Topology explains queer electrical current boost in non-magnetic metal

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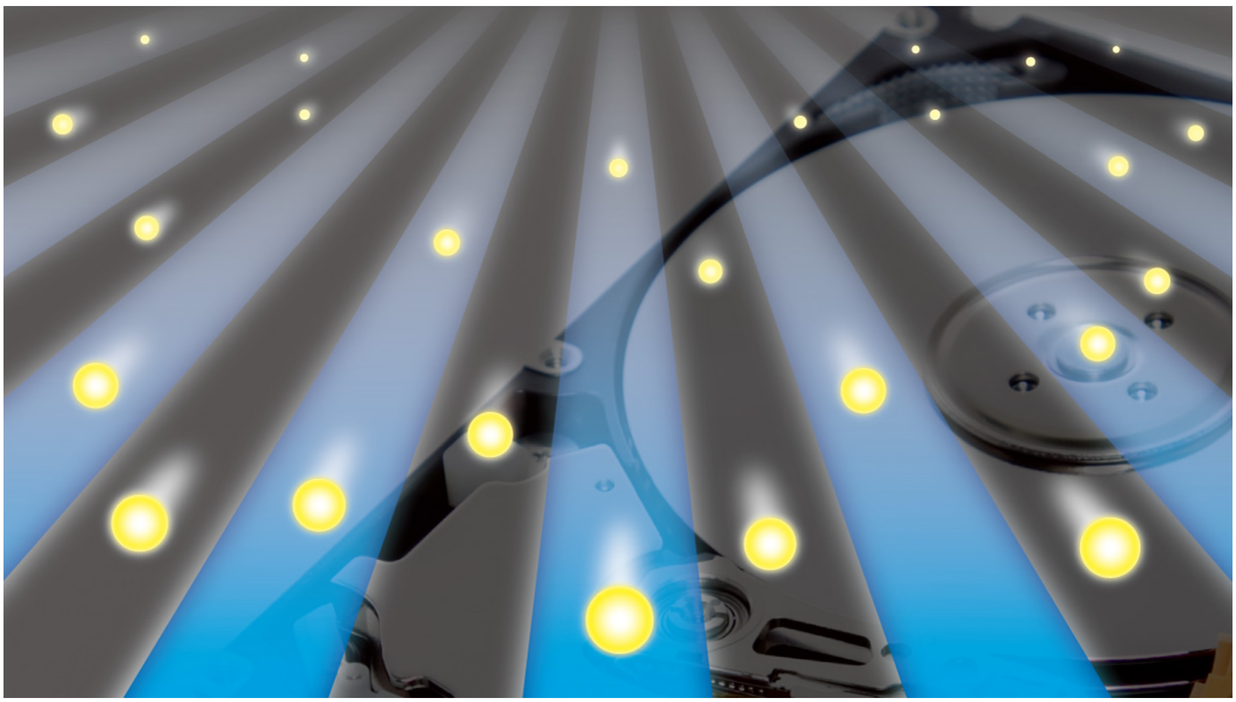

Applying a magnetic field to PdCoO2, a non-magnetic metal, made it conduct 70% more electricity, even though basic physics principles would have predicted the opposite. Credit: Eiri Ono/Kyoto University

Insights from pure mathematics are lending new insights to material physics, which could aid in development of new devices and sensors. Now an international team of physicists has discovered that applying a magnetic field to a non-magnetic metal made it conduct 70% more electricity, even though basic physics principles would have predicted the opposite.

"We never expected that magnetoresistance could be lowered even further in the compound we tested, because in theory it should have increased," says Kyoto University study author Shingo Yonezawa.

Applying a magnetic field to metals affects how well they are able to conduct electricity. Resistance arising from the magnetic field—magnetoresistance—is used in contexts like writing data in hard discs. Because of its wide application potential, material physicists are constantly striving to find new materials that show large-scale magnetoresistance.

Exposing a non-magnetic metal to a magnetic field typically increases its resistance and reduces the amount of electric current that is able to pass through it. Researchers at Kyoto University and the National Institute for Materials Science, in collaboration with researchers at National High-Magnetic Field Laboratory in the US, observed otherwise, however; when they applied a magnetic field to the compound PdCoO2, its resistance actually decreased, consequently increasing electrical current.

"Oxides tend not to deliver currents so readily, but PdCoO2 is one the oxides that actually conduct electricity beautifully," says Yonezawa. "It already has low resistance relative to other oxides."

The phenomenon remained unexplained until colleagues from the United States made a link with an analogy from topology, a mathematics discipline concerning continuous deformations.

"Electrons in some classes of materials have topological characteristics that lead them to be 'boosted' by magnetic fields, ultimately decreasing resistance," continues Yonezawa. Although PdCoO2 was believed to lack such topological characteristics, it turns out that in the magnetic field this material can exhibit a phenomenon similar to these, aided by its very 'clean', layered crystal structure."

Resistance also decreased in compounds $PtCoO_2$ and Sr_2RuO_4, which have similar layered structures to $PdCoO_2$.

"From these observations we now know that the phenomenon generally applies to other oxides with a layered structure," explains Yoshiteru Maeno, a senior author also at Kyoto University. "Further developments in stratified non-magnetic metals with good conductivity should bring about new devices and sensors that have large magnetoresistance even when exposed to weak magnetic fields."

More information: N. Kikugawa et al. Interplanar coupling-dependent magnetoresistivity in high-purity layered metals, *Nature Communications* (2016). DOI: 10.1038/ncomms10903

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