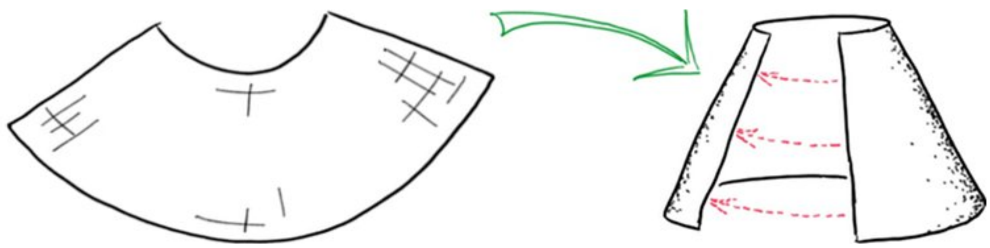
Chiral superconductor generates electric current when properly deformed

May 29 2018, by Physicists In Utrecht And Stockholm Discover Unique Effect



By bending a chiral superconductor out of the plane, an electric current is generated. Credit: Nordic Institute for Physics

Scientists around the world are busy looking for chiral superconductors, which are predicted to be ideal for building quantum computers. Until now, it has not been easy to determine whether a material is clearly a chiral superconductor or not. Together with their colleagues in Stockholm, theoretical physicists at Utrecht University have recently discovered that a unique effect occurs in chiral superconductors that should be easy to measure. In addition to being interesting from a theoretical perspective, this effect also simplifies the search for a chiral superconductor. The results of the research are published in *Physical Review Letters*.

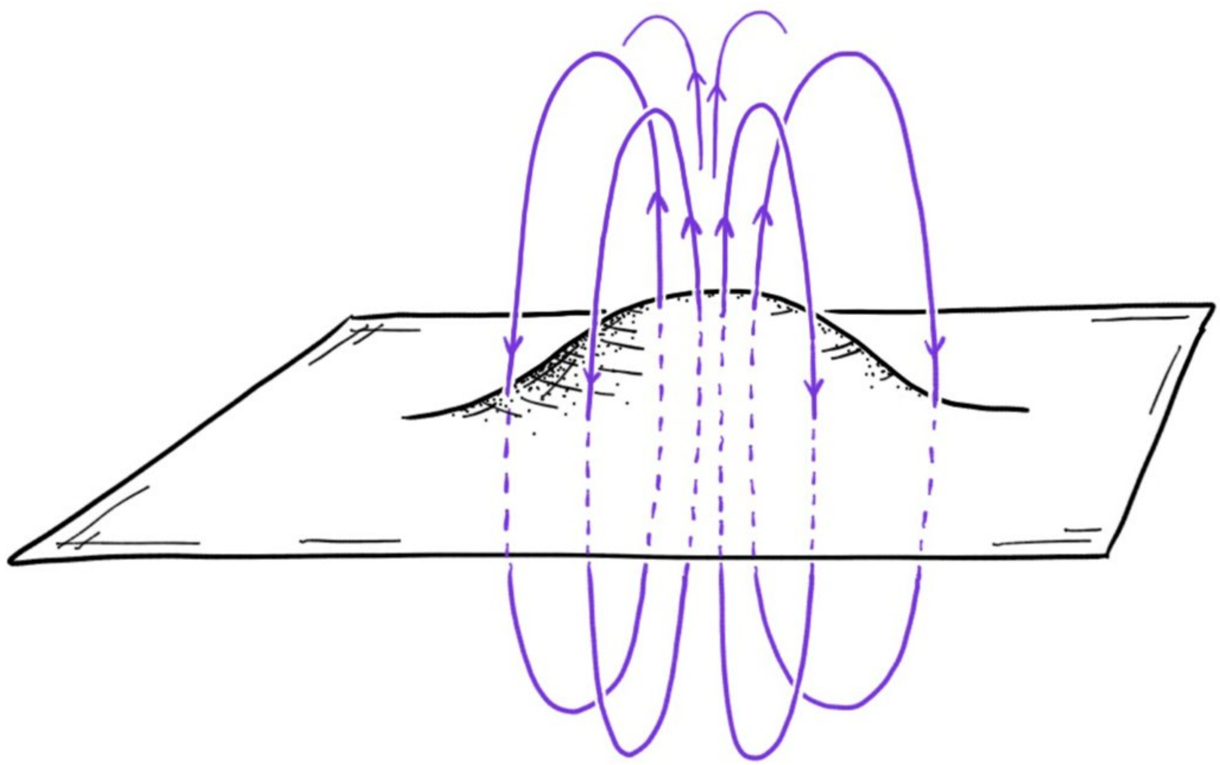
"We show that you can generate an electric current simply by deforming this type of superconductor in the right way, so you don't need voltage or a magnetic field. It's like a kind of origami electrical device," explains research leader Prof. Cristine Morais Smith from Utrecht University. "When you bend the material in a special way, an electric current starts running, and it stops when you bend it back."

Majorana particles

The difference between an 'ordinary' superconductor and a chiral one is that the electrons not only move through the material in pairs, but that the electrons in the pairs also rotate around one another. This produces an interesting effect: so called Majorana particles can form at the ends of a wire made of a chiral superconductor. These particles are expected to be the ideal quantum bits for a quantum computer. The existence of Majorana particles was predicted in 1937 by the Italian theoretical physicist Ettore Majorana, but was experimentally observed only recently by physicists at TU Eindhoven and TU Delft.

Maglev train

An ordinary superconductor can generate an electric current when a magnet is placed nearby. This is called the Meissner effect. The current in the superconductor creates an opposite magnetic field that cancels out the field from the magnet. One of the most remarkable applications of the Meissner effect is the Maglev trains in China and Japan, which can attain speeds of 600 kilometers per hour by floating above the track.



When a thin layer of a chiral superconductor is deformed, a magnetic field emerges spontaneously in the material. Credit: Nordic Institute for Physics

The physicists in Utrecht and Stockholm have now theoretically shown that a similar effect can occur in an extremely thin (two-dimensional) layer of a chiral superconductor when it is bent as shown in the illustrations. Bending appears to create a magnetic field in the superconductor, which means that it is carrying an electric current. This is a geometric version of the Meissner effect.

"In a two-dimensional chiral superconductor, all of the electron pairs rotate on the same plane. Bending the material disturbs the course of the electrons. In order to cancel out the effect of that disruption, a magnetic field is created," explains Dr. Anton Quelle, who wrote part of his dissertation on the subject. "The general rule for this geometric Meissner effect is that in two-dimensional chiral superconductors, bending plus magnetic field must equal zero. This is comparable to the ordinary Meissner effect, in which the internal magnetic field that is generated is equal but opposite to the external magnetic field, so it cancels out the field around the superconductor."

In an ordinary superconductor, the Meissner effect prevents a magnetic field from developing perpendicular to the surface. So if such a magnetic field is seen, it is 'smoking gun' proof that the superconductor is chiral, explains Morais Smith. Although the magnetic field is extremely weak, it can be measured using a SQUID, a sensor that can detect extremely weak magnetic fields.

More information: T. Kvorning et al. Proposed Spontaneous Generation of Magnetic Fields by Curved Layers of a Chiral Superconductor, *Physical Review Letters* (2018). DOI: 10.1103/PhysRevLett.120.217002

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