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Strong self-phase modulation in periodically poled Lithium Niobate under subpicosecond pump pulses.

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Abstract:

We present experimental results showing very strong self-phase modulation of subpicosecond pulses in PPLN. We examine the effect that this has on the efficiency of frequency conversion and estimate the effective nonlinear refractive index to be 3 orders of magnitude greater than in silica.

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Recent progress in fabrication of PPLN offers new effects, the observation of which is very difficult in traditional materials. So far the main activity has been focussed on efficient second harmonic generation and parametric oscillation. Here we present results on strong nonlinear interactions in PPLN, which have to date received little attention, but offer very interesting applications requiring relatively low powers.

Our experimental setup is all diode pumped and involves amplification of sub picosecond pulses (900 fs) at 1543 nm by a chirped pulse amplification (CPA) technique up to peak powers of ~ 40 kW with an average power of ~ 60mW. These pulses are then focussed to a spot size of 36x20 μm diameter inside a 4mm long crystal of PPLN with a domain reversal period of 18.3 μm held at the phase matching temperature of 150 C.

Figure 1 shows the internal efficiency of second harmonic conversion as a function of the peak power of the input pulses. The maximum efficiency obtained was ~ 70% at a peak power of around 10 kW. Subsequently, the second harmonic pulses at 772 nm were launched into a second PPLN crystal phase matched for doubling to 386 nm through 3^{rd} order QPM. The internal efficiency of this process was 11% and coincided with the peak efficiency of 772 nm generation.

The unusual form of figure 1 can be explained in terms of self-phase modulation of the fundamental pulses via cascading of second order nonlinearities [1]. This results in back conversion from second harmonic to fundamental as the pulse power is increased, reducing the conversion efficiency. This SPM is accompanied by strong spectral broadening at the fundamental wavelength as evidenced by figure 2, which shows the output fundamental spectrum and the contrast to the input spectrum (inset). The second harmonic spectrum shows a similar development at high powers. From the spectrum of figure 2 which indicates a nonlinear phase shift of more than π we are able to estimate n_2^{eff} for PPLN and find a value of ~1 10^{-13} cm^2/W. This value is obtained for a "near" phase matched interaction and is in reasonable agreement with the results of reference [1].

For the highest peak pulse powers (> 25 kW) the conversion efficiency reaches a plateau at ~ 50 %. It can be speculated that this "clamping" of the efficiency represents some sort of trapping effect between the fundamental and second harmonic waves [2].

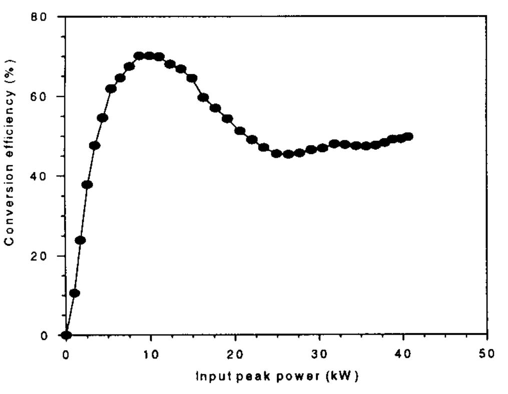

Figure 1: Second harmonic conversion efficiency as a function of peak pulse power.

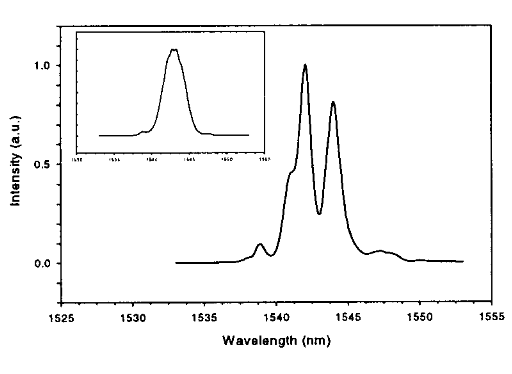

Figure 2: Spectrum of transmitted fundamental wave at peak pulse power of 35 kW with the input spectrum (inset).

[1] P. Vidakovic et al, Optics Letters **22**, 227 (1997).
[2] C.Y Chien et al, Optics Letters **20**, 353 (1995).