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Theoretical study of the criteria and consequences of hydrodynamic electron flow in graphene. SHAFFIQUE ADAM, Yale-NUS College, DEREK HO, INDRA YUDHISTIRA, Center for Advanced 2D Materials, National University of Singapore, NILOTPAL CHAKRABORTY, Yale-NUS College — Experiments on graphene electrons have succeeded in entering the hydrodynamic regime, as demonstrated by successful observations of Wiedemann-Franz law violations [J. Crossno et al. *Science* **351**, 1058 (2016)], and evidence for electron vortices [D. A. Badurin et al. *Science* **351**, 1055 (2016)]. The hydrodynamic regime is expected to occur when electron-electron interactions dominate over all other electron collision mechanisms. We calculate the electron-electron, electron-impurity and electron-phonon scattering rates as a function of temperature, charge doping and disorder (charge puddle) strength. We find that there exists a window in parameter space where electron-electron scattering dominates and hydrodynamic effects become observable. However, we also find that disorder induced carrier density inhomogeneity continues to play an important role in the vicinity of charge neutrality, even in the strongly interacting hydrodynamic regime. For example, although the ratio of thermal conductivity and electrical conductivity show a violation of the Wiedemann-Franz law in the aforementioned experiment, the electrical conductivity as a function of temperature still follows a disorder-driven universal scaling theory first predicted in Adam and Stiles, Phys. Rev. B 82, 075423 (2010). This work was supported by the National Research Foundation of Singapore (NRF-NRFF2012-01).

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