This 9980-kilogram meteorite, which crashed into Australia, contains tiny amounts of natural superconducting material, physicists have found. SYDNEY OATS/WIKIMEDIA COMMONS (CC BY 2.0)

Superconducting materials found in meteorites

By Adrian Cho | Mar. 6, 2018 , 6:20 PM

LOS ANGELES, CALIFORNIA—Meteorites sometimes contain naturally occurring superconductors, materials that conduct electricity without any resistance, a team of physicists has found. The result, reported here today at the annual March meeting of the American Physical Society, won't revolutionize scientists' understanding of the solar system, but it could raise hopes of finding a material that is a superconductor a room temperature—which could potentially lead to technological breakthroughs such as magnetically levitating trains.

"It sounds like they found something and isolated it," says Johnpierre Paglione, a condensed matter physicist at the University of Maryland in College Park, whose team is screening naturally occurring terrestrial minerals.

Conventional superconductors consist of simple metals, such as niobium, lead, or mercury, which become superconducting when cooled to below a characteristic "critical temperature" close to absolute zero—4.2 K in the case of mercury. In 1986, physicists discovered a family of copper-containing compounds that superconduct at temperatures as high as 134 K (−139°C)—a phenomenon known as high-temperature superconductivity whose origins remain one of the biggest mysteries in science. More recently, researchers have found a family of high-temperature iron-based superconductors, and there are myriad other exotic superconductors as well.

Although many scientists strive to synthesize novel superconductors by designing particular properties from the atomic scale up, a team led by Ivan Schuller, a condensed matter physicist at the University of California, San Diego (UCSD), decided to screen existing materials, starting with meteorites. “There are all these materials that God has provided,” Schuller says. “Why not look at them? ”Meteorites form under extreme temperatures and pressures beyond the capabilities of any laboratory on Earth. Thus, they’re fertile places to search for exotic new compounds, Schuller says.

The surest sign of superconductivity is a sudden plunge to zero in electrical resistance when the temperature drops below a critical threshold. But a superconductor has peculiar magnetic properties, too: It can repel an applied magnetic field if it is not too strong because free-flowing currents, swirling within the material, produce a field that cancels the applied one. The phenomenon is known as the Meissner effect, and physicists also try to find new superconductors by looking for it, especially in heterogeneous samples that are only speckled with bits of superconductor and in which the resistance never goes to zero.

However, that technique is not sensitive enough to look for very small amount of superconductor, Schuller says. So, his team put a twist on it to effectively amplify the signal. Both above and below its critical temperature a superconductor can absorb microwaves, but right at the transition the absorption changes.

To look for superconductivity, Schuller’s team placed a small sample within a cavity pumped with microwave radiation. The scientists applied both a strong constant magnetic field and a small oscillating magnetic field. When they cool a superconductor through its critical temperature, the absorption changes dramatically, explains James Wampler, a graduate student at UCSD who presented the results at the meeting. The signal is greatly enhanced, he explains, as the oscillating magnetic field drives the material in and out of superconductivity. The technique is about 1000 times more sensitive than conventional magnetic measurements, Wampler says.

The researchers validated their technique on thousands of samples of materials, Schuller says. And now, they have applied it to small samples scraped from the surfaces of 16 different meteorites, Wampler said at the meeting. They found evidence of superconductivity in samples from two of those meteorites: the Mundrabilla meteorite, a 9980-kilogram chunk of iron discovered in the Australian Outback in 1911, and Graves Nunataks, a carbonaceous meteorite found in Antarctica in 1995.

Once the researchers found the positive magnetic signal, they visually teased out the different types of grains in each powdered sample and used x-ray spectroscopy to identify the materials in the grains that were superconductive. The superconductor in the Grave Nunataks meteorite is an alloy of indium and tin, Wampler says. The one in the Mundrabilla meteorite appears to be an alloy of indium, tin, and possibly lead. Both are well-known superconductors that have critical temperatures around 5 K.

Even though the superconductors aren't exotic, the results show that superconductivity is ubiquitous in the universe, Wampler says "If this is in meteorites, it's everywhere," he says. He declines to speculate on the implications for astrophysics, but notes "there are lots of places in the universe colder than 5 K." Meteorites are generated at pressures and temperatures exceeding lab conditions, Wampler notes, so the ultimate hope is that they may contain superconducting compounds unknown to humans.

Paglione agrees that the field needs to find new materials. "There's a community of people who are looking for new materials," he says, "but it's a bottleneck."

***Correction, 7 March, 11:51 a.m.:** The story has been updated to make it clear which types of samples Ivan Schuller and Johnpierre Paglione have studied.*

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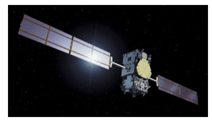

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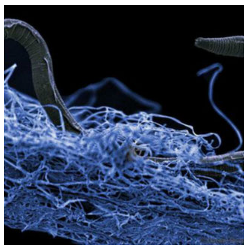

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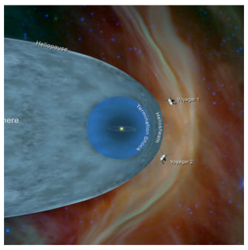

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