CEP stabilization of a 3.5mJ, 5kHz femtosecond laser based on gratings stretcher/compressor and regenerative amplifier

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Synopsis: We demonstrate the CEP stabilization of a 3.5mJ at 5kHz (17W average power) femtosecond laser system composed of an CEP-stabilized oscillator, a compact Öffner stretcher, regenerative and cryogenic amplifiers, and a gratings compressor. A CEP drift of 200 mrad is routinely obtained.

The development of ultrashort laser pulse technology has made it possible to generate laser pulses with duration shorter than 10fs. For these few-cycle pulses, the relative position of carrier sinus wave and the envelope of the pulse is a key issue for attoscience. Therefore, the carrier-envelope-phase (CEP) has to be carefully stabilized in the laser system. The CEP stabilization on a chirped-pulse amplification system employing a grating-based pulse stretcher and compressor and a regenerative amplifier was initially demonstrated but only with low output energy (1mJ) and at 1kHz repetition rate [1]. Here, we present, for Attosecond Physics 2009, a reliable multi-kHz, multi-mJ CEP stabilized femtosecond laser system.

In this system (see Fig. 1), the seed pulse, issued from an octave spanning spectrum oscillator (<7fs), CEP stabilized with an XPS800 device (MenloSystems), is stretched in a very compact, vibrations isolated Öffner stretcher. The spectral dispersion, beam propagation, beam pointing and mechanical stability are optimized by an original geometry. Stretched pulses are pre-amplified in a regenerative amplifier and a water-cooled two-pass amplifier to achieve 1mJ at 5kHz (5W average power). Both amplifiers are pumped by 7mJ of Nd:YAG laser (ETNA – THALES Laser). Regenerative amplifier allows us to have a perfectly Gaussian spatial profile and highest energy and pointing stability due to the laser cavity mode.

The energy is then increased in a cryogenically-cooled multi-pass booster amplifier pumped by 20mJ Nd:YAG laser (ETNA-HP – THALES Laser). Pulse-to-pulse energy stability of pump lasers, optimized at 0.5% RMS, and beam pointing stability preserve the CEP stabilization. Amplified pulses are finally compressed in a gratings compressor where the thermal effects, due to the high-average power on the gratings, are managed to avoid beam and pulse profiles distortion.

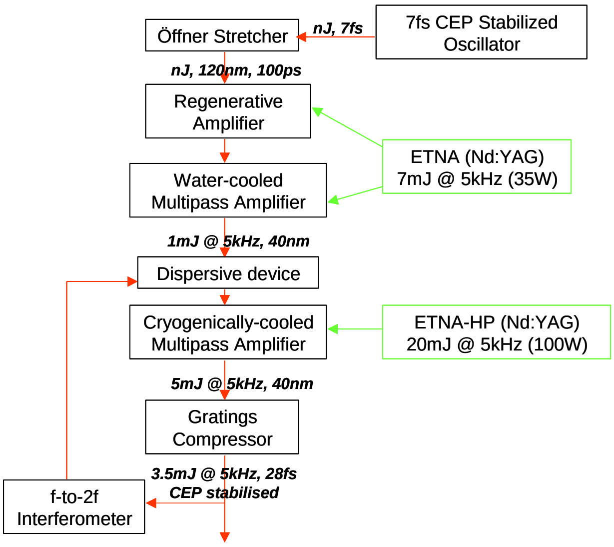

Fig. 1. Schematic of the laser system.

The output pulses are spatially and temporally characterized and we obtain 41nm spectral bandwidth (FWHM) and pulse duration of 28fs. The slow CEP drifts introduced by stretcher/compressor and amplifiers are measured by a f-to-2f interferometer (APS800 – MenloSystems) and corrected by a closed-loop dispersion control device. CEP drifts is routinely maintained below 200mrad.

In conclusion, we will present a unique design of a CEP-stabilized multi-mJ, multi-kHz femtosecond system based on gratings stretcher/compressor, regenerative amplifier and cryogenically-cooled booster amplifier.

References

[1] M. Kakehata, *Optics Express* **12** 2070 (2004).

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