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Hydrodynamic transport in graphene near the charge neutrality point

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Understanding the dynamics of many interacting particles is a formidable task in physics, complicated by many coupled degrees of freedom. A strongly interacting complex microscopic dynamics can often be simplified by a hydrodynamic description of momentum, energy, and charge transport on long length and time scales. For an electronic system at high enough temperature, the enhanced inelastic collisions between charge carriers dramatically accelerate the relaxation towards local thermal equilibrium and yields a hydrodynamic collective behavior. Near the charge neutrality point of the graphene, the electron-electron and electron-hole scattering rates grow linearly with temperature, and the electron-hole plasma of Dirac fermions develops. Here, interactions between particles in quantum many-body systems can lead to the collective behavior described by hydrodynamics of a strongly coupled Dirac fluid. This charge neutral plasma of quasi-relativistic fermions is expected to exhibit a substantial enhancement of the thermal conductivity, due to the decoupling of charge and heat currents within hydrodynamics. Employing high sensitivity Johnson noise thermometry, we report the breakdown of the Wiedemann-Franz law in graphene, with a thermal conductivity an order of magnitude larger than the value predicted by Fermi liquid theory. We will also discuss recent development of magneto-thermal conduction in graphene in the hydrodynamic transport regime.