ScienceNews

'Magnetricity' behaves like electricity

Currents of monopole-like magnetic charges act much like electricity

By Devin Powell
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POLAR OPPOSITESCurrents of magnetricity are born when north poles and south poles split up and move around independently of each other. Steven Bramwell

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Electricity has a new little sister: magnetricity.

A team of physicists in England has created magnetic charges — isolated north and south magnetic poles — and induced them to flow in crystals no bigger than a centimeter across. These moving magnetic charges, which behave almost exactly like electrical charges flowing through batteries and biological systems, could one day be useful in developing “magnetronic” devices — though what such devices would do is anybody’s guess.

In magnets, poles always come in pairs. No matter how many times you cut a magnet in half, down to the atoms themselves, each piece will always have a north and a south — a dipole.

But the magnetic molecules that make up a crystalline material called spin ice are arranged in triangular pyramids that prevent them from lining up comfortably with all of their poles pointing in the same direction. In an awkward compromise, each pyramid tends to have two magnets pointing inward and two pointing outward.

In 2009 Steven Bramwell of the University College London found that sometimes a molecule squirms and flips. Two poles, a north and a south, are born. The molecule itself stays put, but these ghostly poles, which aren't actually attached to a physical object, can move around independently of each other as chain reactions of flipping molecules carry them from pyramid to pyramid.

"Eventually they get so far apart that they lose all memory of each other," says Bramwell. "The dipole splits in half and becomes two monopoles."

Some scientists have questioned the use of the term monopole for a phenomenon that exists only inside spin ice. This term traditionally refers to cosmic monopoles thought to be created during the Big Bang and first theorized by Paul Dirac in 1931.

"A real monopole would be a magnetic charge that would exist in a vacuum," says Michael Bonitz, a physicist at the Institute for Theoretical Physics and Astrophysics in Kiel, Germany. "What they have is a complicated condensed matter system."

Within the confines of the spin ice, though, these wandering poles do behave much like monopoles. The poles have magnetic charge that closely agrees with theoretical predictions and interact with each other according to the same law that governs the interaction of electric charges, Coulomb's Law.

Using brief magnetic pulses, Bramwell and his team have now developed a way to trigger currents of these magnetic charges — "magnetricity" — that last for minutes.

"We apply a magnetic field to create magnetic charges and get them all going the same direction," says Sean Giblin, a physicist at the Rutherford Appleton Laboratory in Oxfordshire and a coauthor of a paper published online February 13 in *Nature Physics*.

These currents have revealed new similarities between magnetic and electric charges. The creation and slow dissipation of new magnetic charges follows the exact same principles that govern charged particles in solutions — such as ions in battery electrolytes.

The way that the spin ice stores magnetic charge is also similar to the way existing devices called capacitors store electric charge. So Bramwell's pie-in-the-sky dream is for magnetricity to someday spawn a new technology called "magnetronics." But he admits it may take a while to get there, especially because these currents appear only in crystals kept close to absolute zero.

PYRAMID SCHEME

When a molecule of spin ice flips, it creates two magnetic poles in neighboring pyramids that can be carried away from each other as other molecules flip. Credit: Steven Bramwell