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Pulse-To-Pulse Spectra of a Picosecond Optical Parametric Oscillator Based on Chirped Quasi-Phase Matching

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The spectrum emitted by singly resonant optical parametric oscillators (OPOs) highly depends on the pump laser temporal regime. For femto- and picosecond synchronously-pumped OPOs (SPOPOs), the successive pulses are coherent and a steady-state spectrum is expected, independently of the initial quantum noise. In this context, papers reporting on the spectral properties of SPOPOs mainly focused on the steady-state spectrum. One should nonetheless point out a recent theoretical paper where the evolution of SPOPOs spectrum upon oscillation buildup was investigated [1]. However, the experimental study of such spectro-temporal dynamics has never been reported despite its high interest to gain physical insights and to assess numerical modeling. Transient regime comprehension is also of first importance regarding applications such as real time spectroscopy based on ultra-fast wavelength tuning of the OPO.

Here, we report on the first experimental investigation of the pulse-to-pulse evolution of the spectrum emitted by a SPOPO. To carry out of such an experimental study, which is made challenging by the high pulse repetition rate of several tens of MHz, we implement an analogous approach as the one used in [2] to measure the pulse-to-pulse spectrum emitted by a supercontinuum source. The output signal beam is coupled to a highly dispersive optical fiber, the spectrum is thus temporally dispersed and can be recorded by use of a fast detector at the output end of the fiber. This investigation of the spectro-temporal dynamics upon buildup of the oscillations is also made possible by use of a Pockels cell that enables to rapidly switch-on the pump at the OPO input.

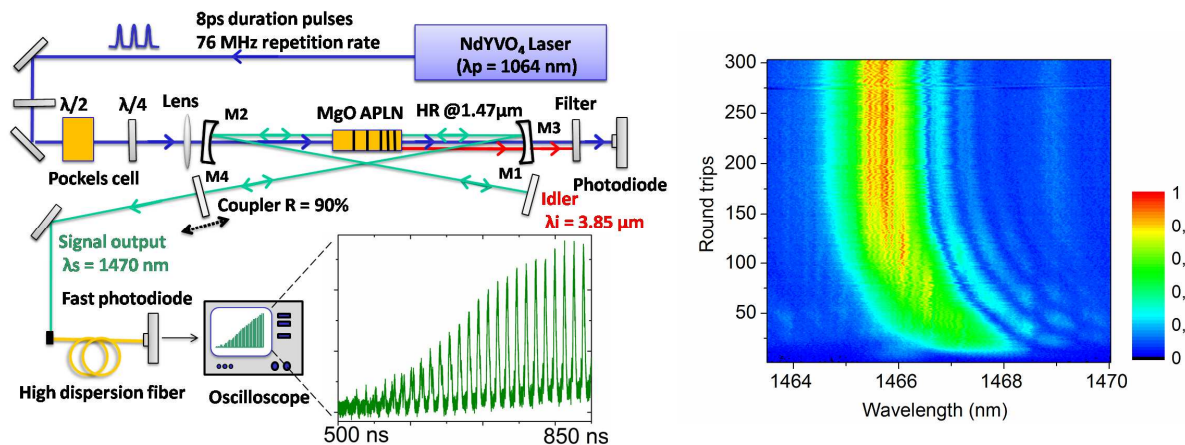


Fig. 1 Experimental setup (a) and pulse-to-pulse spectrum upon buildup of the oscillation (b)

The experimental setup is shown in Fig. 1(a). The SPOPO similar to the one reported in [3] is based on a 60-mm long MgO-doped aperiodically poled lithium niobate (APPLN) crystal (HC Photonics), pumped by a Nd-doped, mode-locked picosecond laser (76 MHz pulse repetition rate and 8 ps pulse duration). Here, experiments are carried out with an apodized chirped quasi-phase matched (QPM) grating with a central chirp rate of $3.9 \times 10^4 \text{ m}^{-2}$, leading to a parametric gain bandwidth of 12 nm and an oscillation threshold of 1 W. The highly dispersive fiber induces a dispersive delay of -2000 ps/nm at the central signal wavelength of 1466 nm. The detection bandwidth of the system is limited by the 5 GHz bandwidth of the detector while the oscilloscope bandwidth is 13 GHz, leading to a spectral resolution of about 100 pm. The oscilloscope trace in Fig. 1(a) shows a typical pulse train recorded at the output of the dispersive fiber. One can clearly see the dynamics of the oscillation buildup. Fig. 1(b) shows an example of spectrum formation. In the buildup regime, one can see a clear evolution of the spectra within the pulse train. We then observe that the spectrum evolves toward a steady-state in which the spectrum is almost identical from one pulse to another and is consistent with the average spectrum. More experimental details and comparison with theoretical calculation will be given and discussed.

References

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