University of Hamburg, Department of Physics

Nonlinear Optics

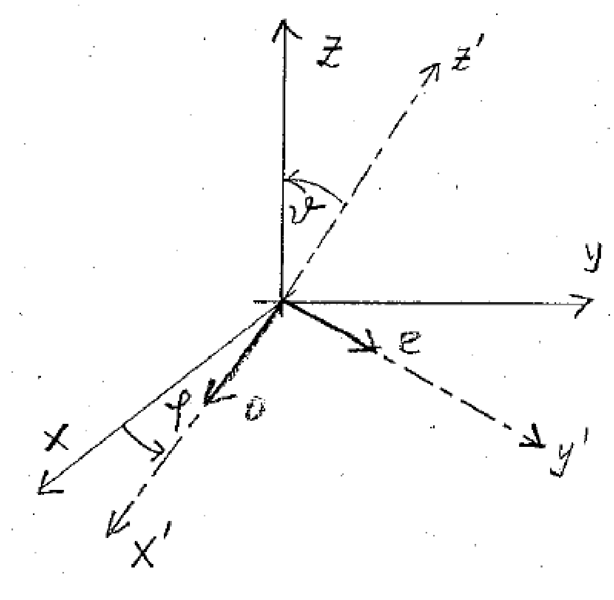
Kärtner/Mücke, WiSe 2018/2019

Problem Set 5

Issued: 23.11.18 Due : 30.11.18

1. **The effective nonlinear coefficient of BBO.**

   Consider the nonlinear crystal β-barium borate (BBO), which belongs to the crystal class 3m with m$\perp$y. The crystal is negatively uniaxial (check chapter 2 of the manuscript). Here, ϑ is the phase-matching angle between the z-axis of the crystal and the $\vec{k}$ vector, and φ is the angle between the polarization of the ordinary beam and the x-axis of the crystal. Assume that the birefringence is weak enough that $\vec{E}$ and $\vec{D}$ fields also for the extraordinary beam are approximately parallel. The optical axis is the z axis.



   (a) Find the expression for the nonlinear polarization $P_i(2\omega)$ in the $x-y-z$ coordinate system of the crystal.

   (b) What is the expression for the nonlinear polarization $P_{i'}(2\omega)$ in the $x^{'}-y^{'}-z^{'}$ coordinate system?.

   (c) Show that the effective nonlinear coefficient d_{eff} for type-I phase matching is:

$$d_{eff}(\varphi,\vartheta) = -d_{11}\cos\vartheta\sin 3\varphi - d_{31}\sin\vartheta$$

(d) What angle φ would you choose?.

Hint:
1. Remember for type I phase matching in a negative uniaxial crystal we generate an output electric field polarized at extraordinary direction (e) from an input electric field polarized at ordinary direction (o) through the SHG process. The input electric field $\vec{E}$ must be polarized $\perp$ to the propagation vector $\vec{k}$ and also $\perp$ to the optical axis z. Due to that $\vec{E}$ is along the $x^{'}$ axis (which is in the $x-y$ plane). On the other hand the extraordinary polarization field must be $\perp$ to the propagation vector $\vec{k}$ and also $\perp$ to the input field $\vec{E}$.

2. The rotation of the coordinate system from $x-y-z$ to $x'-y'-z'$ can be done by two separate rotation steps: first rotate φ with respect to z axis to get $x^{'}$ and secondly rotate ϑ with respect to $x^{'}$ to get the final orientation.