Non-local Hydrodynamics: Analysis of Homogeneous Viscosity Kernels for Atomic and Molecular Fluids

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Classical Navier-Stokes-Fourier hydrodynamic theory adequately describes the rheological properties of the fluid at the scale lengths of the confinement much greater than the dimension of the fluid molecules. Once the confinement approaches molecular dimensions, classical theory must be generalized to allow for local position dependent coefficients. We present an analysis of the exact homogeneous nonlocal viscosity kernels for unconfined atomic and molecular fluids for a variety of state points. This allows using nonlocal generalization of the linear constitutive relation with appropriate boundary conditions to predict the flow profiles for highly confined fluids. We compute the k-space and real-space kernels calculated from the stress autocorrelation functions and the transverse momentum density autocorrelation functions. Functional forms have been found to fit the kernel data. The results show that the kernels have a width of a few atomic diameters which means that the generalized hydrodynamic viscosity must be used in predicting the flow properties of fluids on length scales where the gradient in the strain rate is of the order of atomic dimensions (eg in nanofluidics).