Plenary Talk

Understanding Nanoscale Conductors

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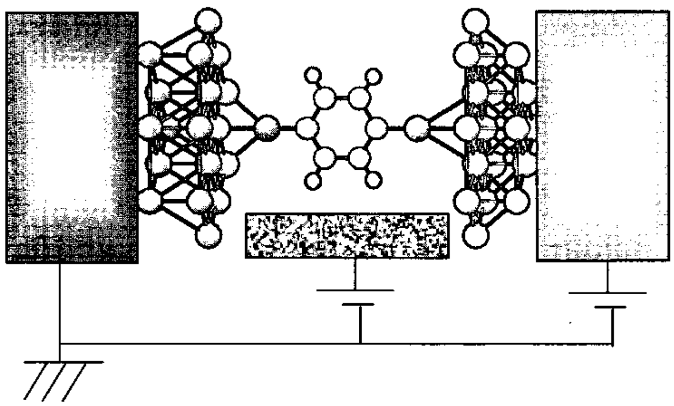
Figure: What is the resistance of a molecule?



It is common to differentiate between two ways of building a nanodevice: a ***top-down*** approach where we start from something big and chisel out what we want and a ***bottom-up*** approach where we start from something small like atoms or molecules and assemble what we want. When it comes to describing electrical resistance, the standard approach could be called a "top-down" one where we start from big complicated resistors and work our way down to molecules primarily because our understanding has evolved in this top-down fashion. But I believe it is instructive to take a bottom-up view of the subject starting from the conductance of something really small, like a molecule, and then discussing the issues that arise as we move to bigger conductors. That is what I will try to do in this tutorial lecture [1].

Remarkably enough, no serious quantum mechanics is needed to understand electrical conduction through something really small, except for unusual things like the Kondo effect that are seen only for a special range of parameters. I will (1) start with energy level diagrams, (2) show that the broadening that accompanies coupling limits the conductance to a maximum of (q^2/h) per level, (3) describe how a change in the shape of the self-consistent potential profile can turn a symmetric current-voltage characteristic into a rectifying one, (4) show that many interesting effects in "nanoelectronics" can be understood in terms of a simple model, and (5) introduce the non-equilibrium Green's function (NEGF) formalism as a sophisticated version of this simple model with ordinary numbers replaced by appropriate matrices. Finally I will describe the distinction between the self-consistent field regime and the Coulomb blockade regime and the issues involved in modeling each of these regimes.

1. S. Datta, "Electrical Resistance: An Atomistic View", Nanotechnology, **15**, S433 (2004).

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