CEP stabilization of an ultrafast laser system for attosecond science

Type: Bachelor's thesis / semester project
Timeframe: 3-4 weeks, preferably starting february 2019
Supervisor: Pierre-Alexis Chevreuil
Reference: 1904MA

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1. Project Description

Today, the frontier of the study of the fastest dynamics lies in the attosecond (10^{-18} s) range. Progress in attosecond science is closely linked to the development of suitable ultrafast laser sources. Today, most attosecond pulses are produced by Titanium-doped Sapphire laser systems. Those systems exhibit intrinsic drawbacks that limits their use for advanced attosecond experiments. To circumvent those limitations, high power, high-repetition rate ultrafast lasers in the mid-infrared (>2µm) are needed. In the Ultrafast Laser Physics group at ETH Zurich, we aim at developing such sources and using them for cutting-edge attosecond experiments. We have recently demonstrated [1] that such a source can be effectively used for the production of attosecond pulses.

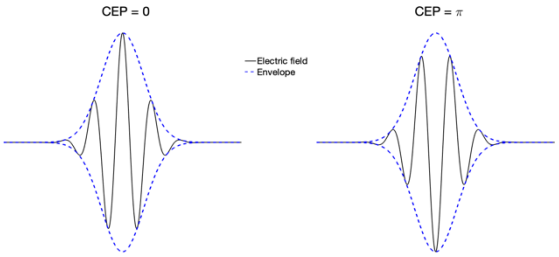

Figure 1 : Effect of the CEP on the electric field of a few cycle laser pulse

This source produces very short pulses (2.2 optical cycles - 17 fs) which are then used for attosecond pulse generation. However, the electric field phase under the envelope of the pulses (the Carrier Envelope Phase, see fig. 1) is currently not stabilized. This stabilization is of primary importance for most attosecond experiments.

The classical approach to stabilize it is to use a so called "f-2f interferometer" (see fig. 2) in which the fundamental wavelength and its second harmonic interact, giving access to the phase of the electric field of the laser. The goal of this project is to develop a variant of this scheme: a 2f-3f interferometer. This will allow to actively stabilize the CEP of the system, and thus enable new attosecond experiments.

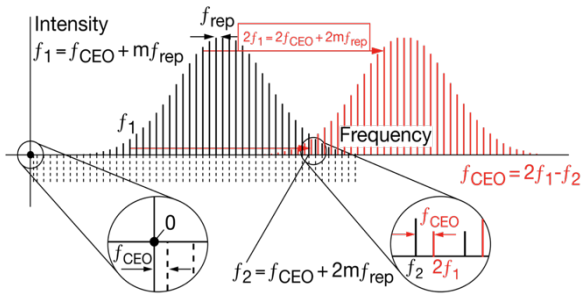

Figure 2 : Principle of a frequency comb stabilization done by a f-2f interferometer. Source : ULP website

2. Project Scope and Goals

- Build a 2f-3f interferometer
- Extracting the phase from the beating signal
- Characterizing the main sources of noise in the system affecting the CEP

3. Requirements

- Interest in experimental lab work with optics, electronics and data processing

4. References

[1] J. Pupeikis, et al., "Water window soft x-ray source enabled by 25-W few-cycle mid-IR OPCPA at 100 kHz", arxiv.org/abs/1910.03236
[2] H. R. Telle, et al., "Carrier-envelope offset phase control: A novel concept for absolute optical frequency measurement and ultrashort pulse generation", Appl. Phys. B 69, 327-332 (1999)