Investigation of beam patterns in OPO employing walk-off compensating crystals

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Introduction

Nanosecond optical parametric oscillators (OPO) are popular sources of tunable radiation with long history tracing back to the beginnings of nonlinear optics. Despite this fact, scientific investigations still reveal interesting facts about them especially in multi-crystal configurations. Recently role of air dispersion in OPG was investigated by S. Ališauskas and co-authors [1]. Anstett et al. showed that choice of OPO cavity also influences beam shape and spectral qualities [2]. Moreover if walk-off compensation is used, conversion efficiency and beam quality could vary drastically [3-5].

Experimental setup

The single resonant OPO is pumped by 3rd harmonic of nanosecond Nd:YAG laser.

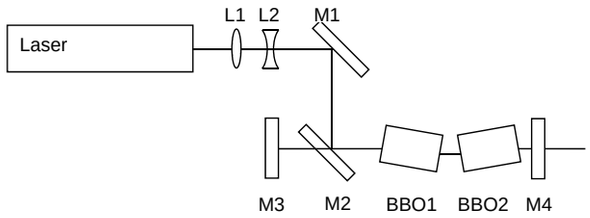
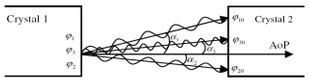


Fig. 1. Experimental setup. L1, L2 – lenses for beam diameter reduction, M1, M2 – pump beam guiding mirrors, M3 – mirror with high reflectivity for signal radiation, BBO1, BBO2 – BBO crystals (θ= 38 deg, ϕ=0 deg) oriented in walk-off compensating orientation, M4 – output coupler with high reflectivity for pump radiation and 10% reflectivity at signal radiation

Theoretical background



$$\varphi^{air} = \varphi_1^{air} + \varphi_2^{air} - \varphi_3^{air} = \left(\frac{k_1^{air}}{\cos(\alpha_1)} + \frac{k_2^{air}}{\cos(\alpha_2)} - \frac{k_3^{air}}{\cos(\alpha_3)}\right) L.$$

Phase difference in air between pump (3), signal(2) and idler(1) waves for different angles in respect to angle of propagation (AoP) is presented above [1]. S. Ališauskas et al. show that under certain assumptions intensity of generated beams is proportional to $1+\cos(\phi^{air})$. At a distance where $\cos(\phi^{air})$ =-1, no generated light should be observed.

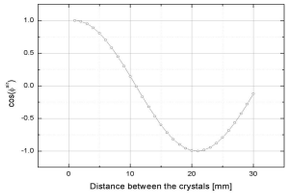


Fig. 2. Dependence of on-axis phase mismatch in air on distance between the crystals. Pump, signal and idler wavelengths are 355, 532 and 1064 nm.

D. J. Armstrong et al. have demonstrated that sign of nonlinearity in second crystal can have significant influence on OPG performance [3].

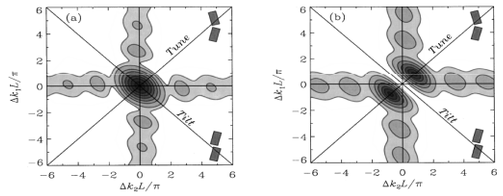


Fig. 3. Contour plots of calculated two-crystal, single-pass parametric gain. Left – crystals are oriented so the signs of d_{eff} are the same. Right – crystals are oriented so the signs of d_{eff} are opposite . From [3].

Results

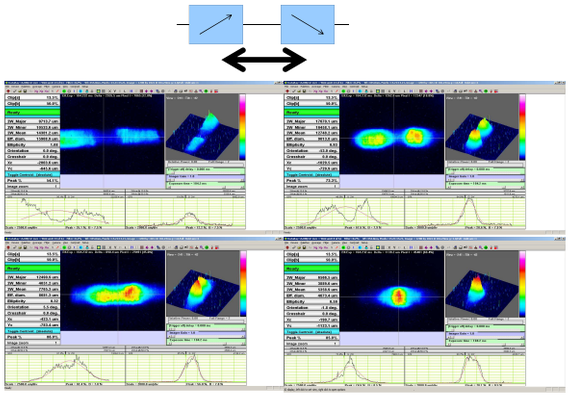


Fig 4. Beam shape as a function of distance between the crystals. The distance is correspondingly left to right, top to bottom: 2, 9, 19, 30 mm

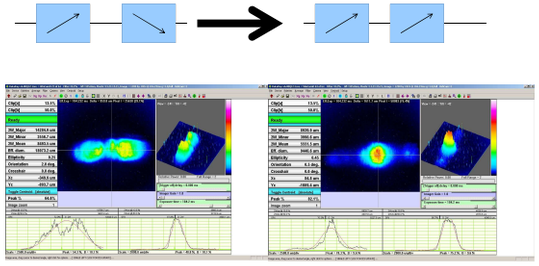


Fig 5. Influence of crystal orientation on beam shape. Left – crystals are placed in walk-off compensating orientation, right – non compensating. In both cases crystals are perpendicular to pump beam.

Conclusions

Investigation of beam profiles of the OPO lead to several important conclusions:

- Effects present traveling wave OPG are also observed in singly resonant OPO.
- In multicrystal OPO, beam profile is influenced by air dispersion and distance between the crystals should be optimized.
- When walk-off compensation is employed, additional effects, stemming from nonlinearity sign, could arise.

Literature

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2.G. Anstett et al., "Reduction of the spectral width and beam divergence of a BBO-OPO by using collinear type-II phase matching and back reflection of the pump beam," Applied Physics B: Lasers and Optics 72(5) p.583-589 (2001).

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