Isabel Eline Hendriks

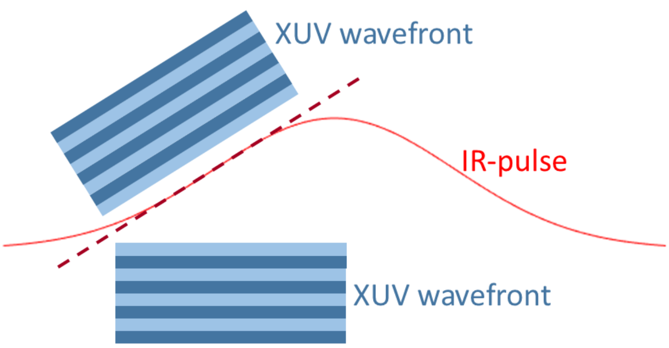
Changing the shape of one light pulse to control the behavior of another light pulse

When we make a video with our phones, the camera captures about 24 frames per second. With this resolution regular processes can be observed, such as a car driving by. When we want to observe a faster process a slow motion video can be made. In a slow motion video, a larger amount of frames per second is captured, which increases the resolution of the video. In order to observe very fast processes, we need very short light pulses to capture enough frames. Light is a wave, so the shortest pulse that can be created has the length of one oscillation. For visible light, this takes about 10^{-15} seconds. However, to observe phenomena that happen on an atomic scale, this is not sufficient. During this period, the electron has already circled the nucleus 13 times. To see phenomena that happen on a shorter time-scale, shorter pulse are needed. Shorter pulses require shorter wavelengths and this implies higher energies. Therefore, we use pulses in the Extreme Ultra Violet (XUV) spectrum.

Current technologies allow us to create XUV pulses in the attosecond regime. Attoseconds are equal to 10^{-18} seconds. The ratio of one attosecond compared to a second is approximately the same as one second compared to twice the age of the universe. These short pulses allow us to observe processes within the atom. An example of this is the excitation or de-excitation of an electron. Using attosecond pulses makes it possible to observe how the electron switches state in such an excitation.

However, in practice it is hard to control attosecond pulses. Since XUV light has such a high energy, it gets absorbed when it interacts with optical devices. Therefore, normal methods to control light, such as mirrors, cannot be used for XUV light. However, in order to use the XUV pulses for atomic research, we need to be able to control these pulses very carefully. To solve this problem a technique called *Opto-Optical Modulation (OOM)* has been developed, which is illustrated in the figure. This method uses a control pulse that changes the direction of the XUV pulse. With this, we can control the phase, direction and shape of the XUV pulse by changing the shape of the IR pulse.

This project shows how to control the shape of the IR pulse. The IR pulse is shaped using a device that consists of about 500.000 pixels (792 x 600 pixels). Each pixel is able to add phase to a fraction of the beam. With this device, which is called a *Spatial Light Modulator*, a spatial phase profile can be added to the beam profile of the IR pulse. The beam profile of the IR pulse is approximately a Gaussian profile. After the pulse has been transmitted through the device, it is focused into the gas. For this project a code has been written that simulates how the a Gaussian beam profile with an applied phase profile focuses. The code is be able to test different phase profiles and gives the resulting profile at the focus. The project uses the code to show how the shape and position of the peak at the focus can be controlled. It also shows how the peak at the focus can be split up into several peaks, and how these peaks can be delayed. This is used to make an interferometer, which is a device that uses the interference patterns of light to measure properties of waves.



Supervisor: Johan Mauritsson and Emma Rose Simpson
Examensarbete 15 hp i vt 2020
Department of Phsyics, Lunds university

*Examensarbetsämne: se kursplan

Bachelor Thesis, Science, Lunds university