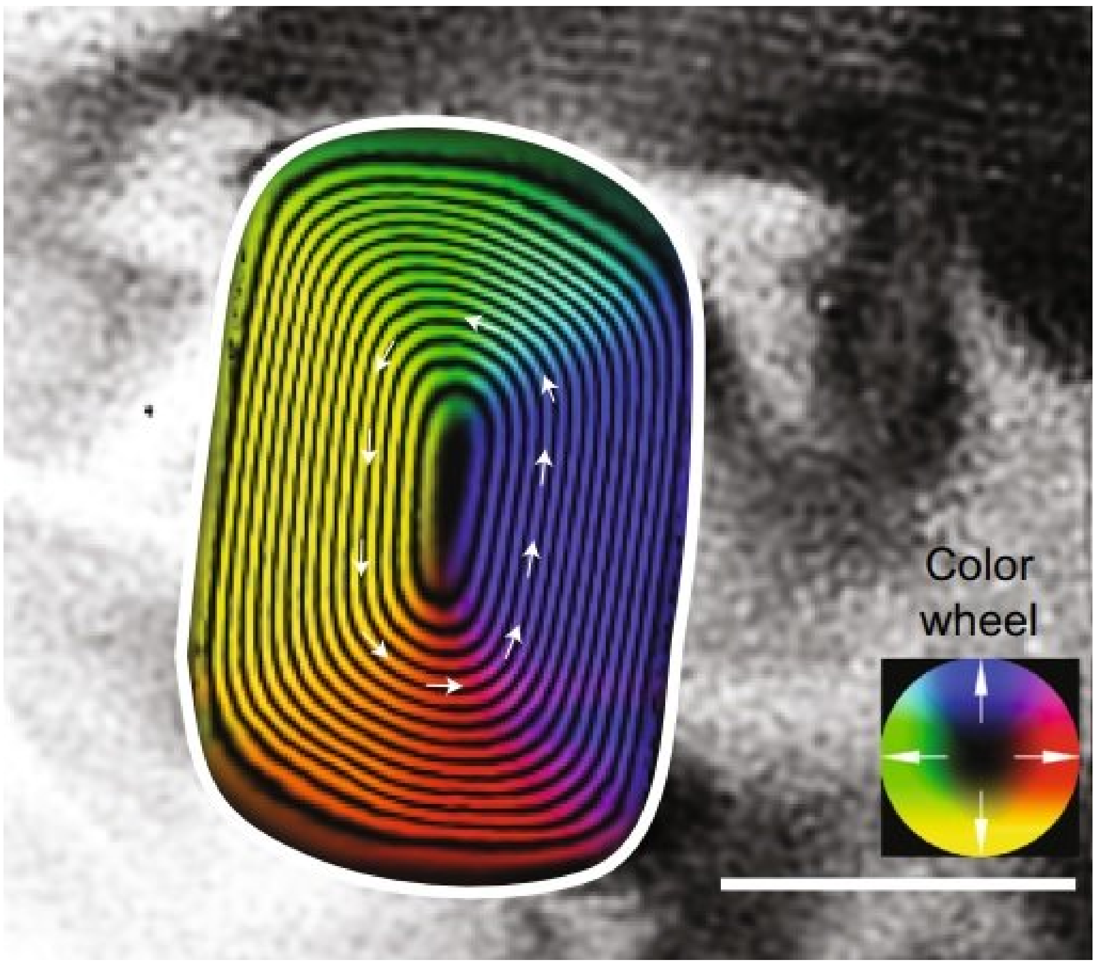
Oldest magnetic record in the solar system discovered in a meteorite

April 5 2018, by Lisa Zyga



Magnetic induction map of a magnetically non-uniform kamacite grain (consisting mostly of iron), which is encased within a dusty olivine crystal in a meteorite. The arrows and the color wheel indicate the direction of magnetic induction. Scale bar: 200 nm. Credit: Shah et al. Published in *Nature Communications*

Researchers have found that an iron-containing mineral called dusty olivine, present in meteorites, retains a record of the magnetic field from the early solar system around 4.6 billion years ago. The results are surprising, as the magnetism in dusty olivine is non-uniform, and non-uniform magnetic materials have previously been thought to be poor magnetic recorders. The discovery may lead to new insight into how the solar system formed—with the help of magnetic fields—from a protoplanetary disk.

The researchers, Jay Shah and coauthors from the UK, Germany, and Norway, have published a paper on the discovery of the oldest magnetic record in a recent issue of *Nature Communications*.

"Our study shows that magnetic fields that were present during the birth of our solar system are credibly contained within meteorite samples that we have in our collections," Shah told *Phys.org*. "With a better understanding of these complex magnetization structures, we can access this magnetic field information, and deduce how our solar system evolved from a disk of dust to the planetary system we see today."

In the field of paleomagnetism, the main objects of study are ancient rocks and other materials which, as they cooled during their formation, acquired a thermoremanent magnetization imparted by the magnetic fields present at the time. By studying these magnetic materials, researchers can find clues as to what kinds of magnetic fields existed in the early solar system.

As the researchers explain in their paper, the underpinning hypothesis in paleomagnetism is Néel's single domain theory, which predicts that uniformly magnetized grains can retain their magnetic states over geological timescales. However, Néel's theory says nothing about non-uniformly magnetized grains, which are the most abundant form of magnetism present in rocks and meteorites. Although some research has suggested that non-uniform magnetization states do not retain their magnetization very well, the question has remained unanswered until now.

The new study shows, for the first time, that iron with non-uniform magnetization states can retain magnetic recordings from more than 4 billion years ago. To show this, the researchers used cutting-edge imaging techniques (nanometric magnetic imaging and off-axis electron holography) to study the magnetic grains in dusty olivine, which are a few hundred nanometers in size.

In tests, the researchers heated the grains above 300 °C, the highest temperature that these meteorites would have experienced since forming 4.6 billion years ago, and observed that the grains retain their magnetic states. As the thermal relaxation times at this temperature are longer than the age of the solar system, the results strongly indicate that the thermoremanent magnetization imparted during their formation has remained stable to the present day.

The researchers expect that the results will lead to a better understanding of the magnetic field in the early solar system, and even how the solar system originated.

"I hope that this study can drive a better understanding of complex magnetization structures that will result in more sophisticated analyses of ancient magnetic fields throughout the solar system, including those on Earth," Shah said.

More information: Jay Shah et al. "The oldest magnetic record in our solar system identified using nanometric imaging and numerical modeling." *Nature Communications*. DOI: 10.1038/s41467-018-03613-1

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Citation: Oldest magnetic record in the solar system discovered in a meteorite (2018, April 5) retrieved 11 May 2024 from https://phys.org/news/2018-04-oldest-magnetic-solar-meteorite.html

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