

High-field reentrant superconductivity in nickelates

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Superconductors can carry electrical current without resistance, making them important for technologies such as energy-efficient electronics and powerful magnets. But there is a catch: strong magnetic fields usually destroy superconductivity.

By studying a new family of nickelate superconductors (Sm,Eu,Ca)NiO₂ in extreme high magnetic fields we found something very unusual. In low critical temperature samples, superconductivity disappears as the magnetic field increases—but then comes back at even higher fields. In samples that superconduct at higher temperatures, superconductivity persists to at least 65 tesla. The reason appears to be an unusual interaction between superconductivity and magnetism inside the material. Magnetic europium atoms in our Eu-doped nickelates samples create an internal magnetic effect that partially opposes the applied field. Under the right conditions, increasing the magnetic field can therefore help protect superconductivity rather than destroy it.

This work suggests a very different design strategy: instead of simply trying to make superconductors resist stronger fields, we may be able to engineer magnetism inside the material to help protect superconductivity. If that principle can be extended and optimized, it could eventually help enable superconducting magnets, sensors and quantum devices that operate in much stronger magnetic fields.

Facilities and instrumentation used: Pulse Field Facility (60 T Midpulse magnet, 75 T Duplex magnet and 65 T short pulse magnet), DC field Facility (45 T hybrid magnet and 41.5 T resistive magnet)

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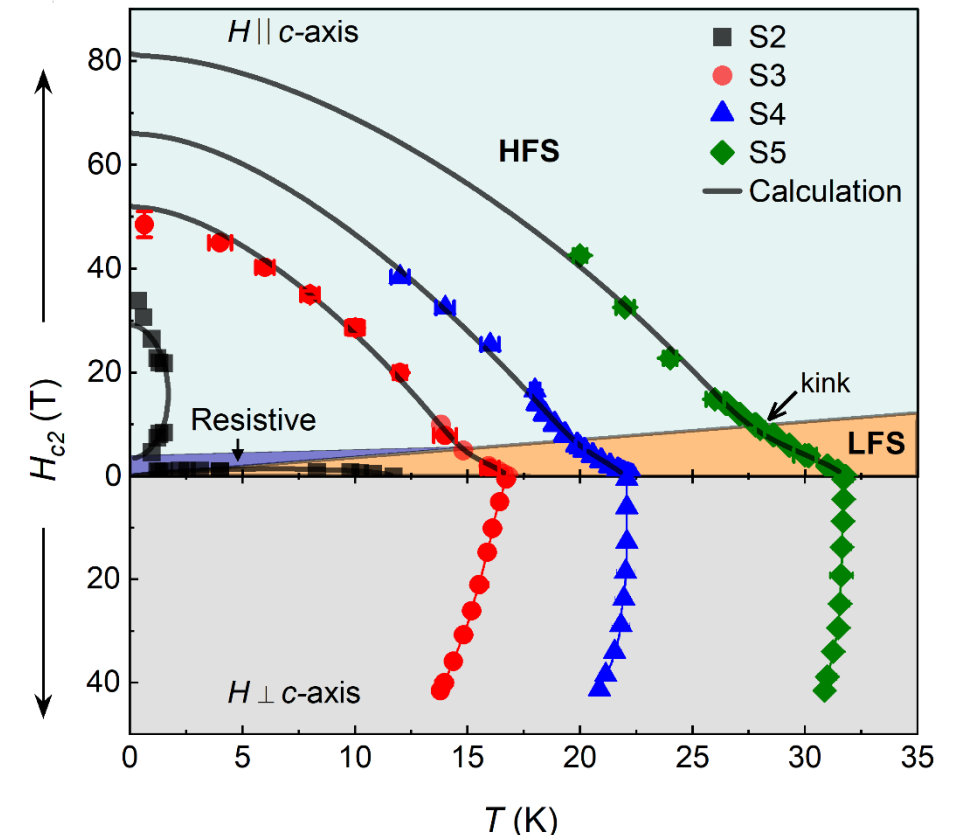


Figure: Evolution of the normal metal to superconductor phase boundaries with temperature and magnetic field for four nickelate thin films with different critical temperatures. The magnetic field is applied perpendicular (lower panel) and parallel (upper panel) to the film surface.