Plenumsvortrag 2

Attosecond Spectroscopy: Watching electrons in motion

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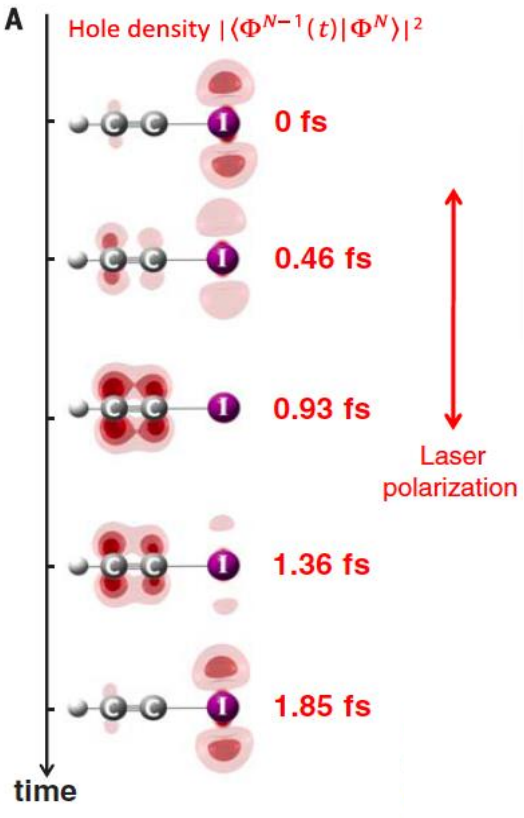
Progress in experimental techniques now enables researchers to directly observe the motion of electrons inside matter. This motion takes place on the time scale of attoseconds (1as = 10^{-18} s). Such measurements probe the most fundamental aspects of chemistry by accessing the true elementary processes underlying molecular reactivity. In this lecture, I will first give a general introduction into the topic of attosecond time-resolved measurements. I will first introduce the principle of pump-probe spectroscopy, then explain how the shortest pulses of light can be generated from a laser and how they can be used to record the motion of electrons inside molecules [1].



In the second part of the lecture, I will discuss what such measurements of electronic dynamics tell us about the various models of electronic structure of atoms and molecules. In contrast to Bohr's atomic model, eigenstates of atoms and molecules do not correspond to time-dependent electronic probability densities. Only superposition states, i.e. so-called Schrödinger-cat states, display time-dependent probability densities. Such time-dependent densities can be created and measured by the techniques of attosecond spectroscopy [2,3]. Such measurements can also be performed on molecules undergoing (photo)chemical reactions [4,5]. In these cases, information is obtained about the breaking and formation of chemical bonds, as well as the redistribution of electronic to vibrational energies in photophysical processes.

Figure 1: Reconstruction of the migration of an electron hole (a missing electron) across a molecule on the attosecond time scale (from [1]).

[1] P. M. Kraus et al., *Science* **2015**, *350*, 740
[2] E. Goulielmakis et al., *Nature* **2010**, *466*, 739
[3] P. M. Kraus et al., *Phys. Rev. Lett.* **2013**, *111*, 243005
[4] H. J. Wörner et al., *Nature* **2010**, *466*, 604.
[5] H. J. Wörner et al., *Science* **2011**, *334*, 208.