Role of Coherence in Quantum Conductance: Opportunities for Control.

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The optical response of nanoscale molecular junctions has been the topic of growing experimental and theoretical interest in recent years, fueled by the fascinating physics involved, the rapid advance of the experimental technology and the premise for long range applications. The ultimate goal of controlling electric transport with coherent light, however, has proven challenging to realize in the laboratory. Here we propose an approach to coherent control of transport via molecular junctions, which bypasses several of the hurdles to experimental realization of optically manipulated nanoelectronics noted in the previous literature. Essential to our approach is the application of semiconductor contacts and optical frequencies below the semiconductor bandgap. Our theory combines very simple, analytical models to study the qualitative transport properties of semicondutor-based molecular junctions with an analytical density matrix theory and numerical quantum dynamics simulation to explore control opportunities. In the talk I will first discuss preliminary results for quantum control of the electronic dynamics via frozen molecular wires, where the vibrational modes of the molecular moiety of the junction play no role. Next I will introduce a (likewise preliminary) unidirectional, coherently driven molecular motor, where solely the vibrational modes are optically controlled. Finally I will combine control of the vibrational and electronic dynamics to introduce an ultrafast, nanoscale switch for electrons.