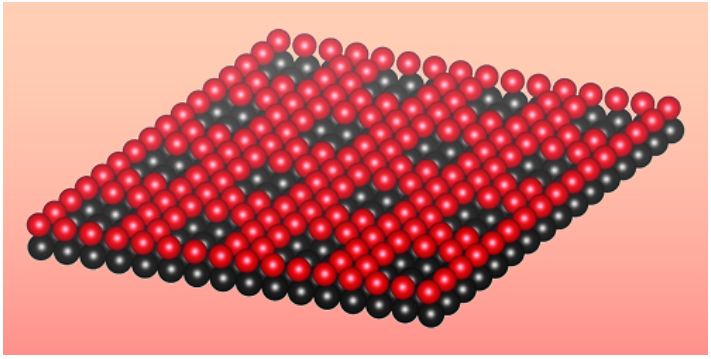
Route to Altermagnetic Superconductivity

Arranging nonmagnetic atoms on the surface of an unconventional superconductor could induce a novel phenomenon called altermagnetic superconductivity.

By **Ryan Wilkinson**

Scientists are on the hunt for materials that display both magnetism and superconductivity. Such materials have been difficult to find because those two effects are typically mutually exclusive. Now Lucas Pupim and Mathias Scheurer at the University of Stuttgart, Germany, propose an innovative way to engineer these materials [**1**]. They show theoretically that the approach could be used to realize altermagnetic superconductivity, an exotic phenomenon with potential applications in spin-based electronics.

In the new method, the tip of a scanning tunneling microscope is used to create a periodic arrangement of nonmagnetic atoms on the surface of an unconventional superconductor. This type of superconductor was chosen because it naturally features multiple competing mechanisms of superconductivity, providing a rich and tunable platform. The presence of the nonmagnetic atoms generates circulating electric currents and associated magnetic moments, inducing the desired magnetic superconductivity. In the specific example studied by the researchers, these magnetic moments exhibit altermagnetism, a recently identified fundamental form of magnetism (see **Viewpoint: Altermagnetism Then and Now**). Altermagnetism combines the spin-dependent electronic properties of ferromagnetism with the zero net magnetization of antiferromagnetism.



Credit: L. V. Pupim and M. S. Scheurer [**1**]

Pupim and Scheurer show that such altermagnetic superconductivity could have three main signatures: a specific magnetic-field pattern, a specific spin pattern associated with electrons in the superconductor's lattice, and a nonzero value for a geometric quantity known as the Berry quadrupole moment. As a result, the phenomenon could be detected in the lab via magnetic-field measurements, spin-sensitive photoemission spectroscopy, and heat-transport experiments that probe the Berry quadrupole moment. The researchers say that their technique could be applied to a variety of unconventional superconductors to learn more about these materials and to potentially realize other exotic superconducting states.

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REFERENCES

1. L. V. Pupim and M. S. Scheurer, "Adatom engineering magnetic order in superconductors: Applications to altermagnetic superconductivity," **Phys. Rev. Lett. 134, 146001 (2025).**