Coherent ultrafast charge and energy transfer processes in nanostructures

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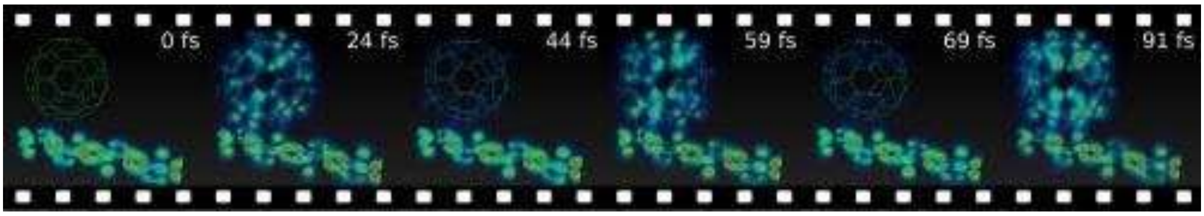
The light-induced transport of energy and charge in nanostructures and across interfaces is of fundamental relevance for a wide range of real world applications, ranging from light-harvesting in biological nanostructures over photocatalysis to solar energy conversion in photovoltaic devices. Usually, the underlying microscopic transport properties are described in particle-like, drift-diffusive models. In my talk, I will discuss several examples in which this classical, particle like transport regime breaks down and the wave-like coherent transport of energy and charge becomes dominant, even in disordered nanostructures and at room temperature. These examples include (i) the periodic exchange of energy between excitons and plasmons in hybrid metal/semiconductor nanostructure (*1-3*) and (ii) the light-induced transfer and transport of electrons in organic semiconductor and organic photovoltaic devices (*4-6*). I will show that the observation of ultrafast Rabi oscillations in hybrid metal-semiconductor systems not only provides unprecedented insight into coherent energy transport in hybrid nanomaterials but also paves the way for the design and implementation of novel, highly efficient ultrafast plasmonic switches. Ultrafast studies of charge transport in organic materials give unexpected evidence for coherent charge transfer processes and outline strategies for molding the flow of charge in nanostructures by tailoring and controlling their coherent coupling to vibrational modes of the materials. These advances became possible by probing the optical properties of nanostructures with a time resolution of few femtoseconds only, faster than any of the functionally relevant vibrational modes of the material.



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