

Birla Institute of Technology & Science - Pilani, K.K. Birla Goa Campus
PHY F433 : Topics in Nonlinear Optics, Second Semester 2022-23
Mid-semester Examination. Date: March 16, 2023. Time: 4.00 to 5.30 hrs.
Max. marks: 60 (To be normalized to 30 as Mid-sem weightage is 30%)

Section 1 : Solve the following four problems [Total 30 marks]

1.1) A laser beam is focussed inside a block of glass ($n=1.5$) to an intensity of 4 MW/cm^2 .

- a) Find the peak electric field (in V/m) at the focal point.
- b) Find the corresponding electric field if it was focussed to the same intensity in air.
- c) Find the magnitude of the peak magnetic field (in mT) of the laser at the focus in air.
- d) Find the value of the dielectric constant of glass (in pF/m).

$(Z_0 = 377 \Omega; \epsilon_0 = 8.854 \times 10^{-12} \text{ F/m}).$

[2 marks each for a-d, Total: 8 marks]

1.2) In 1962, Woodbury and Ng who were experimenting with Q switched pulses from a ruby laser, observed that in addition to the ruby laser line at 694.3 nm, an intense radiation was observed at 767 nm. This was found to be due to SRS in nitrobenzene used for Q-switching.

From the above information, calculate the following:

- a) The angular frequency (ω_m) of the Raman active vibrational mode in nitrobenzene (in rad/s)
- b) The corresponding vibrational frequency (ν_m in THz).
- c) The wavelength this vibrational line, if this mode was IR active (in μm).
- d) The angular frequency of the second order Stokes radiation ($\omega_L - 2\omega_m$; in rad/s).

[2 marks each for a-d, Total: 8 marks]

1.3) For a tetragonal crystal (BaTiO_3) with C_{4v} symmetry [i.e. Z axis is 4 fold rotation axis and there are four mirror planes through the Z axis (one in XZ plane, one in YZ plane, and two planes bisecting these planes)],

a) Show that the first order susceptibility matrix has only two independent elements.

b) Show that this crystal will be birefringent.

[6 marks for a and 3 marks for b, Total: 8 marks]

1.4) Show that the product of the group velocity and phase velocity is :

a) c^2 for an electromagnetic wave propagating in plasma,

b) $3v_{\text{Th}}^2$ for an electron plasma wave, and

c) c_s^2 for an ion-acoustic wave in plasma.

[2 marks each for a-c, Total: 6 marks]

(Please turn over for Section 2 and Section 3)

Section 2 : Answer all the three questions. [5 marks each, Total 15 marks]

Line 1: State whether the each of the following statements is true or false.

Line 2 onwards: If true, justify why it is true;

Line 2: If false, write down the corrected statement by modifying the underlined word/s only.

Line 3 onwards: Justify why the corrected statement is true.

In either case, justification should be at least 3-4 sentences.

2.1) Second order processes cannot be used for third harmonic generation.

2.2) An electromagnetic wave propagating in plasma with Maxwellian velocity distribution will undergo Landau damping.

2.3) Phase conjugation can be done using a second order process.

Section 3 : Answer all the three questions [5 marks each, Total: 15 marks]

Give brief (3-4 sentences) correct explanation for the following.

3.1) Give any five differences between spontaneous Raman Scattering (RS) and Stimulated Raman Scattering (SRS) processes. [8 differences are mentioned in the ppt. You can give any five]

3.2) Explain why p-polarized light incident at an angle on the target can undergo resonance absorption, while s-polarized light cannot.

3.3) Explain a nonlinear process by which the frequency bandwidth of an intense laser pulse can be increased.

----- Wish you all the best -----

Syllabus: First 20 lectures (L-1 to L-20)

Examination Type: Off-line, Open Books/Handwritten notes (unlimited pages)

{No Laptops, No Cell phones, No printouts of lecture ppts}