Multipolar Fermi Surface Deformations: Probing Electron Hydrodynamics in 2D Metals

Davis Thuillier and Thomas Scaffidi

University of California - Irvine

Recent developments in electron hydrodynamics have demonstrated the importance of considering the full structure of the electron-electron scattering operator. This physics has erstwhile been missed due to the use of the single relaxation time approximation. We introduce a first-principles calculation of the scattering operator for electron-electron interactions with multi-orbital effects which makes possible the calculation of both transport coefficients and quasi-conserved quantities given an arbitrary Fermi surface in 2D. As a first application, we calculate the resistivity and viscosity of Sr_2RuO_4 in a regime where electron-electron scattering is dominant and compare the values of these quantities to our simulation to obtain a ratio of the effective lifetimes for momentum and shear deformation relaxation respectively. This ratio is analogous to the ratio of the $l = 1$ and $l = 2$ modes in the free electron model which serves as an indicator of a hydrodynamic regime. We may likewise use this ratio to predict hydrodynamic behavior for bulk 2D metals and thereby broaden the limited number of hydrodynamic candidate materials. We provide the code for these calculations in the software package Ludwig.jl which supports a large class of 2D materials and materials with pseudo-2D band structure.