DESCRIPTION FOR THE GENERAL PUBLIC (IN ENGLISH)

Recently, we have celebrated the International Year of Light and Light-based Technologies. This was in a recognition of the tremendous role that laser physics and optical technologies have played in our everyday life. In order to facilitate further discoveries and new light-based applications, it is fundamental to understand in detail how laser light interacts with matter, especially with its constituents such as atoms or molecules.

With rapid advances in laser technology, it is possible now to generate very short but strong coherent pulses of electromagnetic radiation. It is even possible to control the laser field oscillations within a pulse envelope, meaning that one can create a reproducible, time-dependent force acting on any charge that builds atoms or molecules. At the same time, with developments of precise measuring techniques, very sophisticated effects can be revealed experimentally. In order to explain or to provide reliable predictions for those experiments, it is important and urgent to develop accurate theoretical models. The purpose of this project is to provide such models for two fundamental atomic/molecular processes which occur in a laser field, that is for ionization and laser-assisted radiative recombination.

When a strong laser light shines on an atom or a molecule, the dynamical force exerted by the laser field on the target electrons is comparable to those that bind them inside the target. This can lead to a detachment, or ionization, of electrons. The opposite process is known as laser-assisted radiative recombination. In this process, an electron moving in a laser field is driven by the field to the ionic center. While it recombines, a high-energy photon is emitted. The vast majority of theoretical investigations and our current understanding of both processes rely on the dipole approximation. While the laser field can be understood as a collection of photons carrying the same amount of energy and the same momentum, in the dipole approximation the linear momentum of laser photons is neglected. This also means that, if the laser field is described as a propagating electromagnetic wave, its magnetic component is neglected in all studies based on this approximation. It is like omitting the magnetic component of the Lorentz force acting on the electrons. This will surely have (under certain experimental conditions) far-reaching consequences, which will be studied by this project.

Within this project, we will develop theoretical models and numerical algorithms for treating ionization and laser-assisted radiative recombination beyond the dipole approximation. This will be done for one- and two-atomic targets, and for two-electron systems as well. We expect qualitatively new features to emerge in both studied processes as a result of more accurate treatments of strong laser pulses.