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Ultrafast electron probes of structural dynamics

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Electrons over a wide range of energies can be used to characterize and determine molecular structures. This talk explores the combination of ultrafast-pulsed laser techniques with electron pulses covering a vast range of electron energies. At the very low end, it is shown that even electrons that are bound, albeit loosely, to molecular ions can be used to characterize unique aspects of molecular structure. Examples are the placement of atoms and functional groups within molecules, and the distribution of charges within the particles. Using time resolved measurements, we are able to observe charge transfer within isolated molecules, and the folding dynamics of flexible chain molecules. Electron pulses with high energy are used to elucidate structural dynamics of laser-excited molecular systems. In the usual high electron energy regime, 10's of kV, the experimentally achievable time resolution is restricted by the requirements of total charge flow on the one hand, and space-charge repulsion between electrons within a pulse on the other hand. The development of electron diffraction using very high energy (mega-electron Volt) electrons provides an opportunity to avoid such space-charge problems, potentially allowing for single shot electron diffraction measurements with a time resolution approaching 100 fs. The talk discusses experimental as well as theoretical aspects of the keV and MeV ultrafast time resolved electron diffraction experiments.