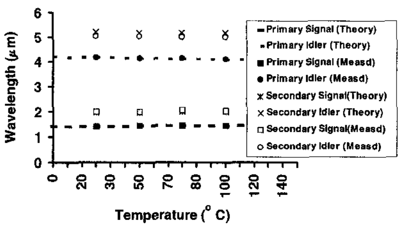
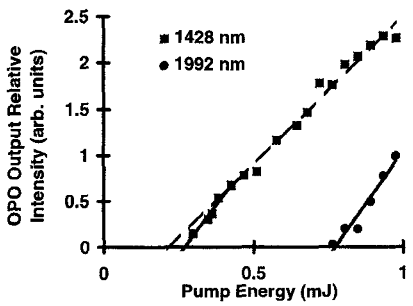


CThY5 Fig. 1 Temperature tuning of the PPLN OPO. Measured wavelengths for the primary and secondary processes are compared with theoretical predictions.



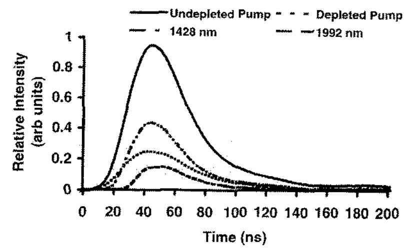
CThY5 Fig. 2 OPO output pulse peak intensity as a function of pump energy for the primary (1428 nm) and secondary (1992 nm) signal wavelengths.

the different poled gratings into the pump beam.[2]

The 28-μm grating was characterized in greatest detail. For 1 mJ pump, we measured pump depletion of 35% and outputs of 130 μJ signal and 40 μJ idler. A monochromator revealed that the measured signal and idler energies actually included contributions from several lines due to multiple nonlinear processes running simultaneously. The primary 1-μm-pumped OPO produced 1.43 μm signal and 4.18 μm idler. Additionally, we observed a secondary OPO pumped by the resonant 1.43-μm signal of the primary OPO, which produced 1.99 μm signal and 5.04 μm idler. Both OPOs could be tuned by varying temperature, as shown in Fig. 1. Output energy at 1.99 μm was approximately 2–3 times smaller than the 1.43 μm signal; output energy at 5.04 μm was approximately 20 times smaller than the 4.184 μm idler. (These ratios are not corrected for spectral dependencies of the monochromator and the detector.) The output also contained lower powers of other wavelengths corresponding to second harmonics, sum frequencies, and difference frequencies of the various lines.

Figure 2 shows output energy as a function of pump input energy. As can be seen the oscillations at 1.43 μm and 1.99 μm have different thresholds but similar slope efficiencies. Figure 3 shows the time delay between the pump pulse and output pulses of the primary/secondary OPOs.

In summary, we have characterized the spectral and temporal behavior of dual parametric oscillations in a PPLN OPO. Relatively efficient secondary oscillation robs power generated at the primary OPO wavelengths and introduces spurious spectral components.



CThY5 Fig. 3 Plot of the output pulse of the undepleted and depleted pump, and the primary and secondary signals. The pump and the primary signal had a delay of about 20 ns; the primary and secondary signals had a delay of about 10 ns.

These effects are particularly evident in PPLN because of the high nonlinear drive and the fortuitous coincidence of multiple phase-matching conditions. We intend to use a PPLN OPO in a multispectral laser radar where such effects are undesirable.[3] We hope to control them with frequency selective elements in the cavity or by injection seeding.

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CThY6 5:45 pm

Single-crystal sum-frequency generating optical parametric oscillator

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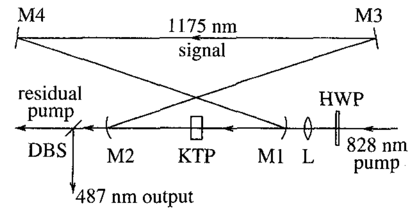
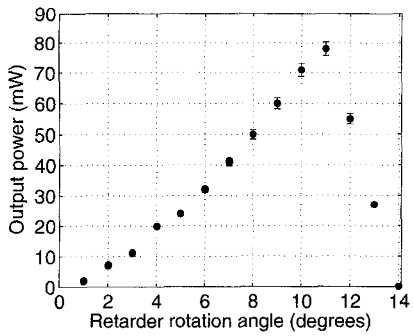
Frequency conversion using synchronously pumped optical parametric oscillators (OPOs) extend the wavelength range of ultrafast laser systems to longer wavelengths.[1] Upconversion to shorter wavelengths is also possible with use of an additional intracavity nonlinear crystal for second harmonic generation[2] (SHG) or sum frequency generation[3] (SFG). Recently, a single-crystal frequency-doubled OPO was demonstrated.[4]

Here, we report a sum-frequency generating OPO where a single crystal is employed for both parametric oscillation and sum frequency generation. Our OPO is based on a KTP ($KTiOPO_4$) crystal that is pumped by a Ti:sapphire laser operating at a wavelength of 828 nm. When pumped at this wavelength, the KTP crystal is phase matched for a signal wavelength of 1175 nm in a type-II geometry. The corresponding idler wavelength is 2800 nm. The KTP crystal is also phase matched for SFG of the pump and the signal beams to yield a blue output beam at 487 nm. A rotation of the input pump polarization is required to phase



CThY6 Fig. 1 Single-crystal sum-frequency generating OPO setup.



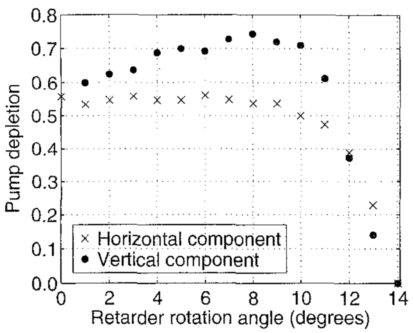
CThY6 Fig. 2 Conversion efficiency of sum-frequency generating OPO as a function of the retarder rotation angle.

match both processes at the same time. To our knowledge, this is the first demonstration of phase-matched optical parametric oscillation and sum frequency generation within a single crystal.

A modelocked Ti:sapphire laser with 150-fs-long pulses at a repetition rate of 76 MHz provides the pump beam to the OPO. We constructed a ring cavity consisting of four mirrors that are high reflectors as shown in Fig. 1. The 5-mm-long KTP crystal is positioned at the intracavity focus between the curved mirrors M1 and M2. A half-wave retarder (HWP) is placed at the input of the OPO to rotate the polarization of the pump beam. The blue beam exits the cavity through M2 and is separated from the residual pump beam with a dichroic mirror (DBS).

There is very little sum-frequency generation when the half-wave retarder is adjusted to 0° so that the pump beam is horizontally polarized. Rotating the input pump polarization increases the sum-frequency output power dramatically. Figure 2 shows the output blue power as a function of retarder rotation angle for 750 mW input pump power. We obtain a maximum of 78 mW blue power at a retarder rotation angle of 11°, corresponding to 10% power conversion efficiency. Figure 3 shows the depletion of the horizontal and vertical polarization components of the pump beam as a function of retarder rotation angle.

In conclusion, we have demonstrated a sum-frequency generating OPO that employs a single nonlinear crystal for both parametric generation and sum frequency generation. The two-step conversion is efficient, since both nonlinear conversion processes are phase matched in the same crystal. We expect significant improvement on these initial results by optimizing the cavity mode and the crystal length.



CThY6 Fig. 3 Pump depletion of sum-frequency generating OPO as a function of the retarder rotation angle.

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