國立清華大學命題紙

九十 學年度第二學期 電機工程 學系 博士班研究生資格考試

科目 光電子學 科號 共 2 頁第 1 頁 *請在試卷(答案卷)內作答

1. (14 points)

(a) A plane wave is incident upon a plate with the complex amplitude transmittance $\exp[\, j\, k_0 * n * d]$, where k_0, n and d are constants.

Is the output wave a plane wave, spherical wave, cylindrical wave, or other? Verify your answer. (6%)

(b) A plane wave is incident upon an inhomogeneous plate with the complex amplitude transmittance $\exp[\, j\, k_0 * (x^2+y^2) / f\,]$, where k_0 and f are constants.

Is the output wave a plane wave, spherical wave, cylindrical wave, or other ? Verify your answer. (8%)

2. (11 points)

Can any two optical beams interfere with each other to form a clear fringe pattern (a fringe pattern with a visibility of say, close to unity) ? Explain why? (11%)

3. (25 points)

Explain the following without using math formulas. No physics, no credit. For example, no credit will be given to the type of answers: "A is *m* and B is *n*" or "The increase of A causes the decrease of B". The correct answer should be "A is *m* and B is *n*, because ..." or "The increase of A causes the decrease of B, because ..."

i. (3 points) In a cylindrically symmetric system, the eigenmodes in a spherical-mirror resonator are expressed by the Laguerre-Gaussian polynomials. Explain why in practice the typical laser modes from a spherical-mirror resonator are Hermite Gaussian modes.

ii. (3 points) The eigenmodes of a spherical-mirror resonator consist of all orders of the Hermite-Gaussian modes and Laguerre-Gaussian modes. Explain why in practice most laser outputs have a TEM_{00} mode.

iii. (4 points) If you would like to focus a typical laser beam into a minimum spot size, what measures would you take? What would be the minimum waist size you can get?

iv. (3 points) From Maxwell's equations, prove that TEM_{nm} laser modes are not TEM waves.

v. (3 points) Explain why the refractive index in a typical dielectric is always larger than 1 at the optical frequencies.

vi. (3 points) If the dipoles of a dielectric respond to an electric field instantaneously, what would happen to the pulsewidth of a short laser pulse propagating in such a material? (This material has no memory. The dipole response of this dielectric does not depend on any electric-field excitation at prior time.)

vii. (3 points) Explain the relationships among the loss, the linewidth, and the photon lifetime of an optical resonant system.

viii. (3 points) The velocity of light in vacuum is 3×10^8m/s. If you would like to drastically reduce the velocity of light to, say, 10 m/s, what would you do?

4. (15 points)

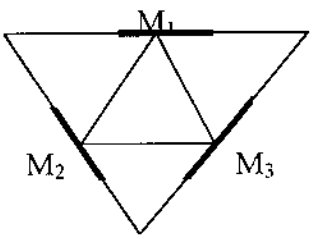
Consider the interface between two optical isotropic mediums with refractive index of n_1 and n_2, respectively. Where $n_1 > n_2$. (a) Construct the normal surfaces (k-surfaces) at the interface. (b) Light incident on the interface from medium n_1 to medium n_2 at an angle of incidence θ, determine the direction of the refracted light on your normal surface construction graphically. Show that the result is equivalent to Snell's law. (c) Determine the critical angle on your normal surfaces construction graphically.

5. (10 points)

Mr. Wang has a piece of quarter wave plate, and there is no indication whatsoever of orientation for the slow and fast axes. Can you determine the orientation of the axes for him? How?

6. (13 points)

As shown in the figure, a 3-mirror ring resonator with cavity length l is formed on a glass material with refractive index n. Each mirror reflection introduces a phase shift of π. Find the resonance frequencies and the free spectral range of the resonator.



7. (12 points)

The transition strength $S = \int \sigma(\nu) d\nu$ of a molecular gas with homogeneous broadening linewidth $\Delta\nu = 100$ MHz is $S = 2 \times 10^{-20}$ cm^2-Hz.

(1) Calculate the absorption cross section at line center, i.e. $\sigma(\nu_o)$. (7%)

(2) Find the absorption coefficient $\alpha(\nu_o)$ for a molecular concentration of $N = 10^{18}$ cm^{-3}. (5%)