Toward Coherent Control in the Nanoscale

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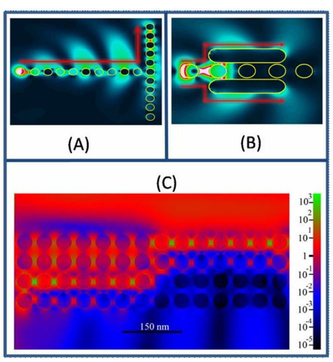
Inelastic electron tunneling via molecular-scale junctions can induce a variety of fascinating dynamical processes in the molecular moiety. These include vibration, rotation, inter-mode energy flow and reaction. Potential applications of current-driven dynamics in heterojunctions range from new forms of molecular machines and new modes of conduction, to new directions in surface nanochemistry and nanolithography.

In the first part of the talk, I will discuss the qualitative physics underlying current-driven dynamics in molecular-scale devices, briefly outline the theory we developed to explore these dynamics, describe the results of ongoing research on surface nanochemistry and molecular machines, and sketch several of our dreams and plans in these areas.

The application of light to control molecular motions and electronic transport in junctions is intriguing, since photonic (by contrast to electronic) sources offer (sub)femtosecond time resolution and tunable phase and polarization properties. One of several challenges, however, is the requirement of coherent light sources that are tightly localized in space. It is here that plasmonics offer an opportunity.

In the second part of the talk, we will combine plasmonics physics with concepts and tools borrowed from coherent control of molecular dynamics with two goals in mind. One is to introduce new function into nanoplasmonics, including ultrafast elements and broken symmetry elements. The second is to develop coherent nanoscale sources and apply them to coherent control of both molecular dynamics and electric transport in the nanoscale.



Several simple elements in what we envision developing into coherently controlled nanoplasmonics are schematically illustrated in Fig. 1. The T-junction of Fig. 1A guides electromagnetic energy traveling down the leg into one or the other of the two symmetry-equivalent arms of the junction. Figure 1B depicts a hybrid construct, which combines elements that provide local enhancement with elements that provide long distance propagation in order to minimize losses. The structural parameters of the construct are optimized using a genetic algorithm. Fig. 1C depicts a plasmonic nanocrystal, developed to separate an incident plane wave into two frequency components and funnel each component in a different direction normal to the direction of incidence. To conclude the talk, we will return to nanoelectronics, and illustrate the application of plasmonics to control of transport in the nanoscale, with a view to ultrafast electric switches.