Parametric Transfer in a Synchronously Pumped Optical Parametric Oscillator

H.S.S.Hung, J. Prawiharjo, D.C.Hanna and D.P.Shepherd

Optoelectronics Research Centre, University of Southampton, Southampton SO17 1BJ, U.K., Tel.. +44 23 80593373 Fax +44 23 80593149
hssh@orc.soton.ac.uk

We experimentally investigate the fidelity of parametric transfer of ultrashort pulse characteristics from the near-infrared pump to mid-infrared idler in a synchronously pumped optical parametric oscillator. The sonogram technique is used to characterize the spectral phase and amplitude of the pulses.

Programmable shaping of femtosecond optical pulses has been shown to be a useful technique for controlling the dynamics of chemical reactions and other physical phenomena. Most of this work has been with pulses in the near-infrared (NIR) or shorter wavelength regimes to control excited state processes. However, the use of shaped pulses in the mid-infrared (MIR) would allow access to ground state dynamics. While direct programmable pulse shaping in the MIR has recently been demonstrated [1] with a germanium acousto-optic modulator, the majority of the work in this regime has relied upon parametric transfer of shaped NIR pulses to the MIR via a single-pass difference frequency generation (DFG) process [2,3]. Our recent work has shown that adaptive MIR pulse shaping can also be achieved by shaping a NIR pump of a synchronously pumped optical parametric oscillator (SPOPO) [4]. However, both the DFG and OPO processes can place limitations on the fidelity of the transfer, and hence, on the range of pulse shapes that could be obtained by this method. We have numerically investigated parameters affecting parametric transfer initially for single pass DFG [5] and, more recently, for a SPOPO system.

In this work, we experimentally investigate the factors affecting parametric transfer in a SPOPO and finally demonstrate high-fidelity transfer with complete characterization of the pump and idler pulses using a cross-correlation sonogram technique [6]. The effects of temporal walk-off (TWO), group delay dispersion (GDD), signal bandwidth, signal amplification and pump depletion were considered. We achieve high fidelity transfer to the idler by choosing pump-idler TWO=0, compensation of the pump-signal TWO by cavity length tuning, minimal signal amplification using a 100% output coupler, high pump depletion at 4 times above threshold and signal bandwidth narrowing to 80GHz using a 150μm thick etalon. Figure 1(b) shows the retrieved idler sonogram trace measured under these conditions bearing a good resemblance to the retrieve pump sonogram trace in Fig. 1(a). Comparison to Fig. 1(c) where there is no signal bandwidth narrowing or cavity length tuning emphasizes the importance of actively preserving fidelity.

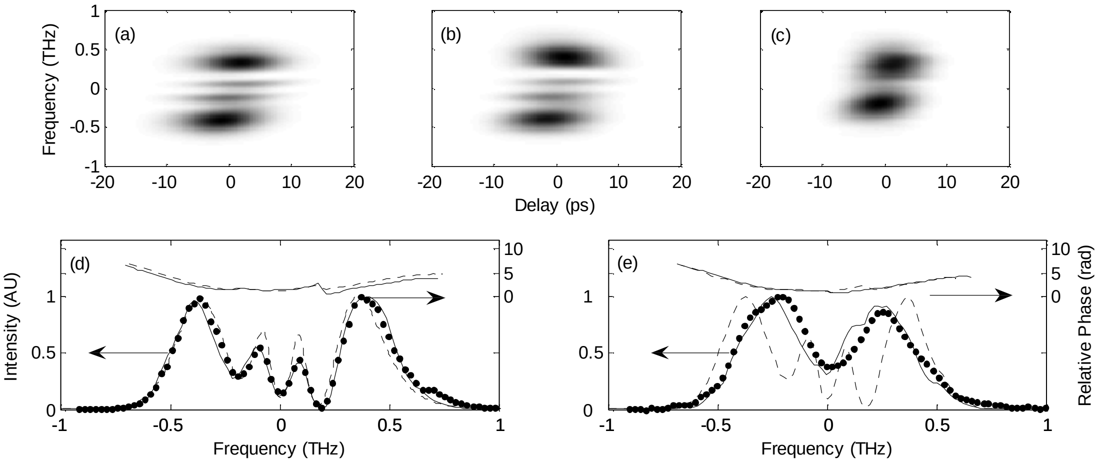

Fig 1. Retrieved sonograms of (a) the input pump pulse, (b) the high fidelity idler pulse, and (c) the poor fidelity idler pulse for uncontrolled transfer. (d) and (e) show the retrieved pump spectrum and phase (dashed) compared with the measured idler spectra (dotted), retrieved idler spectra and phase (solid) for the SPOPO arrangements maintaining and not maintaining high fidelity transfer.

References

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