The electron on its way out

Light can be described by small particles named photos, each of them carrying a package of energy (E = hv) with them as you can see in orange in the figure below. When they collide with atoms or molecules, they hand over this energy to the electron (e^-) sitting in an atom. Consequently, the electron can part from the atom. This process is called photoionization and was described by Einstein in the 20th century. It results in an ion (A+) and a free electron and can be understood by a small example.

Imagine that the electron lives in a valley, the atom, where it enjoys high living standard and a stable environment. This valley is everywhere surrounded by a mountain area. The electron can only leave this valley if it gets additional energy to climb over the mountain, otherwise it remains trapped. It is the photon that provides this additional energy and allows the electron to climb over the mountain and be freed from the valley. During an experiment, we want to be able to know exactly which path the electron took to climb over the mountain and how much time it took the electron. However, to observe a single electron at once can become tricky. Imagine that several valleys lie close together and several electrons are trapped in those separate vallets. If the photon energy is high enough, it has the chance to release several electrons from different valleys. When this happens, it becomes difficult to retrace which valley each electron came from and the information about their path and time evolution is lost. Therefore, the energy needs to be dosed to just the right amount in order to only release one electron at a time. This experimental condition is used within this thesis and is known as coincidence condition.

We want to know how much time it takes the electron to leave the atom. This requires a measurement tool that can distinguish where the electron is positioned at the same speed at which the electron moves. Since the electron moves at an attosecond scale which equals 10^{-18} seconds and our human observation timescale happens at $10^0 s$, we require special tools to track the electron in time. Attosecond light pulses can act as flashes to illuminate the electron at different positions quickly enough to distinguish its movement over time. An everyday life equivalent concept of this is the shutter of a camera.

Since only one electron can be observed at once, it takes longer time to collect sufficient data and the size of stored information increases. Big data is a challenge for many research and industrial areas where lots of statistics need to be collected and processed. Suitable algorithms can be designed to facilitate data analysis.

Photoionization dynamics is at the heart of many processes that define our everyday life processes , such as biomolecular reactions, interstellar formations and solid state systems. While the resultant components of photoionization are known, the details of its time-evolution are yet to be fully understood. The aim of researchers is to fully understand the temporal evolution of photoionization to eventually be able to fully control this process and reproduce it artifically.