Ultrafast nano-optics: watching electrons move

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Probing and manipulating the motion of electrons in complex solid state, molecular or biological nanostructures in real time is a fundamental challenge in contemporary physics. The experimental methods that can visualize these quantum processes, in particular time-resolved light-, x-ray and electron microscopy, are currently undergoing an extremely rapid development. In my talk, I will present recent experimental progress achieved in Oldenburg in this direction. Specifically, I will discuss the role of quantum coherence for ultrafast charge separation processes in organic solar cells and how it might become possible to efficiently switch plasmonic wave packets in metallic nanostructures on ultrafast time time scales. Finally I want to describe some new experimental approaches for ultrahigh space- and time-resolution light and electron microscopy. I will report on recent experiments combining plasmonics and strong field photoemission to generate ultrashort, sub-cycle electron pulses from sharp metal tapers. A first implementation of these sources in an ultrafast point-projection electron microscopy will be discussed.