https://doi.org/10.1051/epjconf/202226701008

Terahertz radiation in tailored two-color laser fields with a stabilized doubly resonant optical parametric oscillator

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Strong tailored two- and three-color optical waveshapes can be useful for effective generation of light at very high (XUV) and very low (THz) frequencies [1,2]. In particular, for generation of THz radiation, strong and stable asymmetric temporal-waveshapes are needed. Phase locked doubly-resonant optical parametric oscillators (DROPOs) can contribute with intensities high enough for this goal. In this work, we stabilize our degenerate DROPO by using a locking scheme which utilizes monitoring of a "spurious"-sum-frequency product (SFG) of signal and pump in the amplifier crystal – a method proposed very recently in [3]. In our experiment, we synchronously pump the DROPO by a home-built Yb:YAG Kerr-lens mode-locked thin-disk laser, emitting pulses at a wavelength of 1030 nm with a pulse duration of 250 fs, 20 W output power and 33 MHz repetition rate.

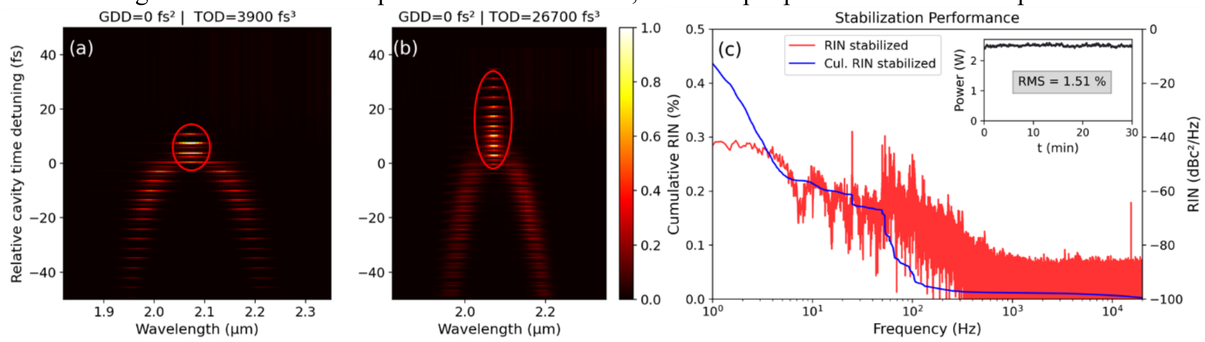

Fig. 1. Extending the self-locking region by changing the third-order dispersion (TOD). (a), (b) Experimental cavity length scans for small and large values of TOD, respectively. The self-locking region is marked with the red ellipse. (c) Relative intensity noise (RIN) of the signal output of the DROPO for active PI controller (red). The cumulative RIN for the stabilized system is less than 0.9% (blue). Inset shows longtime measurement of the output power.

For the optimum performance of the stabilization, a large self-locked region of the spectrum is beneficial. Here we show that the phase locking region can be significantly extended by introducing high-order dispersion (TOD) into the cavity [4]. As shown in Fig.1 (a) and (b), the self-locked region is highly dependent on TOD: with increasing TOD, the group-velocity matching parabola becomes narrower, the self-locked region increases.

Furthermore, we use SFG as the error signal for the stabilization of the system which can be modified by spectral filtering for different incident angles. From Fig. 1(c) we can see that this approach allows to reduce the noise drastically for all frequencies below -40 dBc^2/Hz. The cumulative RIN is here below 0.5% which is quite low. The output power is stabilized for an extended time periods of order of 30 minutes and more.

In conclusion, the introduction of TOD in the cavity can significantly increase the self-locking region of DROPO. Also, we were able to stabilize our DROPO using an SFG-based scheme. With all this, as we believe, we made an important step towards creating steady multi-color waveforms for intracavity strong-field optics.

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