

# New particle is both matter and antimatter

Researchers see signature of 'Majorana particles' inside superconducting iron.

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Since the 1930s scientists have been searching for particles that are simultaneously matter and antimatter. Now physicists have found strong evidence for one such entity inside a superconducting material. The discovery could represent the first so-called Majorana particle, and may help researchers encode information for quantum computers.

Physicists think that every particle of matter has an antimatter counterpart with equal mass but opposite charge. When matter meets its antimatter equivalent, the two annihilate one another. But some particles might be their own antimatter partners, according to a 1937 prediction by Italian physicist Ettore Majorana (see '[A solid case for Majorana fermions](#)'). For the first time researchers say they have imaged one of these Majorana particles, and report their findings in the 3 October *Science*<sup>1</sup>.

The new Majorana particle showed up inside a superconductor, a material in which the free movement of electrons allows electricity to flow without resistance. The research team, led by Ali Yazdani of Princeton University in New Jersey, placed a long chain of iron atoms, which are magnetic, on top of a superconductor made of lead. Normally, magnetism disrupts superconductors, which depend on a lack of magnetic fields for their electrons to flow unimpeded. But in this case the magnetic chain turned into a special type of superconductor in which electrons next to one another in the chain coordinated their spins to simultaneously satisfy the requirements of magnetism and superconductivity. Each of these pairs can be thought of as an electron and an antielectron, with a negative and a positive charge, respectively. That arrangement, however, leaves one electron at each end of the chain without a neighbor to pair with, causing them to take on the properties of both electrons and antielectrons — in other words, Majorana particles.

As opposed to particles found in a vacuum, unattached to other matter, these Majoranas are what's called emergent particles. They emerge from the collective properties of the surrounding matter and could not exist outside the superconductor.

The new study shows a convincing signature of Majorana particles, says Leo Kouwenhoven of the Delft University of Technology in the Netherlands who was not involved in the research but previously found signs of Majorana particles in a different superconductor arrangement. “But to really speak of full proof, unambiguous evidence, I think you have to do a DNA test.” Such a test, he says, must show the particles do not obey the normal laws of the two known classes of particles in nature — fermions (protons, electrons and most other particles we are familiar with) and bosons (photons and other force-carrying particles, including the Higgs boson). “The great thing about Majoranas is that they are potentially a new class of particle,” Kouwenhoven adds. “If you find a new class of particles, that really would add a new chapter to physics.”

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Physicist Jason Alicea of the California Institute of Technology in Pasadena, who also did not participate in the research, said the study offers “compelling evidence” for Majorana particles but that “we should keep in mind possible alternative explanations — even if there are no immediately obvious candidates.” He praised the experimental setup for its apparent ability to easily produce the elusive Majoranas. “One of the great virtues of their platform relative to earlier works is that it allowed the researchers to apply a new type of microscope to probe the detailed anatomy of the physics.”

The discovery could have implications for searches for free Majorana particles outside of superconducting materials. Many physicists suspect neutrinos — very lightweight particles with the strange ability to alter their identities, or flavors — are Majorana particles, and experiments are ongoing to investigate whether this is the case. Now that we know Majorana particles can exist inside superconductors, it might not be surprising to find them in nature, Yazdani says. “Once you find the concept to be correct, it’s very likely that it shows up in another layer of physics. That’s what’s exciting.”

The finding could also be useful for constructing quantum computers that harness the laws of quantum mechanics to make calculations many times faster than conventional computers. One of the main issues in building a quantum computer is the susceptibility of quantum properties such as entanglement (a connection between two particles such that an action on one affects the other) to collapse due to outside interference. A particle chain with Majoranas capping each end would be somewhat immune to this danger, because damage would have to be done to both ends simultaneously to destroy any information encoded there. “You could build a quantum bit based on these Majoranas,” Yazdani says. “The idea is that such a bit would be much more robust to the environment than the types of bits people have tried to make so far.”

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## References

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1. Nadj-Perge, S. *et al.* *Science* <http://dx.doi.org/10.1126/science.1259327> (2014).