Evidence found of superfluidity in extremely cold 2D gas of fermions

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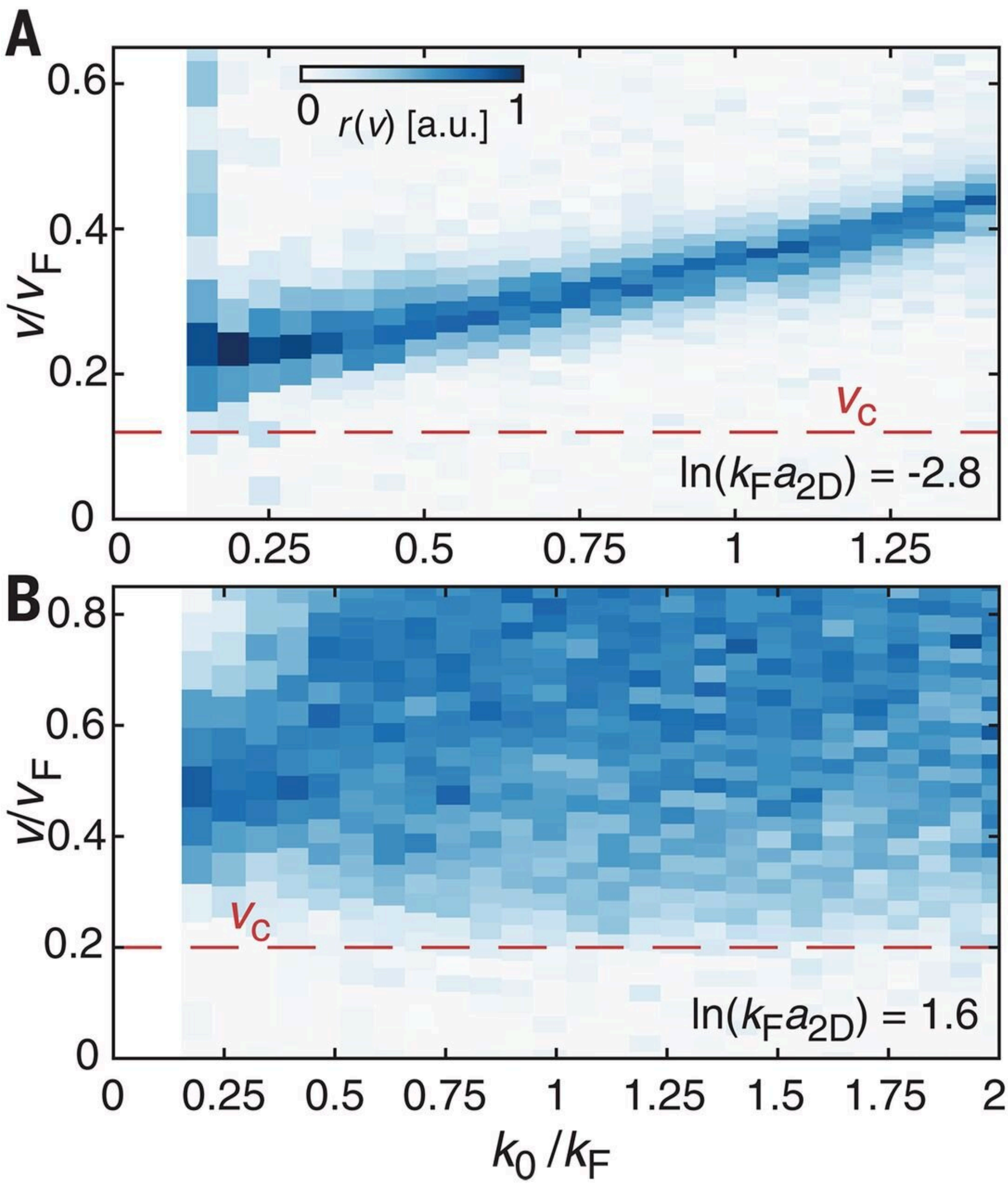

Phononic and pair-breaking excitations in a 2D Fermi gas. Credit: *Science* (2021). DOI: 10.1126/science.abc8793

A team of researchers working at the Institut für Laserphysik, Universität Hamburg, has found evidence of superfluidity in an extremely cold 2D gas of fermions. In their paper published in the journal *Science*, the group describes their work with a 2D Fermi gas and what they learned from it.

One of the big challenges remaining in physics is to understand the factors at play with superconductors operating at high temperatures. One approach to achieving that goal involves studying superfluidity in materials. Superfluids are materials that can flow without viscosity—though only at speeds lower than their critical velocity. In this new effort, the researchers looked at the possibility of a 2D Fermi gas as a superfluid. Prior research has shown that 3D Fermi gases can exhibit superfluid characteristics, and theory has suggested that 2D Fermi gasses could, as well—but until now, it had never been demonstrated.

The experiment and demonstration by the team in Germany began with the researchers isolating approximately 6,000 lithium-6 ions creating a Fermi gas. They then used optical and magnetic equipment to cool the gas down to near absolute zero—this held the ions firmly in place. The researchers then created a "box" for the atoms by suspending them in a lattice created using two blue lasers. This allowed for confining the atoms into a 2D configuration. The researchers then forced the gas through the lattice using dual red laser beams using an interference pattern. Changing the frequency of the lasers allowed the researchers to vary the speed at which the gas was moved through the lattice.

The researchers then tested the gas in the lattice to see if it moved without viscosity and if so, at what speeds. Testing was done by checking the temperature in the lattice as the gas moved—in the absence of viscosity, no heat is generated. Their experiments showed the gas to be a superfluid and that it phase-transitioned to a regular gas at 35 nK—which they note, agrees with what had been theorized. They suggest their work has created a path forward for studying superfluidity in 2D fermionic materials.

More information: Lennart Sobirey et al, Observation of superfluidity in a strongly correlated two-dimensional Fermi gas, *Science* (2021). DOI: 10.1126/science.abc8793

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