Modern Optics II: Nonlinear Optics
SHEET VII

Second harmonic with finite beams July 2017

Exercise 1 *Second harmonic with spatially limited beam*

Let assume that we have a KDP crystal, that we want to use for second harmonic of an incidence continuous laser operating at $\lambda = 1064$ nm. The crystal is cut to achieve type-I phase matching (eoo) and is 1 cm-long.

1. Calculate the phase-matching angle for second harmonic.
2. Calculate what intensity $I(\omega)$ is needed to acheive 58 % conversion efficiency assuming that the incident beam is a *plane-wave*. What is the walk-off angle ?
3. In the case of low conversion efficiency (10 %), what is the power required for $L = 2Z_R$? What is the waist of the beam (w_0) in the center of the cyrstal ? What is the beam diamter at the entrance on the crystal $2w$?
4. What is the loss of of harmonic due to walk-off ?

The parameters for KDP are $n_o(\omega) = 1.4942$*,* $n_e(\omega) = 1.4603$*,* $n_o(2\omega) = 1.5129$*,* $n_e(2\omega) = 1.4709$*.* $\chi^{(3)} = 0.56$ *pm/V.*

Exercise 2

Lithium Niobate is a very popular nonlinear material that can be used either in birefringent phase-matching or in quasi-phase-matching. In the present case, we use the crystal at $\lambda = 1064$ nm. At this wavelength phase matching occur (eoo).

1. Calculate the input intensity required for a plane-wave input for a conversion of 58% in the second harmonic.
2. Assuming that the beam is now Gaussian and the lenght of the cyrstal is $L = 2Z_R$, find the input power required for a conversion efficiency of 10%.

The parameters for $LiNbO_3$ *are* $n_o(\omega) = 2.2340$*,* $n_e(\omega) = 2.1554$*,* $n_o(2\omega) = 2.3251$*,* $n_e(2\omega) = 2.2330$*,* $\chi^{(3)} = 36$ *pm/V.*