

Nonlinear Optics 2024 — Homework 1

Due Wednesday, January 28, 2024.

In classical stationary nonlinear optics, the polarization is written as a power series in the electric field.

$$\begin{aligned} P &= \epsilon_0 \chi(E) E = \epsilon_0 \chi^{(1)} E + \epsilon_0 \chi^{(2)} E^2 + \epsilon_0 \chi^{(3)} E^3 + \dots + \epsilon_0 \chi^{(n)} E^n + \dots \\ &= P^{(1)} + P^{(2)} + \dots + P^{(n)} + \dots \end{aligned}$$

The susceptibilities $\chi^{(n)}$ can be real numbers, imaginary numbers, tensors. The field can contain more than one frequency. For instance, the second order term:

$$\epsilon_0 \chi^{(2)} \mathcal{E}^2 \cos^2(\omega t)$$

describes second harmonic generation, optical rectification, and two photon absorption. Identify these effects in the complex representation.

Write the third order polarization in complex representation that leads to:

- An intensity dependent index of refraction.
- Third harmonic generation.
- Field induced second harmonic.
- Parametric amplification.