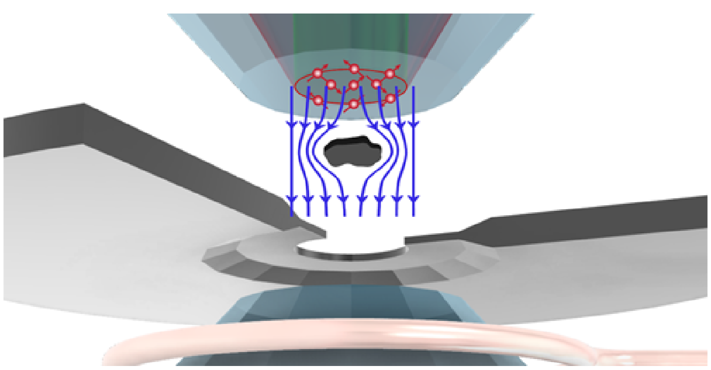
The Meissner Effect Mapped at High Pressure

A new data-analysis method allows researchers to visualize a superconductor expelling an applied magnetic field under high-pressure conditions.

By **Martin Rodriguez-Vega**

Except in limited regions, magnetic fields cannot penetrate a superconductor—a phenomenon known as the Meissner effect. Researchers routinely make use of this effect to detect defects in the material, which are sites that can trap the magnetic field. However, some materials require high pressures to be coerced into superconducting states, making magnetic-field measurements impractical. Now Cassandra Dailledouze from the University of Paris-Saclay and her colleagues have mapped a magnetic field contorting around a superconductor under a pressure of 4 gigapascals [**1**]. Their result was made possible by the development of a fast and robust data-analysis method.

High pressures can be applied to a material by squeezing it between two cone-shaped diamonds. The top diamond can also double as a magnetic-field sensor because of the presence of nitrogen-vacancy (NV) centers—lattice defects endowed with spin. When excited by microwaves, NV centers emit light whose intensity depends on the strength and orientation of the local magnetic field.



Credit: C. Dailledouze *et al.* [**1**]

Dailledouze and her colleagues applied pressure and a magnetic field to a sample of Hg-1223, a mercury-based cuprate superconductor. They excited the NV centers by applying microwaves at various frequencies, and they recorded the intensity of the resulting light emission. A statistical analysis of the dataset revealed information about the magnetic-field strength and orientation across the sample. Mapping these quantities produced a visualization of the Meissner effect and revealed the existence of defects in the superconductor.

Hg-1223 superconducts at ambient pressure and can therefore be tested without using this new technique. But the researchers say that their signal-analysis protocol could be applied to nickelates and superhydrides, materials that superconduct only at high pressures.

Martin Rodriguez-Vega is an Associate Editor for ***Physical Review Letters.***

REFERENCES

1. C. Dailledouze *et al.*, “Imaging the Meissner effect and flux trapping of superconductors under high pressure using N-*V* centers,” **Phys. Rev. Appl. 23, 064067 (2025).**

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