# UC Irvine physicists create new framework to explain how electrons in a solid can flow like water

The team’s theory could inform the development of next-generation technologies.

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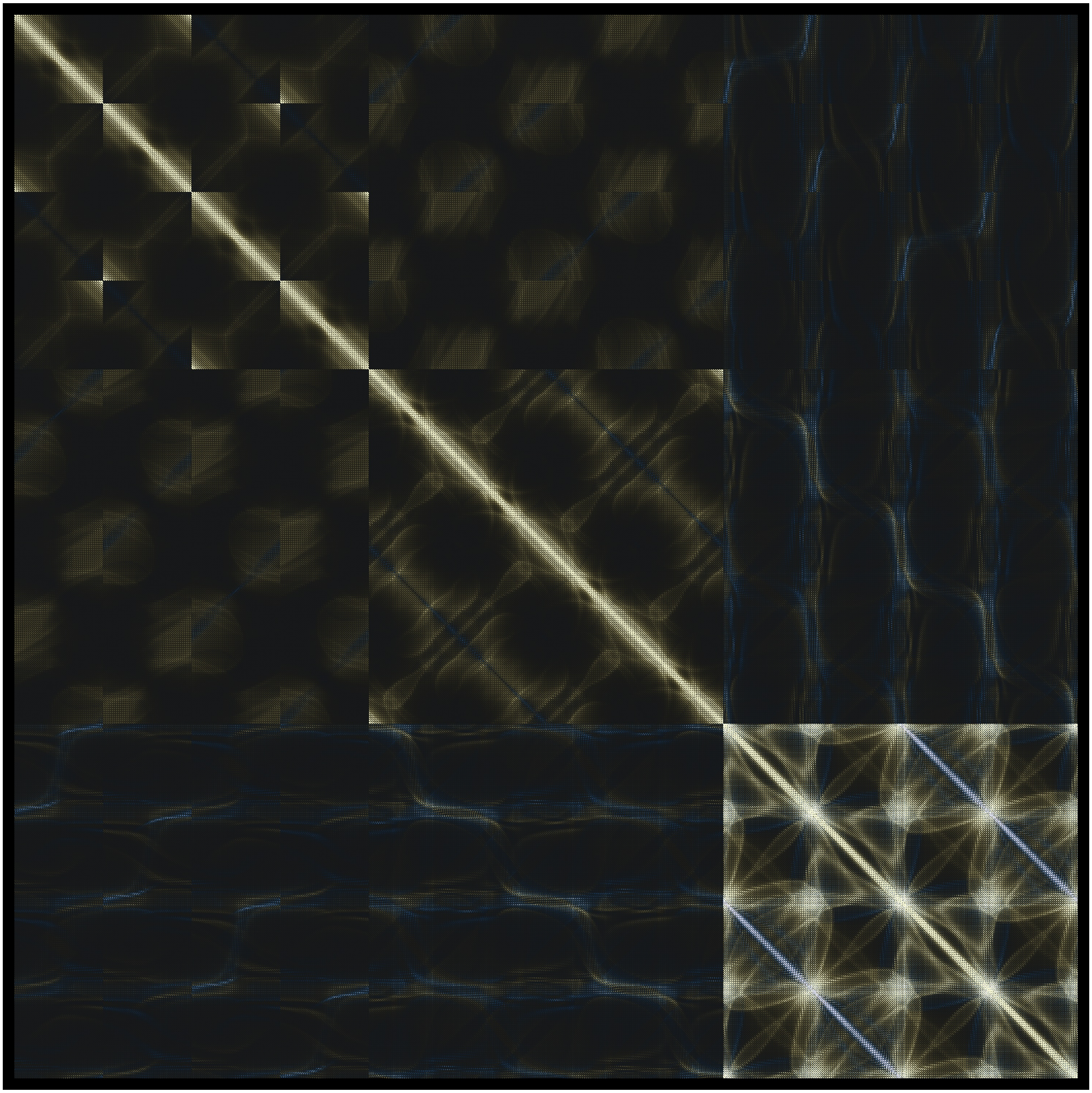

A high resolution map of the collisions between electrons in the material the UCI team studied.

Picture Credit:
Davis Thuillier

**Research Spotlight**

Electrons are typically thought of as independent particles that operate separately from other electrons. But a field called hydrodynamics casts electrons in an entirely new light by explaining how the particles can, instead of acting in isolation, flow together like a liquid.

Until now, scientists have only been able to theorize how hydrodynamics might work under very limited circumstances, but in new research published in *Physical Review Letters*, a team led by scientists at the University of California, Irvine describes for the first time the first theoretical framework to describe electron hydrodynamics in all kinds of materials, particularly metals.

“Hydrodynamic materials represent a fundamentally new way that electrons can move through solids,” said Thomas Scaffidi, UC Irvine professor and lead author of the new research. “Our work could lead to new kinds of electronic technologies where electron flow is engineered much like engineers already design fluid flow in aerodynamics or microfluidics. It’s about unlocking a new design space for controlling electricity.”

The new theoretical framework succeeds where other frameworks failed by studying how sound waves affect materials. In typical metals where electrons behave in typical fashion independent of one another, disturbances in the form of sound waves relax at a similar rate. But in hydrodynamic materials, those same disturbances relax at different rates, meaning the electrons are dampening out vibrations in the way a fluid would and not a solid.

Scaffidi’s doctoral student, Davis Thuillier, ran numerical simulations of metals to study nearly one trillion hypothetical electron collision processes.

“This is important because it reveals that real hydrodynamic materials have a much richer behavior than other simpler models predicted,” Scaffidi said. “That richness both deepens our understanding of strongly interacting electrons and offers new ‘knobs to turn’ in potential devices.”

These devices include improved microchips. In current generations of microchips, a major limitation is the lack of heat loss as a device operates. But if electrons flow hydrodynamically, they can move with less resistance and, potentially, reduce wasted energy and heat build-up.

Next, the team wants to apply the new framework to a wide range of different materials beyond the metals they used in their model.

**Citation: David Thuillier *et al.*, Multipolar Fermi Surface Deformations in Sr 2RuO4 Probed by Resistivity and Sound Attenuation: A Window into Electron Viscosity and the Collision Operator. *Phys. Rev. Lett.* 135, 29 Sept 2025. DOI:** https://doi.org/10.1103/2fcg-zmwt

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