Photorefractive properties of a SBN crystal

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We investigate the energy transformation in two-wave-mixing in dependence on the applied electrical field and derive experimental relationships between electrooptical coefficients and electro-optical coupling gains responsible for the energy transformation

1 Introduction

In this paper we investigate the influence of the applied external electric field on the electro-optical coupling gain in a SBN:60 crystal at moderate laser intensities and show also the possibility to derive two out of three electro-optical coefficients knowing electro-optical coupling gains and one of the electro-optical coefficients. This work is based on results of our previous publication, where electro-optical coefficients of a BCT crystal were investigated [1].

2 Two-wave-mixing in SBN

SBN-crystals have three non-zero electro-optical coefficients r_{13}, r_{33}, $r_{42} = r_{51}$. In the case of two-wave-mixing (Fig. 1a) these coefficients form the tensor

$$\hat{r} = p_s \begin{pmatrix} a\cos(\alpha) & 0 & c\sin(\alpha) \\ 0 & a\cos(\alpha) & 0 \\ c\sin(\alpha) & 0 & b\cos(\alpha) \end{pmatrix} p_p \qquad (1)$$

with the parameters $a = n_o^4 r_{13}$, $b = n_e^4 r_{33}$ and $c = n_o^2 n_e^2 r_{42}$, the rotation angle of the crystal α (Fig. 1), the ordinary and extraordinary refractive indices n_o and n_e, the polarization states of the interfering signal (s) and pump (p) waves p_s and p_p.

We define the c-axis to be perpendicular to the crystal surface, where the fanning is directed to (Fig. 2).

Knowing the tensor of the electro-optical coefficients one can derive the imaginary part of the electrooptical coupling gain [2]

$$\gamma_{eo}^{im} = i\frac{2\pi}{n\lambda\cos(\vartheta)}\hat{r}E_{sc} \qquad (2)$$

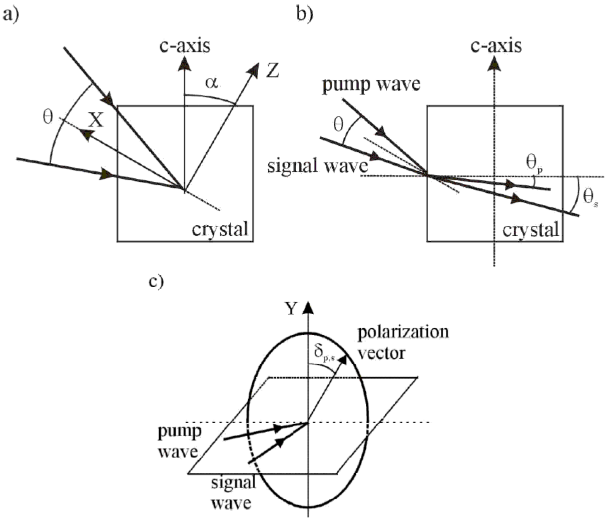

Fig. 1 *a) Orientation of the interfering waves and definition of the angle α, b) propagation of the interfering waves, c) orientation of the polarization vector.*

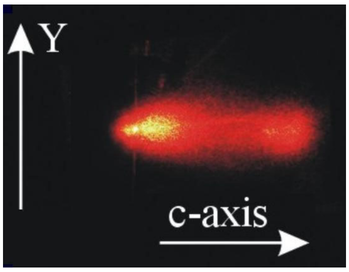

Fig. 2 *Definition of the direction of the c-axis by the fanning direction.*

Experimentally one can get the values of the imaginary electro-optical constant by measuring of the coupling constant for two-wave-mixing in two cases $I_p >> I_s$ (γ_1) and $I_p << I_s$ (γ_2).

$$\gamma_1 = \frac{1}{L}\ln\left(\frac{I_{pin}I_{sout}}{I_{pout}I_{sin}}\right), \quad \gamma_2 = \frac{1}{L}\ln\left(\frac{I_{pout}I_{sin}}{I_{pin}I_{sout}}\right), \qquad (6)$$

where the indices “in” and “out” correspond to the input and output beams and L describes the grating thickness. The half of the difference of the experimental coupling gains gives the imaginary electro-optical constant [2]

Since there are a few geometric limitations in the experimental arrangement due to the form of our crystal and the way of application of the external electric field, the optimal setups we can realize are shown in Fig. 3

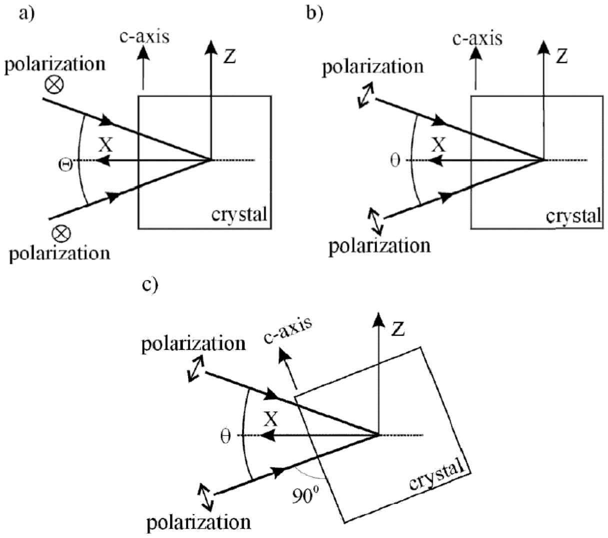

Fig. 3 *Schemes of the experimental setups for investigation of the relationships between electro-optical coefficients and electrooptical coupling gains.*

3 Experiment

We have varied the applied electric field from 0 up to 4 kV/cm and have found that the coupling gain does not depend on the value of the applied electric field independently of the input beam intensities. A typical experimental graph of the electro-optical coupling gain versus applied electric field is given in Fig. 4. This means that the saturation field E_q is essential smaller than the applied field E_0 so that $E_q \approx E_{sc}$, and it is sufficient to carry out the experiments without applied electrical field in order to find the relationships between the electro-optical coefficients of the crystal.

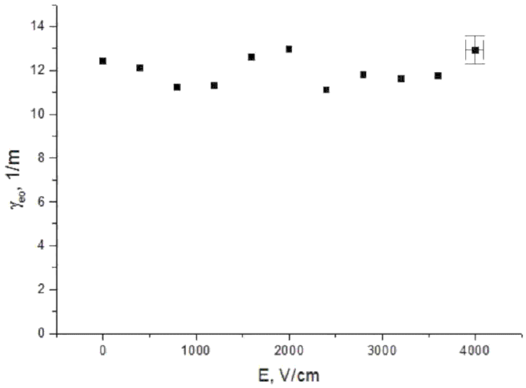

Fig. 4 *Typical dependence of the electro-optical coupling gain on the applied electric field corresponding to the setup in fig. 3a.*

Experimentally we obtain for the imaginary electro-optical constant the values $\gamma_{eo}^{im} = 40.0 \, {}^{1}\!/_{m}$ and $\gamma_{eo}^{im} = 40.3 \, {}^{1}\!/_{m}$ for schemes Fig. 3b and 3c.

Knowing the electro-optical coefficient $r_{13} \approx 70 \, {}^{pV}\!/_{m}$ from the literature [2, 3] we can determine the effective number of the ionized charges $N_{eff} \approx 0.2 \cdot 10^{21} \, {}^{1}\!/_{m^3}$, and other electro-optical coefficients $r_{33} \approx 210 \, {}^{pV}\!/_{m}$, $r_{42} \approx 60 \, {}^{pV}\!/_{m}$.

4 Conclusions

In conclusion, we found that the electro-optical coupling gain, which is responsible for energy transformation in two-wave-mixing, does not depend on the applied electrical field for geometrical conditions given in our paper. Knowing the electro-optical coefficient r_{13} from the literature we determined the effective number of the exited charges and the electro-optical coefficients r_{33} and r_{42}.

References

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