

Current-driven phenomena in surface nanoscience

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Resonance conductance, ubiquitous in molecular hetero-junctions and in STM surface experiments, is often inelastic; in the course of the tunneling event, electron energy is channeled into vibrational modes and triggers molecular dynamics. The qualitative physics underlying current-driven, resonance-mediated dynamics in molecular electronics is simple and general. Equilibrium displacement between the initial and resonant states produces a nonstationary superposition in the nuclear subspace that evolves during the resonance lifetime. Upon electronic relaxation the system is internally excited and interesting dynamics is likely to ensue.

While the physics underlying resonant inelastic current is very general, the single-molecule STM and molecular hetero-junction environments open unique and fascinating opportunities. The former introduces the possibility of determining dynamical properties through the combination of observations with a quantum mechanical theory. The latter introduces the possibility of developing individually-driven molecular machines, and new means of manipulating the conductivity of molecular scale devices.

In the talk I will discuss the qualitative physics underlying current-driven surface phenomena, mention the theory we developed to explore these dynamics, and describe the results of recent and ongoing research, focusing on a series of surprising observations of STM-triggered phenomena on silicon and graphene surfaces. Before concluding, I will sketch several of our favorite dreams in these areas.