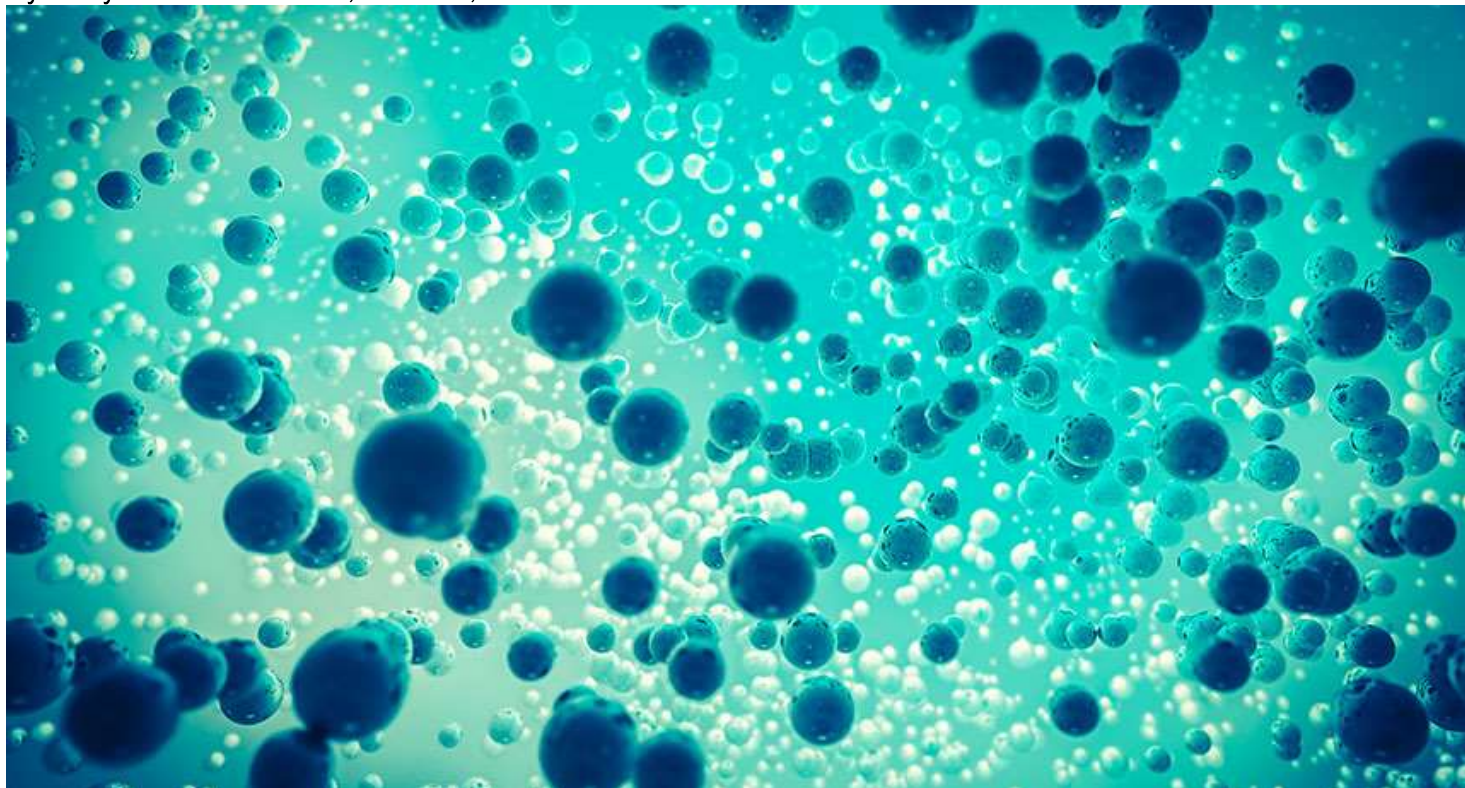
MAGAZINE OF THE SOCIETY FOR SCIENCE & THE PUBLIC

News: Condensed Matter

Faux particles commit physics faux pas

Quasiparticle known as type-II Weyl fermion violates Lorentz symmetry

By Emily Conover 3:00am, June 12, 2017



WEYL STYLE In solids, groups of particles can act in concert, behaving like a single, fundamental type of particle, known as a fermion. One such type of quasiparticle, called a type-II Weyl fermion, breaks a fundamental rule of physics called Lorentz symmetry.

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A weird new particle imitator flouts the established rules of particle physics. The discovery could help scientists simulate how particles behaved just after the Big Bang or lead to the development of new devices with unusual electromagnetic properties.

The curious new phenomenon involves a particle-like entity called a quasiparticle, formed from a jostling mosh pit of electrons that collectively act like a single particle in a solid. Found in a compound of lanthanum, aluminum and germanium, the new quasiparticle is a bit of a renegade, physicist M. Zahid Hasan of Princeton University and colleagues report June 2 in *Science Advances*. Known as a type-II Weyl fermion, the quasiparticle breaks a rule called Lorentz symmetry, which states that the laws of physics are the same no matter the observer's perspective, whether moving or stationary.

Lorentz symmetry is the foundation of Einstein's special theory of relativity, which details the physics of observers zipping along near the speed of light. For a real particle, violating Lorentz symmetry would be an unallowable faux pas, but for quasiparticles, the rules are looser, so type-II Weyl fermions can behave in a way a normal particle wouldn't.

Fermions are a class of elementary particle that includes quarks, which make up protons and neutrons, and electrons. There are three different types of fermions: Dirac, Majorana and Weyl. Dirac fermions are the garden-

variety type and include electrons and quarks. Majorana fermions are their own antiparticles. Neutrinos, notoriously lightweight and elusive particles, could be either Majorana or Dirac fermions; scientists aren't yet sure which.

Weyl fermions are a massless variety of fermion. No examples have been found in particle physics. But the quasiparticle version of Weyl fermions burst onto the scene in 2015, when scientists first discovered them in a compound made of tantalum and arsenic (*SN*: 8/22/15, p. 11). Soon, scientists realized that their Lorentz-violating relatives, type-II Weyl fermions, might likewise pop up in solids.

In the new study, Hasan and colleagues measured the relationship between the energy and momentum of the quasiparticles, showing that they were consistent with type-II Weyl fermions. Although previous experiments have shown hints of the unusual quasiparticles, those measurements were skin-deep, assessing particles only on the surface of the material, Hasan says. With surface measurements alone, it's hard to confirm the type-II Weyl fermions are there, says physicist Alexey Soluyanov of ETH Zurich. But Hasan and colleagues peered inside the material. "Experimentally, this work really is a nice example," Soluyanov says.

In solids, Weyl fermions lead to unusual behavior. Put a normal material in a magnetic field, and resistance to the flow of electricity grows, but in a solid with Weyl fermions, a magnetic field makes current flow more easily. Type-II Weyl fermions are even stranger, due to their Lorentz-violating properties. In a material with these quasiparticles, a magnetic field in one direction can increase conductivity, while in another direction it can decrease conductivity. "This type of thing can have interesting applications," says Hasan. "In a single material, just by changing the direction of the field, now we can get different behaviors," flipping between insulating and conducting, for example.

The new material could also provide insight for particle physicists. "Of course, people have wondered what happens when you break Lorentz invariance," says physicist Adolfo Grushin of Institut Néel in Grenoble, France. Type-II Weyl fermions could help scientists better understand theories that violate the rule. "It's a good test-bed," says Grushin.

For example, Hasan says, "we can test theoretical ideas in the early universe," simulating how particles may have behaved just after the Big Bang, when Lorentz symmetry may not have been obeyed.

S.-Y. Xu et al. [Discovery of Lorentz-violating type II Weyl fermions in LaAlGe](#). *Science Advances*. Published online June 2, 2017. doi: 10.1126/sciadv.1603266.

A. Grant. [Elusive particle shows up in 'semimetal'](#). *Science News*. Vol. 188, August 22, 2015, p. 11.

A. Grant. [Quasiparticles help physicists make sense of the world](#). *Science News*. Vol. 186, October 18, 2014, p. 22.

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