Pulse shaping in an optical parametric oscillator with fibre feedback

P. S. Lloyd, M. V. O’Connor, M. A. Watson, B. C. Thomsen, D. P. Shepherd, and D. C. Hanna
Optoelectronics Research Centre, University of Southampton, Southampton, SO17 1BJ, United Kingdom
Tel: +44 (0)2380 593138; Fax: +44 (0)2380 593142
moc@orc.soton.ac.uk

Ultrashort pulses in the infrared have a wide range of applications and synchronously pumped optical parametric oscillators (SPOPOs) have proven to be attractive sources in this context, providing femtosecond and picosecond pulses with broad tuning ranges in the near- and mid- infrared. A goal of the work reported here is to develop methods to control the temporal and spectral shape of these pulses so as to meet the optimal requirements of a given experiment. For this, parametric gain offers not only the broad signal gain bandwidth to support short pulse amplification, but also the ability to manipulate the idler characteristics via control of the signal pulses [1].

Here we present experimental results based on a high-gain SPOPO in combination with feedback through a single-mode fibre, whose role is to broaden the spectrum via self-phase modulation. The use of fibre feedback in a SPOPO has been reported previously and was found to result in an improved stability with respect to cavity length effects as well as a more compact design [2]. However, the operating conditions did not give significant spectral broadening in the optical fibre. The aim of the work presented here is to use spectral broadening in the fibre to exploit the full parametric gain bandwidth available and demonstrate pulse shaping of the signal in an OPO.

The schematic of the fibre-feedback OPO is show in Figure 1. The signal generated in the periodically poled lithium niobate (PPLN) is launched into a 2.2m-long standard telecoms fibre, which is single mode at the signal wavelength. The light emerging from the end of the fibre is fed back into the PPLN crystal in synchronism with the pump pulse train. A standing-wave OPO, with no fibre feedback, was aligned by inserting mirrors M3 and M4 into the cavity. As the pump power was not sufficient to achieve parametric generation in the PPLN, the standing-wave OPO was used to optimize the launch efficiency of the fibre-feedback loop. Mirrors M3 and M4 were then removed and appropriate cavity length adjustments made to restore oscillation. The characteristics of the fibre were chosen to shape the temporal and spectral properties of the signal pulse through dispersion and nonlinearity in the fibre. A typical output spectrum from the fibre-feedback OPO (see Figure 2) shows an increase by a factor of 5 compared with that from the OPO in a standing-wave design with no fibre feedback. Initial results with an external grating compressor show that significant compression up to a factor of 4 can be achieved. Future work is aimed at adaptively controlling the generated spectrum and temporal behaviour within the OPO cavity and investigating the transfer of these characteristics to the idler pulses.


Fig. 1. Schematic of the synchronously pumped optical parametric oscillator. M1-M4: high reflecting mirrors for the signal, f1-f3: lenses, OC: 55% output coupling mirror for signal.

Fig. 2. Output spectrum of the OPO with free-space feedback (---) and with fibre feedback (—).