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Transport in nanoscale systems: hydrodynamics, turbulence, and local electron heating

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Transport in nanoscale systems is usually described as an open-boundary scattering problem. This picture, however, says nothing about the dynamical onset of steady states, their microscopic nature, or their dependence on initial conditions [1]. In order to address these issues, I will first describe the dynamical many-particle state via an effective quantum hydrodynamic theory [2]. This approach allows us to predict a series of novel phenomena like turbulence of the electron liquid [2], local electron heating in nanostructures [3], and the effect of electron viscosity on resistance [4]. I will provide both analytical results and numerical examples of first-principles electron dynamics in nanostructures using the above approach. I will also discuss possible experimental tests of our predictions. Work supported in part by NSF and DOE.

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[2] R. D'Agosta and M. Di Ventra, "Hydrodynamic approach to transport and turbulence in nanoscale conductors," cond-mat/05123326; J. Phys. Cond. Matt., in press.
[3] R. D'Agosta, N. Sai and M. Di Ventra, "Local electron heating in nanoscale conductors," cond-mat/0605312; Nano Letters, in press.
[4] N. Sai, M. Zwolak, G. Vignale and M. Di Ventra, "Dynamical corrections to the DFT-LDA electron conductance in nanoscale systems," Phys. Rev. Lett. 94, 186810 (2005).