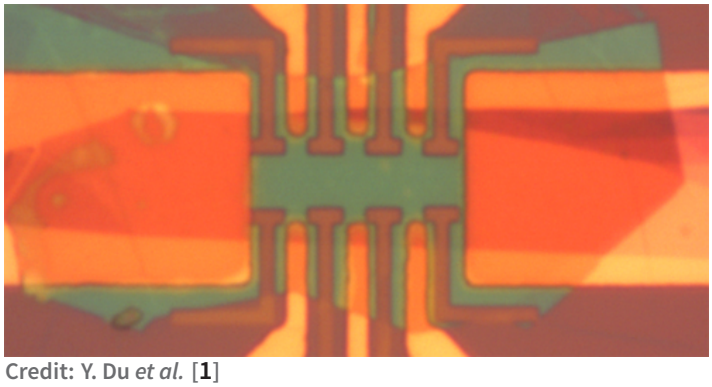
Strong Hints of a Bose Metal

An enigmatic and anomalous metallic state turns out to be intrinsic rather than a consequence of crystalline defects.

By **Charles Day**

A strong enough magnetic field destroys superconductivity even at absolute zero. But in some materials, known as type-II superconductors, superconductivity and magnetic-field-induced vortices can coexist before that threshold is crossed. Type-II superconductivity becomes more fragile as the superconductor becomes thinner. Eventually, some theorists say, the combination of an applied magnetic field and two dimensionality begets a Bose metal, a finite-resistance state whose charge carriers, like those in a superconductor, are Cooper-paired electrons. Now Xiaoxiang Xi of Nanjing University, China, and his collaborators have found evidence consistent with a Bose metal in atomically thin films of niobium diselenide ($NbSe_2$) [**1**].

A Bose metal is a theoretical concept that could, in principle, account for the observed properties of a so-called anomalous metallic state (AMS), which differ from those of the regular metallic state. Hints of an AMS first appeared in 1989. However, the possibility remained that the AMS could be a manifestation of a sample's preparation and thinness rather than an intrinsic effect like, say, the fractional quantum Hall effect. This is because superconductivity-destroying quantum and thermal fluctuations are stronger in two dimensions than in three dimensions, as is the tendency of impurities and other defects to localize electrons and reduce conductivity.



Credit: Y. Du *et al.* [**1**]

To characterize how the AMS in $NbSe_2$ emerges as the material becomes thinner, Xi and his collaborators made devices out of bulk, trilayer, and bilayer crystals. Various measurements confirmed that the AMS is a real intrinsic effect: Raman spectroscopy indicated the presence of superconducting fluctuations in the nonsuperconducting AMS state, while the vanishing of Hall resistance with thickness pointed to the AMS charge carriers being Cooper pairs. Although the fluctuations and Hall resistance are both hallmarks of a Bose metal, Xi refrains from claiming a discovery. "We think the definition of a Bose metal remains somewhat ambiguous," he says.

Charles Day is a Senior Editor for *Physics Magazine*.

REFERENCES

1. Y. Du *et al.*, "Unveiling resilient superconducting fluctuations in atomically thin $NbSe_2$ through Higgs mode spectroscopy," **Phys. Rev. Lett. 134, 066002 (2025).**