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Viscosity, Current Vortices and Negative Nonlocal Resistance in Graphene

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Abstract:

Quantum-critical states of diverse strongly correlated systems are predicted to feature universal collision-dominated transport resembling that of viscous fluids. However, investigation of these phenomena has been hampered by the lack of known macroscopic signatures of the hydrodynamic regime at criticality. Here we identify vorticity as such a signature and link it with an easily verifiable striking macroscopic transport behavior. Produced by the viscous flow, vorticity can drive electric current against an applied field, resulting in a negative nonlocal voltage. We argue that the latter plays the same role for the viscous regime as zero electrical resistance does for superconductivity. Besides offering a diagnostic of viscous transport which distinguishes it from ohmic currents, the sign-changing electrical response affords a robust tool for directly measuring the viscosity-to-resistivity ratio. The strongly interacting electron-hole plasma in high-mobility graphene provides a bridge between quantum-criticality and the cornucopia of fluid mechanics phenomena.