A CEP-stable infrared OPA system capable of high-repetition-rate operation

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Abstract: We present a passively CEP-stabilized OPA setup delivering pulses with up to 12 μJ pulse energy in the IR. The setup is designed to sustain high-repetition-rate pump pulse energies and is therefore feasible for an upgrade to 50 kHz with negligible heat deposition in the OPA. The amplified pulses are spectrally broad enough to be compressed down to the few-cycle regime using chirped mirrors.

I. INTRODUCTION

Repetition rate is the limiting factor for various applications of intense ultrashort optical pulses, especially rare events like electron rescattering[1], and momentum correlation experiments[2]. Other groups have presented setups operating at high repetition rates in different wavelength regimes[3,4]. In contrast, we present an easily accessible setup operating in the infrared compatible with conventional Ti:Sapphire chirped pulse amplifiers..

II. EXPERIMENTAL SETUP AND RESULTS

Our setup uses a Ti:Sapphire oscillator delivering pulses centered at 800 nm. The pulses are stretched using transmission gratings and amplified in a 1-kHz regenerative amplifier. The amplified pulses are then compressed to a duration of 43 fs using a transmission grating compressor, before entering a two-stage OPA system.

Currently, the pulse energy after the compressor is adjusted to match operating conditions after a planned upgrade to 50 kHz, resulting in pump pulse energies of 15 μJ for the first and 120 μJ for the second OPA stage. The seed is created by white light generation, followed by difference frequency generation (DFG), resulting in a spectrum spanning from 1200 nm to 2400 nm. Due to the nature of DFG, the pulses are passively CEP-stabilized.

An outline of the setup is depicted in Fig. 1. The use of 1-mm BIBO crystals in both OPA stages allows for broadband amplification and keeps the introduced chirp to a minimum.

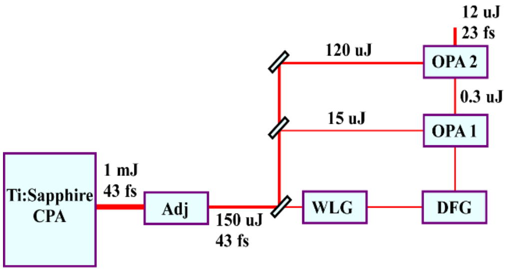

Fig. 1. Scheme of the experimental setup, pulse energy is adjusted after the CPA system to match high-repetition rate case (Adj), seed is supplied by white light generation (WLG) in a 5-mm sapphire crystal and DFG in a 1-mm BIBO crystal, both OPA stages (OPA 1 and OPA 2) also use 1-mm BIBO crystals

The current setup delivers up to 12 μJ of pulse energy at 1 kHz repetition rate. Exchanging the regenerative amplifier to one operating at 50 kHz is planned for the immediate future. Thermal lensing effects in the regenerative amplifier are also being investigated.

SHG-FROG measurements show group delay mostly matching that introduced by 2.5 mm of BIBO directly after the second OPA stage. Figure 2 a) shows the spectrum measured after the OPA, while Fig. 2 b) shows the group delay reconstructed from the FROG measurement. The FROG error is 0.7 %.

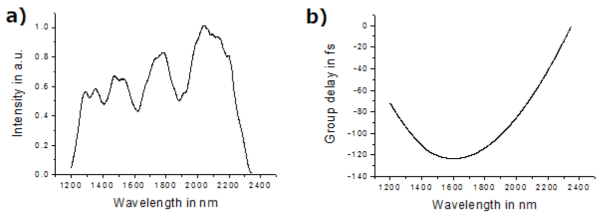

Fig. 2. a) Spectrum after second OPA stage b) Group delay retrieved from FROG trace

III. CONCLUSIONS

The presented setup generates CEP-stable pulses in the IR with 12 μJ of pulse energy. The spectral width and group delay are sufficient for compression to the few-cycle regime with chirped mirrors, offering a compact and robust source of intense few-cycle pulses. The repetition rate will be increased to 50 kHz by replacing the regenerative amplifier, opening the door to new strong-field applications while keeping the accessibility of a technically mature Ti:Sapphire system.

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