In this project we will analyze fundamental processes of quantum electrodynamics driven by intense laser fields. Among them, we shall focus on the Compton scattering, Bethe-Heitler process, Sauter-Schwinger mechanism, and related phenomena. The theoretical treatment of such processes has received renewed attention due to the development of new international laser facilities with the ability to deliver pulses with very large intensities. On the other hand, it is also of interest to study the orbital-angular momentum properties of photoelectrons emitted in ionization by ultrashort and nearly-relativistic laser pulses. For this reason, the control of *electron-vortex states* generated in photoionization is also going to be analyzed.

Arguably, the invention of the laser has been one of the most important technological achievements of the previous half century, leading to many applications in an enormous variety of fields, such as medicine, biology or telecommunications. Lasers are also key tools in the understanding of fundamental phenomena in physics and cosmology. The long-predicted gravitational waves were in fact detected in the *Laser Interferometer Gravitational-wave Observatory* due to the achievements in laser technology. Also lasers were used in the generation of Bose-Einstein condensates.

Of fundamental importance for scientific and technological purposes is that coherent laser light can be compressed in time. It was in 1980's when D. Strickland and G. Mourou made use of this property to increase considerably the intensity of the available laser systems. Their technique, called *chirped pulse amplification*, lead to the generation of "…the shortest and most intense laser pulses ever created by mankind". For this reason, they were awarded the Nobel Prize in physics in 2018. Nowadays, table-top lasers are able to deliver pulses with intensities close to 10^{18} W/cm^2. The contribution of Strickland and Mourou have found applications in many realms of modern research. Among them, one can cite the femto- or attosecond science and the experimental observation of strong-field quantum phenomena. While the former area requires very short-in-time laser pulses to monitor the ultrafast evolution of molecules or atoms, the latter makes use of intense laser fields to explore the interaction of light and matter. For these reasons, the scientific community has recognized the necessity to create new research facilities capable to deliver even more intense and shorter laser pulses. This is in the hope of achieving a better understanding of light-matter interactions and to develop novel imaging and spectroscopic techniques. Among those facilities we can mention the *Extreme Light Infrastructure*, which consists of three pillars dedicated to the study of nuclear physics, attosecond science, and plasma physics.

Part of this project will be devoted to the *nonlinear Compton scattering* driven by bi-chromatic and bi-circular laser pulses. In intense light fields an electron interacts with a large number of photons, leading to the recoil of the particle and the emission of highly energetic radiation. This process may be used as a source of coherent pulses of gamma or X-rays. The resulting radiation could, in principle, find application in medical imaging, X-ray ultrafast microscopy, and many others. Furthermore, the gamma photons can create electrons and positrons in the Breit-Wheeler process. Moreover, one of the most interesting problems in QED is the so-called Sauter-Schwinger mechanism, i.e., the electron-positron pair production from the vacuum stimulated by electric fields. This process is difficult to observe experimentally due to the ultrahigh field intensities required. However, with the construction of new and powerful laser facilities such extreme fields are closer to be achieved. Finally, we will study relativistic photoionization and laser-assisted recombination of electrons by atoms. They can have applications in electron microscopy and laser fields diagnostics, respectively.