國立清華大學命題紙

一百學年度第二學期 光電工程研究所 博士班研究生資格考試

科目 光電子學一 共 3 頁第 1 頁 ＊請在試卷(答案卷)內作答

1. Consider the ABCD matrix for an optical system:

(a) (6%) If matrix element A=0, what is the special characteristic of this system? Draw a simple picture showing the relationship between input and output rays along with your description.

(b) (4%) Now what happens when B=0?

2. A white light source is filtered with a monochromator and sent into a Michelson interferometer. The transmission of the monochromator $T(\lambda)$ is

$$T(\lambda)=\begin{cases}1, & (\lambda_0-\frac{1}{2}\delta\lambda)<\lambda<(\lambda_0+\frac{1}{2}\delta\lambda)\\ 0, & otherwise\end{cases}$$

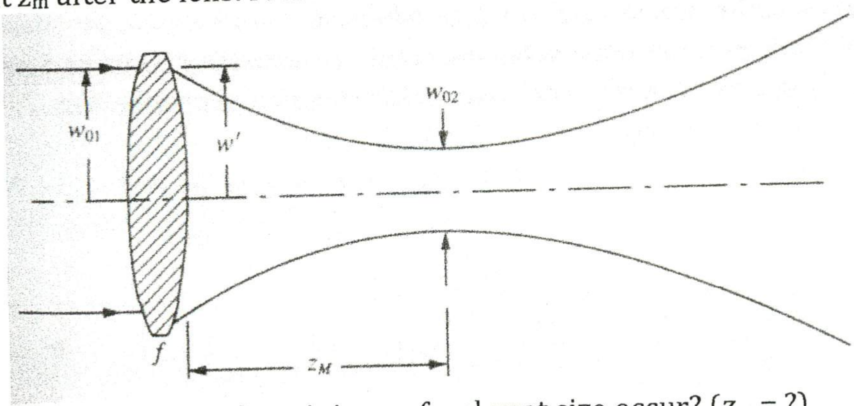
with a width of $\delta\lambda = 0.1$ nm centered at λ_0=795nm.

(a) (4%) Please find the transmission function $T(\omega)$ of the monochromator in terms of the optical frequency ω, and find its width $\delta\omega$.

(b) (5%) Please find the interference intensity $I(x)$ at the output of the interferometer as a function of the path length difference x (consider monochromatic wave).

(c) (6%) A white light source, which is filtered with a monochromator with transmission function $T(\lambda)$ defined above, is sent to the interferometer. Please find the interference intensity $I(x)$ at the output of the interferometer as a function of the path length difference x.

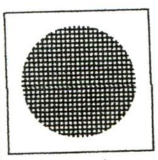
3. (10 %) The figure below shows the focusing of a Gaussian beam by a lens with a focal length f, where w_{01} is the spot size right before the lens and w_{02} is the minimum focal spot size achieved at z_m after the lens. Please calculate the following in terms of f, w_{01}, and l_0.



(a) Where does the minimum focal spot size occur? (z_m = ?)

(b) What is the minimum spot size at the focus? (w_{02} = ?)

4. (a) (7%) A transparency slide, as shown in the left figure, is placed at the object plane of a 4-f imaging system, and a spatial filter, as shown in the right figure, is placed at the Fourier plane. Sketch the diffraction pattern at the image plane qualitatively. Explain your answer in detail.

(b) (8%) Explain the basic design principles for the safety grid on a micro-wave oven door.

5. (a) (2%)Derive the dispersion relation, i.e., how ω (temporal frequency) is related to β (spatial

frequency), from the Maxwell equation in free space as shown below.

$$\nabla^2\Psi - \frac{1}{c^2}\frac{\partial^2\Psi}{\partial t^2} = 0$$

(b) (2%)Do the same for a Schrodinger-like equation as shown below.

$$\nabla^2\Psi - \frac{1}{ic}\frac{\partial\Psi}{\partial t} = 0$$

(c) (3%)Explain, when given a spatially localized wavepacket, which of the above two equations is diffusive or diffusionless and why. Note that diffusion refers to the fact that a spatially localized wavepacket will expand as a function of time.

(d) (5%) Consider a metallic slab waveguide with thickness d as shown below, and derive its dispersion relation. (3%) Under what condition the derived dispersion relation becomes diffusive or diffusionless?

6. (10%) A Wollaston prism (WP) is made of two cemented uniaxial crystals A, B with the same ordinary and extraordinary indices n_0, n_e but orthogonal optic axes (Figure 1). Explain what will happen at the output when an elliptically polarized light is normally incident on such a WP. Justify your answer.

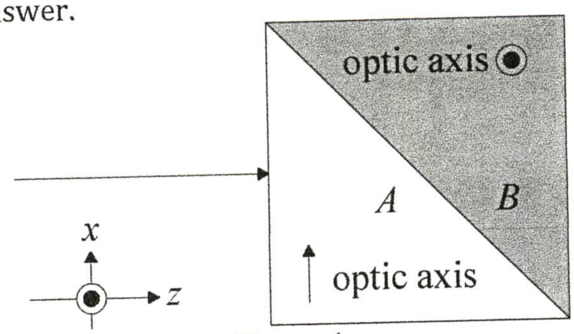


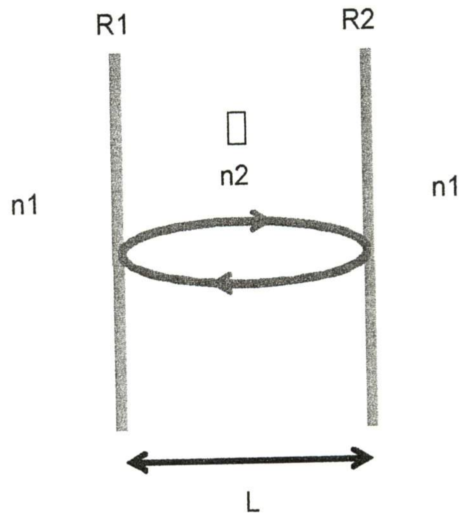
Figure 1.

7. Consider electromagnetic waves resonating inside a Fabry-Perot cavity as shown in the figure below. R1 and R2 are the reflectivity at the two end of the cavity. a is the attenuation coefficient and n1, n2 are the refractive indices.

(1) (5%) What is the finess?

(2) (5%) What is the photon life time?

(3) (5%) What is the quality factor?



8. (a) (5%) Show that the ***power spectral density***, $S(\nu)$, defined as $S(\nu) \equiv \lim_{T\to\infty}\frac{1}{T} < |V_T(\nu)|^2 >$, is the Fourier transform of the autocorrelation function, $G(\tau)$, i.e.

$$S(\nu) = \int_{-\infty}^{\infty} G(\tau)\exp(-j2\pi\nu\tau)\, d\tau,$$

where $V_T(\nu) = \int_{-T/2}^{T/2} U(t)\exp(-j2\pi\nu t)\, dt$, and $G(\tau) = \lim_{t\to\infty} \frac{1}{2T}\int_{-T}^{T} U^*(t)\; U(t+\tau)\; dt$.

(b) (5%) The ***mutual intensity*** of an optical wave at points on the x axis is given by

$$G(x_1, x_2) = I_0 \exp[-\frac{(x_1^2 + x_2^2)}{W_0^2}]\exp[-\frac{(x_1 - x_2)^2}{\rho_c^2}],$$

where I_0, W_0, and ρ_C are constants. Derive an expression for the normalized mutual intensity $g(x_1, x_2)$ and sketch it as a function of $x_1 - x_2$. What is the physical meaning of the parameters I_0, W_0, and ρ_C?