國 立 清 華 大 學 命 題 紙

九十一 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

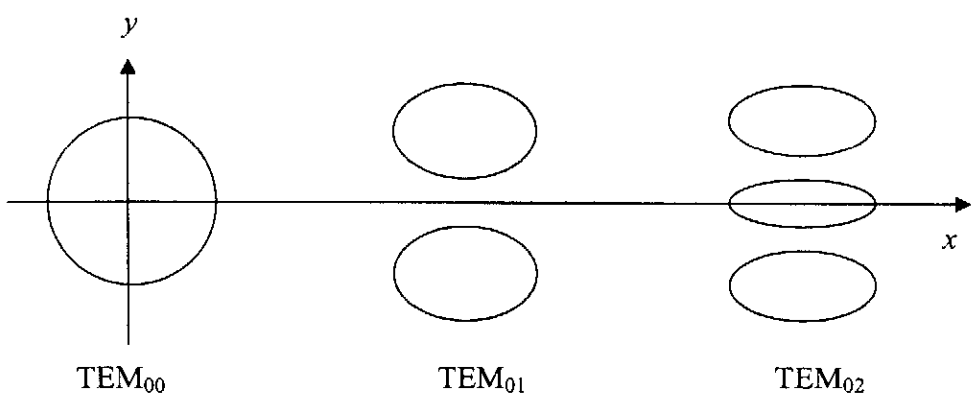
1. Consider a wave in the form $U(r) = a(r) \exp[- j k_0 S(r)]$, where a(r) is the amplitude, S(r) the phase and k_0 equal to $2\pi / \lambda_0$. Assume a(r) varies slowly over the distance λ_0. Prove the eikonal equation $| \nabla S |^2 = n^2$ in the limit $\lambda_0 \rightarrow 0$, where n is the refractive index. (12%)

2. Suppose an optical wave with a Gaussian envelope in time domain (i.e., an optical pulse with a Gaussian pulse shape) propagates through a medium, starting at z = 0
   (a) What is the pulse envelope at z = L if the medium is non-dispersive. (5%)
   (b) Compute the pulse envelope at z = L if the medium is dispersive.[You may solve the wave equation $\partial^2 \boldsymbol{E} / \partial z^2 = (1/c^2) \partial^2 \boldsymbol{E} / \partial t^2$ with $\boldsymbol{E} = E(z,t) \exp[j(\omega_0 - k_0 z)]$ while considering paraxial approximation. Here E(z,t) represents the pulse envelope. Note that you don't need to derive the answer in an explicit form, but **only need to describe how you get the answer.**] (8 %)

3. For a TEM_{00} Hermite Gaussian laser beam in vacuum, prove that the phase velocity along the laser axis, *z*, is always larger than the velocity of light in vacuum, 3×10^8 m/sec. (5%)

4. For a TEM_{00} Hermite Gaussian laser beam in vacuum propagating in the *z* direction, find the radius of the beam at $z = z_0$ at which the phase velocity of the electromagnetic wave is equal to the velocity of light in vacuum, 3×10^8 m/sec.(5%)

5. The following is the conceptual plot of the intensity distributions of the TEM_{00}, TEM_{01}, and TEM_{02} Hermite Gaussian beams. The laser beams propagate along the *z* direction.



(a) Argue from Maxwell's equations that there must be z component electric field in a Hermite Gaussian beam with a finite beam cross section.(5%)

(b) Determine which of the three modes, TEM_{00}, TEM_{01}, and TEM_{02} has the strongest axial electric field, E_z ? (5%)

6. Explain the physical origin of dispersion in an optical material.(5%)

7. Describe in detail the basic working principle of wave retarder (or wave plate as commonly called). (5%)

8. Two linear polarizers are placed on top of each other and in front of a uniaxial crystal, an object is placed behind the crystal. Describe in detail the image of the object when you view in front of the polarizers if (i) two polarizers are crossed to each other (ii) when one polarizer is removed (iii) when the other polarizer is removed (iv) when both polarizers are absent. (10%)

9. It is possible to split a laser beam into two linearly polarized beams by sending it through a single piece of uniaxial optical crystal plate at normal angle of incidence, how would the optical axis of the crystal oriented? Explain in detail. (10%)

10. An optical resonator is formed by two mirrors with radius of curvature R_1, R_2 and separation d.

(a) Write the expression of resonant frequencies $\nu_{q,l,m}$ for longitudinal and transverse mode index (q,l,m) . (7%)

(b) If $R_1=R_2=d$, that is, symmetric confocal resonator, sketch the positions of (q,l,m) modes on the frequency axis. (6%)

11. Write the lineshape function for a lifetime broadening transition with FWHM linewidth $\Delta\nu$. (6%)

12. A light source was found to have a Gaussian spectrum with center frequency ν_o and FWHM linewidth $\Delta\nu$. Write its lineshape function. (6%)