A new method for carrier-envelope phase stabilization of high power regenerative amplifier

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Synopsis: A new method is proposed to stabilize the carrier-envelope phase of femtosecond laser pulse from a high power regenerative amplifier with a water-cooled Ti:sapphire rod. This method introduces dispersion in the amplifier system to compensate the phase drift and keeps the pulse duration unchanged.

Chirped pulse amplification (CPA) is a well-developed technique for generating high-power laser pulses with durations as short as 10 fs, and commercial systems are available that generate pulses as short as 25 fs. The pulses from the CPA amplifier can be further compressed to 5 fs with energy on the order of 1 mJ using nonlinear bandwidth broadening. For such intense, few-cycle pulses, it is crucial to control their carrier-envelope (CE) phase for strong-field atomic physics studies. In the past few years, CE phase stabilization was mainly studied on multi-pass CPA system.[1] As a widely used amplification system, regenerative amplifier has been shown that the CE phase stability of the seed laser pulse could be maintained after the amplification. [2] In this work, we introduce a new method to actively stabilize the CE phase of the laser pulse from a regenerative amplifier.

The laser system consists of a CE phase stabilized oscillator (Coherent Micra-CEPS) and a Coherent Legend Elite regenerative amplifier. Half of the oscillator beam is sent to an f-to-2f interferometer (Menlo System XPS800) to lock the oscillator CE phase. The f-to-2f interferometer was integrated together with the oscillator and thermal-controlled through a water cooled base-plate. The oscillator beam generated a beat note more than 40 dB signal-to-noise inside the f-to-2f interferometer. The detected beat note was locked at the quarter of the repetition rate within the noise level of 150 mrad over several hours.

The phase stabilized output of the oscillator beam was stretched to ~150 ps in grating based stretcher and used to seed a Legend-Elite regenerative amplifier pumped by a Coherent Evolution 30 DPSS pump laser. The output of the amplifier was compressed to sub-40 fs with energy of 3.5 mJ at 1 kHz.

A collinear f-to-2f interferometer was used to measure the interference pattern and retrieved the slow CE phase drift of the amplified pulse. The retrieved phase was used to generate a feedback signal to control the dispersion inside of the amplifier. Figure 1 shows the stabilized phase data which has been taken over 30 minutes. The overall phase noise was 287 mrad.

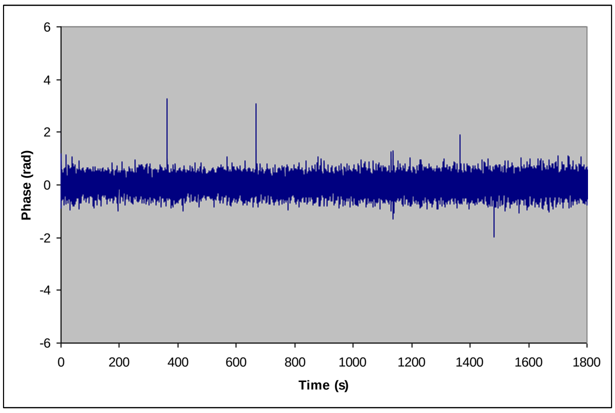

Fig. 1. Stabilized CE phase data.

Many of the CE phase stabilized systems reported in the literature use cryogenic cooling of the Ti:sapphire amplifier to minimize temperature-induced CE phase drift. In this work, the Ti:sapphire rod of the amplifier was only water cooled at the room temperature. Further investigation to improve the regenerative amplifier phase stability is in progress.

References

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