Parametric Transfer in a Synchronously Pumped Optical Parametric Oscillator: Toward Coherent Control

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Mid-infrared (MIR) ultrashort optical pulses with electronically programmable shapes are a key experimental ingredient in using light to control the outcome of chemical reactions involving molecules whose vibrational energy levels are in the interesting fingerprint region. The limitations of electronically programmable devices for direct shaping of MIR pulses have created an interest in indirect pulse-shaping techniques, i.e. transferring shaped pulses through a nonlinear optical parametric process. Such an approach has been previously demonstrated using a difference-frequency generation (DFG) process [1,2]. Recently, we demonstrated an alternative approach of indirect pulse shaping using a synchronously-pumped optical parametric oscillator (SPOPO) [3], which only requires a single pump source of shaped pulses, and thus avoids the need for another synchronized pulse source.

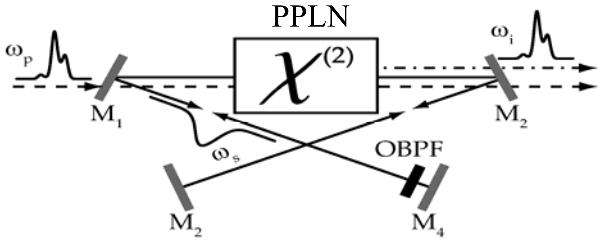

Fig. 1 Schematic illustration of our SPOPO setup. M1 and M2 are curved mirrors, and M4 is replaceable with a partially transparent mirror.

In this work, we investigate the parametric transfer in a SPOPO with a periodically-poled lithium niobate (PPLN) gain medium, as schematically illustrated in Fig. 1, both numerically and experimentally, and demonstrate a high fidelity parametric transfer. In our investigations, we implemented a sonogram technique to characterise the pulses [5]. We identified the necessity of placing an optical band-pass filter, i.e. an etalon, in the cavity to restrict the spectral width of the resonating signal pulse. We investigate the effects of this etalon, and other resonator parameters, including pump power and output coupling, as well as the chromatic dispersion of the PPLN crystal. In terms of resonator parameters, our work showed that high fidelity parametric transfer can be achieved by greatly restricting the signal spectral width, working in a high pump depletion regime, and using highly reflective mirrors at the signal wavelength for the cavity. In terms of the chromatic dispersion, the temporal walk-off (TWO) between the pump and signal pulses can be compensated by adjustment of the cavity length, while the TWO between the pump and idler pulses must be reduced by working at an appropriate set of wavelengths or using a short crystal.

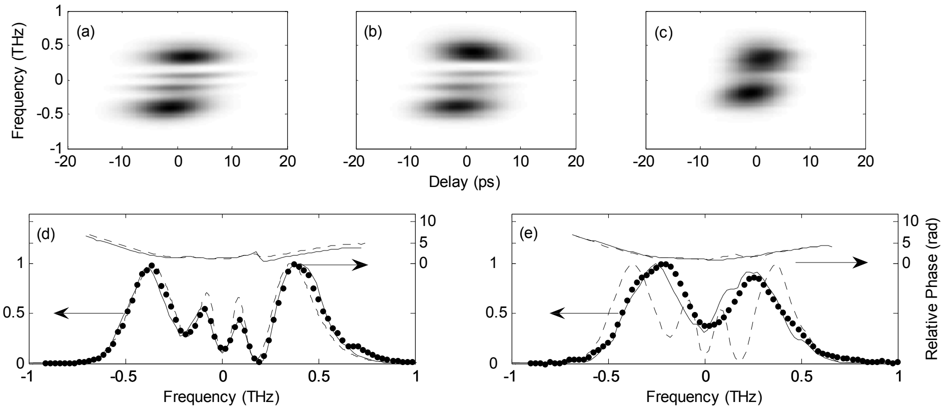

Fig. 2 Retrieved sonograms of (a) the input pump pulse, (b) the high fidelity transferred idler pulse, and (c) the poorly transferred idler pulse. The retrieved pump pulse spectral intensity and phase are shown in (d) and (e) as dashed curves. The retrieved idler pulse spectral intensity and phase profiles for high and low fidelity transfer are shown in (d) and (e), respectively, as solid curves. The measured idler spectra are shown as dots.

References

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