Klaus Kroy (U Leipzig):

Nonisothermal fluctuating hydrodynamics and Brownian motion

Abstract:

The classical theory of Brownian motion (i.e., the thermal dynamics of small particles suspended in liquids) follows from coarse graining the underlying linearized fluctuating hydrodynamics of the solvent. We extend this procedure to globally nonisothermal conditions, requiring only a local thermal equilibrium in the solvent. Starting from the conservation laws, we establish the stochastic equations of motion for the fluid momentum fluctuations in the presence of a suspended Brownian particle. These are then contracted to the nonisothermal generalized Langevin description of the suspended particle alone. The resulting noise spectrum is governed by a frequency-dependent temperature. We show how the effective temperatures at which the particle coordinates and (angular) velocities appear to be thermalized emerge from this central quantity. They are temperatures in the sense of the second law of thermodynamics and determine the efficiencies of “hot Brownian heat engines” and the thermodynamic uncertainty relation for a “hot Brownian swimmer”.