# Orientation-dependent ionization in intense laser pulses:

# A tool for time-resolved imaging?

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The possibility of performing time-resolved imaging studies of molecules using ultrashort intense light pulses is currently steering a lot of interest. Many schemes are based on the so-called three-step model in which a strong linear polarized laser pulse distorts the Coulombic potential of a molecule in such a way that close to the electric-field maxima of a laser cycle an electron can tunnel out. This electron is subsequently accelerated by the electric field until the direction of the field vector reverts and the released electron may be driven back to the ion it originated from. This encounter may induce processes like elastic scattering, inelastic scattering (including excitation or fragmentation), or high-harmonic generation. In the latter case the electron recombines radiatively with its ion. All the three processes should reveal structural information while the laser-cycle dependence of the ionisation step provides time resolution.

In this talk the first step of the three-step model, strong-field ionisation of molecules, is investigated in more detail. This should shed more light on the question how the created and thus also the rescattering electron wavepacket looks like for different molecules and what consequences this has for imaging schemes based on the three-step model. Furthermore it is discussed whether the ionisation step itself and thus the so-called direct electrons that form the vast majority may reveal (time-resolved) structural information. For this purpose, two theoretical approaches have been developed recently. In one case the time-dependent Schrödinger equation (TDSE) describing both electrons of an $H_2$ molecule (in full dimensionality) has been developed. An alternative approach is based on the single-active-electron (SAE) approximation, but allows for treating in principle arbitrary molecules. After a discussion of the validity of the SAE for $H_2$ its orientation-dependent ionisation is discussed. Then the results obtained within SAE for $N_2$, $O_2$, and $CO_2$ are compared to experiment. An explanation is provided for the surprising experimental result for $CO_2$. Finally, results for $H_2O$ are presented. The effect of the dipole-moment on the ionisation in extremely short (1- to 2-cycle) laser pulses is demonstrated.