Images Capture Unusual Quantum Turbulence

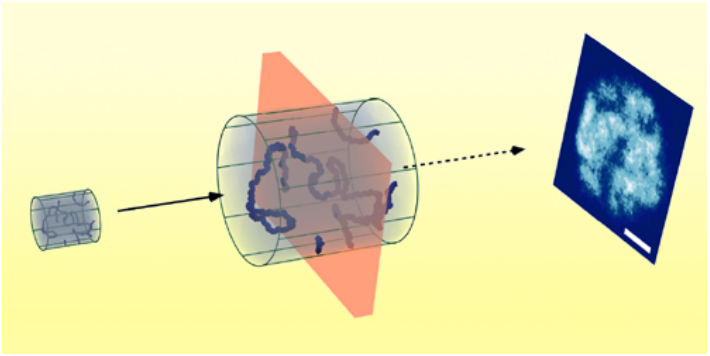
Random tangles of vortex lines have been observed untangling in an ultracold gas.

By **Rachel Berkowitz**

Quantum fluids exhibit turbulence in ways both similar to and distinct from their classical counterparts. The most common shared feature is the flow of energy from large to small scales, transferred via vortices. Now Sebastian Morris of the University of Cambridge in the UK and his colleagues have observed a unique form of quantum turbulence that has no classical counterpart [**1**]. Their experiments in an ultracold gas provide direct evidence of so-called Vinen, or "ultraquantum," turbulence—a random tangle of vortex rings that unravels without any energy transfer as the fluid settles into equilibrium.

Upon perturbation, quantum fluids such as superfluid helium and Bose-Einstein condensates can swirl around networks of thin vortex lines. Theorists have long predicted how these tangled vortices should unravel and decay while the fluid relaxes. Experimentalists have detected signs of this process in superfluid helium (but only indirectly) and in atomic gases (but only in 2D).

To obtain direct evidence of vortex dynamics in 3D, Morris and colleagues cooled ultracold potassium atoms in a cylindrical optical trap to just above absolute zero. Using a quantum-gas magnifier, they captured snapshots of the particle density in circular slices of the gas. These density maps revealed imprints of random vortex lines entering and exiting the slice. Imaging the gas as it relaxed yielded the fractional area covered by the vortex lines over time, constituting a direct measurement of the density of the tangles.



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

Repeating the experiment while varying the parameters showed that the vortex decay rate was independent of the interparticle interaction strength. The results agreed with previous experiments using superfluid helium despite dramatic differences in the microscopic dynamics. This agreement, the researchers say, suggests the universality of Vinen turbulence across superfluids.

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REFERENCES

1. S. J. Morris *et al.*, "Observation of Vinen turbulence during far-from-equilibrium Bose-Einstein condensation," **Phys. Rev. Lett. 137, 193403 (2026).**