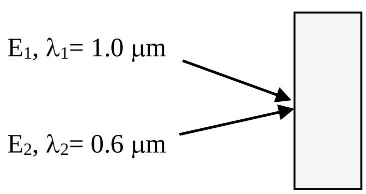
NONLINEAR OPTICS (PHYC/ECE 568)

Fall 2017 - Instructor: M. Sheik-Bahae
University of New Mexico

Homework #2, Due Monday, Sept. 19

Problem 1. Two optical beams E_1 and E_2 with wavelengths of 1.0 and 0.6 μm respectively are incident on a nonlinear material.



(a) Assuming a $\chi^{(2)}$ nonlinearity, what new wavelengths can possibly be generated in this material?

The above nonlinear material is now replaced with a <u>centro-symmetric</u> material for the reaming part of this problem.

(b) What is the dominant nonlinear susceptibility?

(c) Assuming $\chi^{(3)}$ nonlinearity, what new wavelengths λ_j can possibly be generated in this material that <u>simultaneously</u> involve the interaction of both E_1 and E_2 beams? Write down the corresponding nonlinear polarization $P(\lambda_j)$ including their $\chi^{(3)}(\lambda_j; \lambda_k, \lambda_q, \lambda_p)$ terms (ignore Cartesian indices).

(d) If $|E_1|>>|E_2|$, identify the most dominant terms in part (c).

(e) Write down the nonlinear polarization terms associated with self- and cross phase modulation of each beam (identify $\chi^{(3)}(\lambda_j; \lambda_k, \lambda_q, \lambda_p)$ terms)

(f) Under what condition the simultaneous presence of both beams leads to a nonlinear attenuation (absorption) of both beam? Describe this process, the required energy resonance (use diagrams), and the nature of the complex susceptibility $\chi^{(3)}(\lambda_j; \lambda_k, \lambda_q, \lambda_p)$ (with respect to part e).

(g) Under what condition the simultaneous presence of both beams leads to a nonlinear attenuation (absorption) of one beam (which?) and gain in the other (which?)? Describe this process, the required energy resonance (use diagrams), and the nature of the complex susceptibility $\chi^{(3)}(\lambda_j; \lambda_k, \lambda_q, \lambda_p)$ (with respect to part e and f).

Problem 2. **Two-Photon Spectroscopy:**

The 1S-2S transition in atomic Hydrogen (E=10.206 eV) is investigated using two-photon spectroscopy with two narrow-band CW laser sources. A pump laser with fixed wavelength λ_1=200nm and a tunable laser (λ=250-350 nm) are used in a counter propagating arrangement as shown.

(a) Qualitatively plot the transmission of the probe beam as a function of its tunable wavelength λ_2.

(b) Will the result in (a) be any different if they two beams were co-propagating? (Hint: think Doppler!)