A New Spin on Superconductivity

Researchers have made the first definitive measurements of an elusive superconducting state.

By **Marric Stephens**

In almost all superconductors discovered to date, Cooper pairs—the quasiparticles that carry the supercurrent—are formed from the pairing of two electrons with opposite spins. But theory predicts that, under some delicate and exacting conditions, Cooper pairs can also form from electrons with parallel spins. Now a team at Okayama University in Japan led by Guo-qing Zheng has made the first definitive measurement of such "spin-triplet" superconductivity [**1**].

Spin-triplet superconductivity is much rarer than the usual spin-singlet superconductivity because the electron-pairing mechanism is easier to disrupt. The two kinds of superconductivity can be distinguished using nuclear magnetic resonance (NMR), as a material's nuclear-spin properties are affected by its electron spins. The smoking gun of spin-triplet superconductivity is a superconducting phase whose spin properties vary with temperature and with the strength and direction of a magnetic field. Hints of the phenomenon have previously been seen in uranium-containing compounds, whose strong magnetic fluctuations readily sustain spin-triplet superconductivity. Even so, conclusive evidence has proved difficult to obtain because uranium's strong spin–orbit coupling makes it almost impossible to separate the effects of the Cooper pairs from those of the outer valence electrons.

Zheng and his team looked instead to $K_2Cr_3As_3$, whose lack of strong spin–orbit coupling makes NMR measurements less ambiguous. The reason the material is relatively unstudied is twofold: NMR requires large, high-quality single crystals, which are difficult to synthesize; and $K_2Cr_3As_3$ reacts strongly with oxygen, which complicates the measuring process. The researchers spent three years learning how to overcome these problems before they were able to measure superconducting phases with three distinct sets of nuclear-spin properties. All three arise from spin-triplet pairing and one of them hosts exotic quasiparticles called Majorana states, which could serve as a platform for fault-tolerant quantum computing.

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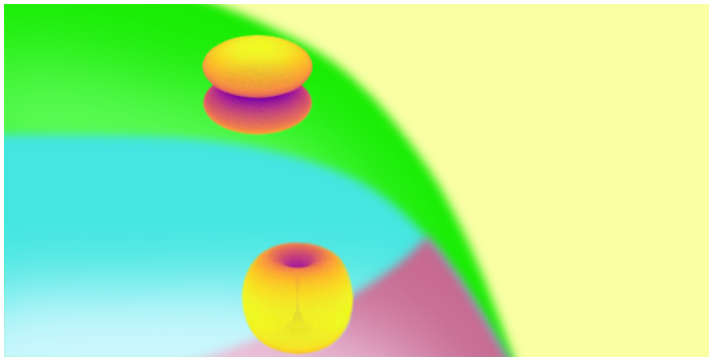

Credit: S. Ogawa *et al.* [**1**]; adapted by APS

REFERENCES

1. S. Ogawa *et al.*, "Multiple phases in $K_2Cr_3As_3$: A playground for manipulating topological superconductivity," **Phys. Rev. Lett. 137, 086003 (2026).**