CHAPTER 7

CONCLUSION

In this work, we have demonstrated BBO optical parametric oscillators pumped at 532nm and 266nm. The generation of second harmonic generation from the fundamental 1064nm radiation of Nd:YAG lasers has been carried out using KD*P and D-CDA crystals and aspects of their pump beam quality and efficiencies have been investigated and discussed. The results have shown that D-CDA is more suitable for second harmonic generation of a multimode laser beam while KD*P proved a better choice in frequency doubling of supergaussian laser sources. Although both crystals were employed in the studies of nonlinear SHG , in its usage as a pump source of BBO parametric oscillator, the beam quality has been considered and for this reason the supergaussian beam was chosen for pumping of the OPO, discussed in Chapter 4.

In the subsequent chapter, different pumping schemes for BBO parametric oscillator have been discussed. Besides the conventional cavity configuration which involves a two mirror cavity, two other cavity designs have been demonstrated to produce continuously tunable radiation. Lower threshold has been obtained using an OPO cavity with pump reflection. Without a pump reflector, the threshold was found to be 17mJ while a lower energy threshold of 12mJ was acheived with a pump reflector. An OPO

design with intracavity pump steering mirror was also experimented and demonstrated. This cavity reduces the possibility of optical damage to cavity mirrors that we had experienced with conventional longitudinal pumped cavities before this.

KD*P was also used in fourth harmonic generation(FHG) of a Nd:YAG laser because of the damage incurred on a BBO FHG crystal due to tight focusing and suspected low crystal quality. Maximum conversion efficiency of 23% was obtained with the KD*P at a 532nm pump energy of 145mJ and the output was used to pump a BBO OPO. The cavity that incorporated an intracavity pump steering mirror was used to demonstrate the 266nm pumped OPO when the normal straight cavity failed to produce any parametric oscillation.

7.1 Further Research

The extension of nonlinear interaction in crystals to tunable parametric oscillators have proceeded to applications in ultrashort (picoseconds and femtoseconds) lasers. The work in pulsed systems has been mainly concentrated on the use of BBO crystals, which often have been pumped by an ultraviolet beam since in this case, the output can cover a larger fraction of the visible range in addition to the near infrared [3]. Both OPO's generating picosecond [4] and femtosecond [5] pulses have been demonstrated using BBO. A new NLO crystal lithium triborate (LBO) is currently used in OPO systems. The biaxial crystal has a number of

advantages over BBO [6]. The transmission extends further into the ultraviolet, it is not hygroscopic and its optical damage threshold is reported to be two times higher than that of LBO. LBO has been used most often for generation of higher harmonics and for OPO pumped by nanosecond pulses [7, 8].

There are a number of topics to be addressed, which will, hopefully, form the subject of subsequent dissertation or theses.

It can be concluded from the experimental descriptions and discussions in Chapters 3 and 5 that the extension of harmonic generation to high average power laser sources places other requirements on the nonlinear medium. In addition to adequate size and nonlinearity, high power SHG requires crystals with good thermal properties and wide temperature phase matching peak. If the laser beam quality is poor, then the nonlinear crystal must also have a wide acceptance angle.

One research area of interest would be the harmonic generation of a quasi-cw femtosecond laser system. For harmonic generation of quasi-cw laser sources, nonlinear crystals must have a large nonlinear coefficient and be available in adequate lengths at very low optical loss for harmonic generation internal to the laser resonator [1]. At present we have acheived results of SHG to 380nm of a femtosecond Ti:sapphire laser (Spectra Physics Tsunami) in LBO . The pulsewidth of the pump system was 100fs. Conversion efficiency was very low due to the inappropriate crystal cut for the pump wavelength used and instability of the femtosecond pump [9]. However, this result can be improved to obtain a better quality SHG output

that can be employed in pumping a BBO or LBO parametric oscillator. There is a great need for tunable femtosecond laser sources with high-pulse repetition rates. The first broadly tunable femtosecond OPO was demonstrated by Edelstein and co-workers [5] using a KTP crystal. With one set of mirrors, a tuning range from 820 to 920nm and 1.92 to 2.54μm was acheived. In ultrafast regime to maintain the shortest possible pulsewidth, the parametric conversion crystal must be very thin to avoid group-velocity dispersion and to phase match the entire femtosecond spectrum [10]. The wide tuning range available from a femtosecond OPO can be a useful tool for studies of soliton propagation in fibres which can be further extended to soliton-based optical amplifier systems.

Although a 266nm pumped BBO OPO has been successfully demonstrated, the whole tuning range was not acheived. This was suspected to be due to to the large change in phase matching angles at 266nm pump wavelength which requires the use of several crystals of different cuts. It is still of interest to obtain the whole tuning range. This can be acheived by 355nm pumped OPO. In the case of Nd:YAG pumping, the most versatile practical OPO is currently the third harmonic pumped BBO OPO [2, 8, 11].

In conclusion, the whole duration of the project and efforts invested into it provide experimental techniques and useful knowledge of nonlinear three-wave interaction and is hoped to be able to cater as reference , for subsequent work in this area of nonlinear optics.

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