Θεμα 1

(α)

$$\begin{pmatrix} A & B \\ C & D \end{pmatrix} = \begin{pmatrix} \frac{2}{n} - 1 & \frac{2R}{n} \\ \frac{2(1-n)}{nR} & \frac{2}{n} - 1 \end{pmatrix}$$

$$f_2 = -\frac{1}{C} = \frac{1}{2}\frac{n}{n-1}R$$

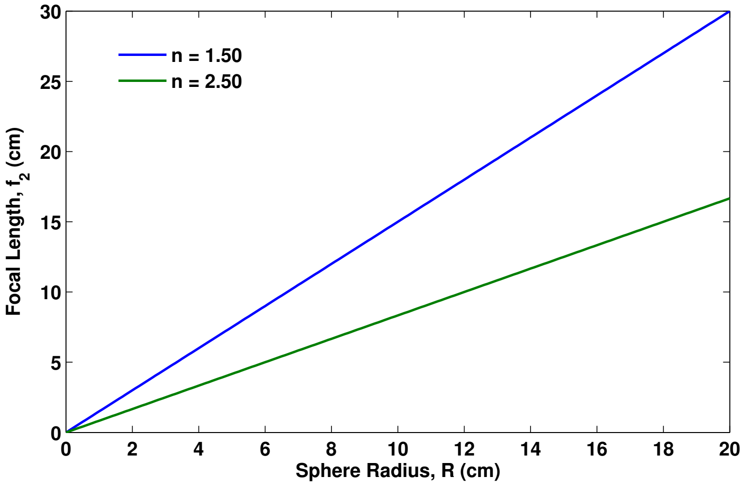

Figure 1: Focal length of the dielectric sphere as a function of the sphere radius for two refractive indices $n = 1.50$ and $n = 2.50$.

(β)

$$\begin{aligned} r = v &= \frac{D-1}{C} = R = +10.0\,cm \\ s = w &= \frac{1-A}{C} = -R = -10.0\,cm \\ p &= \frac{D}{C} = \frac{R(2-n)}{2(1-n)} = -5.0\,cm \\ q &= -\frac{A}{C} = -\frac{R(2-n)}{2(1-n)} = +5.0\,cm \\ f_1 &= \frac{1}{C} = -15.0\,cm \\ f_2 &= -\frac{1}{C} = +15.0\,cm \end{aligned}$$

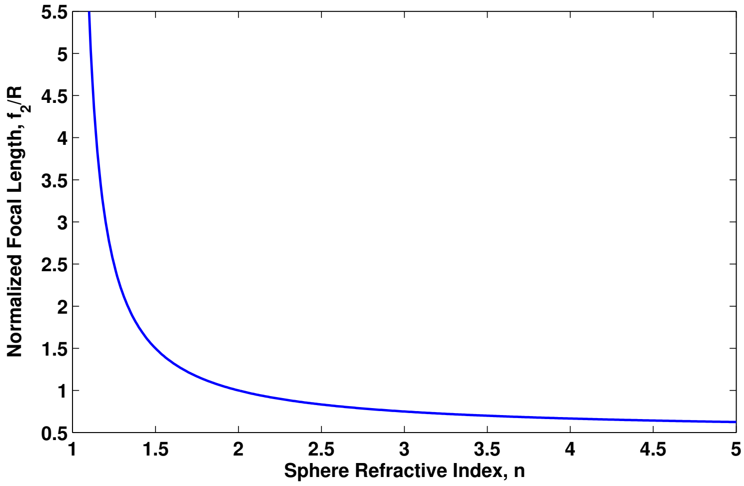

Figure 2: Normalized Focal length (f_2/R) of the dielectric sphere as a function of the refractive index $(1 < n \leq 5)$

Note: The principal and nodal points H_1, H_2, N_1, and N_2 all coincide with the center of the sphere.

(γ)

$$B_{eq} = 0 \longrightarrow x = 16.25\,cm \qquad \text{real image, inverted} \quad A_{eq} = m = -0.75$$

(δ)

$$s = 35.0\,cm \qquad s' = 26.25\,cm, \quad \text{and} m = -\frac{s'}{s} = -0.75$$

$\Theta\epsilon\mu\alpha \quad 2$

(α)

$$\begin{aligned}
\text{Shortest Distance} &= z_n = 172.4138\,cm, \\
\text{Longest Distance} &= z_f = 238.0952\,cm, \\
\text{Depth of Field} &= DoF = 65.6814\,cm, \\
\text{For } s = H &= \frac{f^2}{c}\frac{1}{fnumber} = 1250\,cm, \\
& \quad z_n = 625\,cm, \quad \text{and} \quad z_f = \infty.
\end{aligned}$$

(β)

$$\text{Shortest Distance} = z_n = 189.3939\,cm,$$

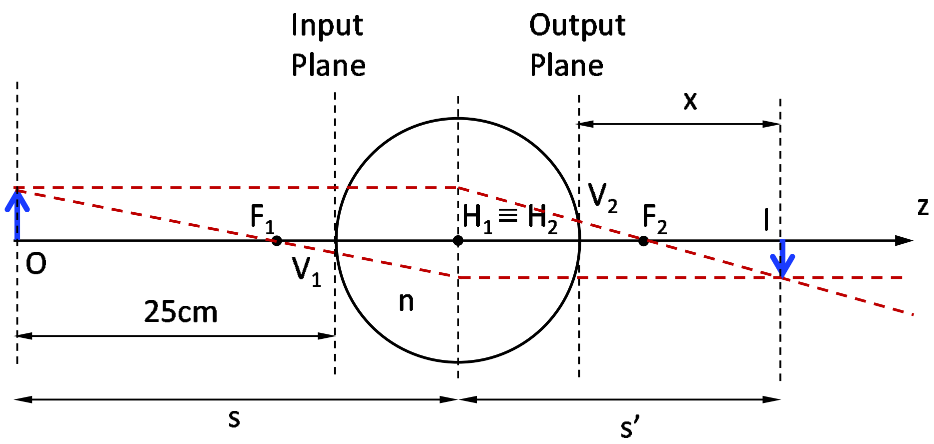

Figure 3: Ray diagram using the cardinal points of the dielectric (glass) sphere.

$$\begin{aligned}\text{Longest Distance} &= z_f = 211.8644\,cm, \\ \text{Depth of Field} &= DoF = 22.4705\,cm, \\ \text{For } s = H &= \frac{f^2}{c}\frac{1}{fnumber} = 3571.4\,cm, \\ & z_n = 1785.7\,cm, \quad \text{and} \quad z_f = \infty.\end{aligned}$$

$\underline{\Theta\epsilon\mu\alpha \;\; 3}$

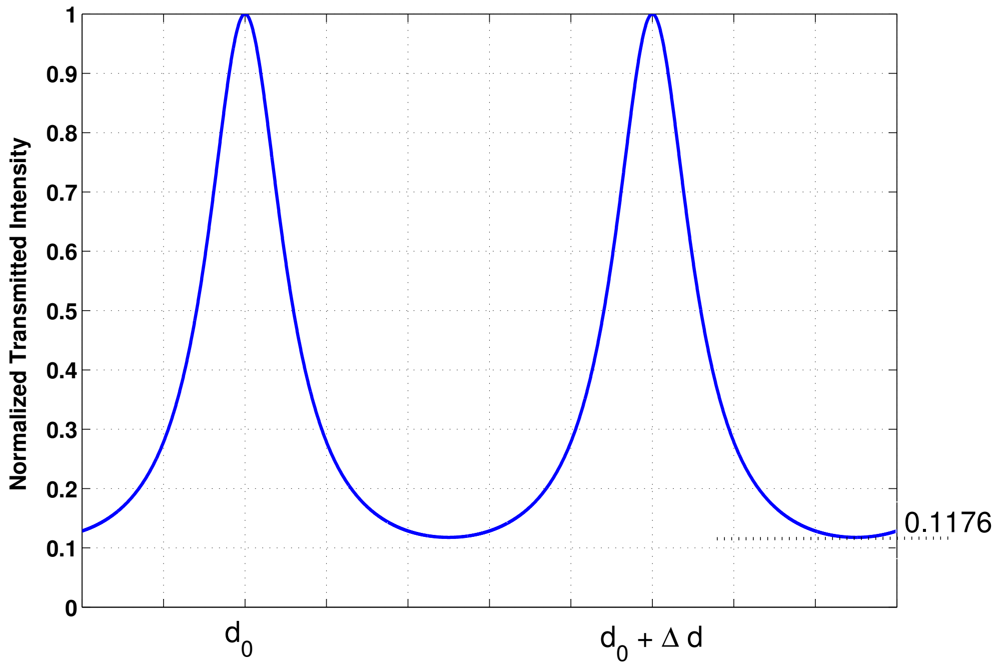

Figure 4: Normalized Transmittance of Fabry-Perot as a function of its thickness d_0.

(α)

$$\Delta d = \frac{\lambda_0}{2} = 0.3164\,\mu m.$$

(β)

$$\Delta\nu_{FSR} = 15 \times 10^9\,Hz = 15\,GHz$$
$$\Delta\lambda_{FSR} = 0.20021792 \times 10^{-10}\,m = 0.20021792\,\text{Å}.$$

(γ)

$$m_{max} \simeq 31605.$$

(δ)

$$F = 7.5034,$$
$$R = r^2 = 0.4892825.$$

(ϵ)

$$\Delta\lambda_{min} = 4.6533 \times 10^{-12}\, m = 4.6533 \times 10^{-2} \text{Å},$$
$$\mathcal{R} = 1.35989 \times 10^{5}.$$

<u>$\Theta\epsilon\mu\alpha$ 4</u>

(α)

$$I(x) = I_0 \frac{\sin^2\left[k\frac{s}{2}\frac{x}{L}\right]}{\left[k\frac{s}{2}\frac{x}{L}\right]^2} \frac{\sin^2\left[4k\frac{d}{2}\frac{x}{L}\right]}{\sin^2\left[k\frac{d}{2}\frac{x}{L}\right]}$$

$$\begin{aligned}
\text{diffraction} &: \quad x_{min} = m\lambda_0\frac{L}{s} \quad m \in Z, m \neq 0 \\
\text{interference(main peaks)} &: \quad x_{max} = m'\lambda_0\frac{L}{d} \quad m' \in Z \\
\text{interference} &: \quad x_{min} = \frac{m_1}{4}\lambda_0\frac{L}{d} \quad m_1 \in Z \quad \text{and} \quad m_1 \neq 4m'
\end{aligned}$$

(β)

$$\begin{aligned}
\text{diffraction nulls} &: \quad x_m = m\lambda_0 100000\,(\mu m) = m10\,(cm), \quad m \in Z, m \neq 0 \\
\text{interference nulls} &: \quad x_{m'} = m'\lambda_0\frac{500000}{60}\,(\mu m) = m'\frac{5}{6}\,(cm), \quad m' \in Z \quad \text{and} \quad m' \neq 4m \\
\text{1st main peak} &: \quad I/I_0 = 16, \\
\text{2nd main peak} &: \quad I/I_0 = 16 \times 0.6839, \\
\text{3rd main peak} &: \quad I/I_0 = 16 \times 0.1710, \\
\text{zero of fifth main peak} &: \quad \frac{s}{d} = \frac{1}{5}.
\end{aligned}$$

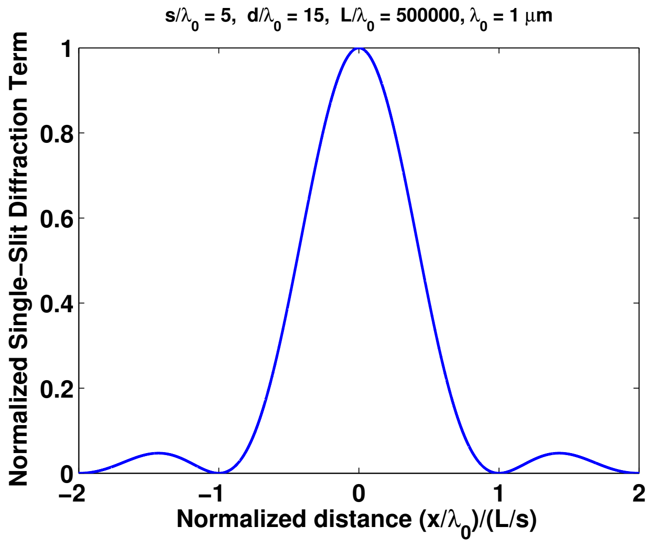

Figure 5: Normalized single-slit diffraction term as a function of the normalized distance $(x/\lambda_0)/(L/s)$.

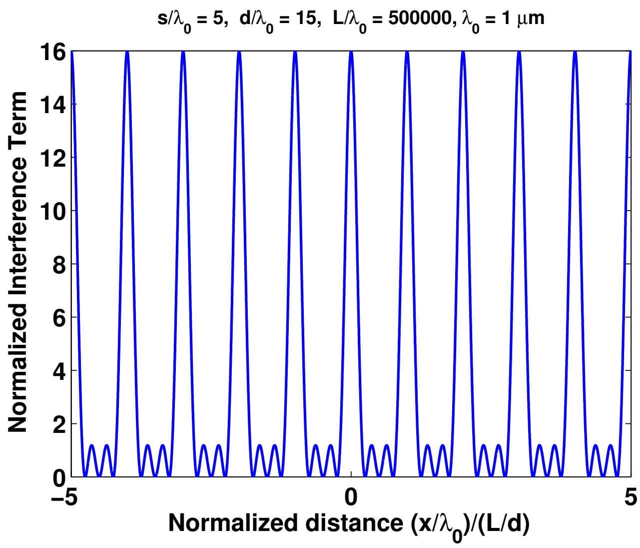

Figure 6: Normalized 4-slit interference term as a function of the normalized distance $(x/\lambda_0)/(L/d)$.

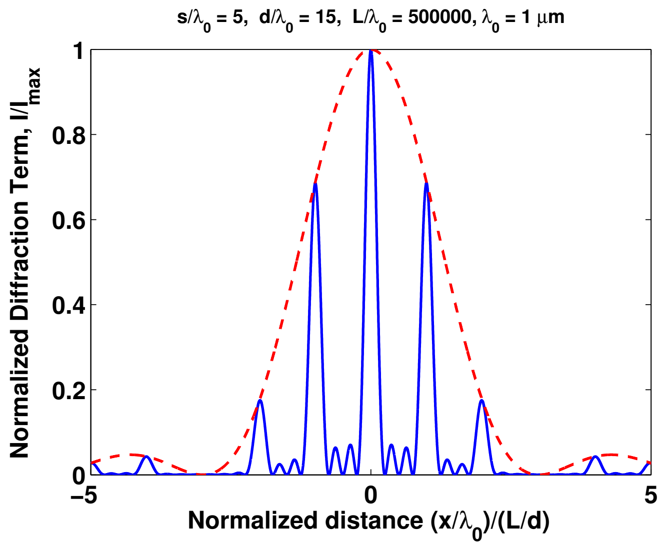

Figure 7: Normalized combined diffraction-interference term as a function of the normalized distance $(x/\lambda_0)/(L/d)$.

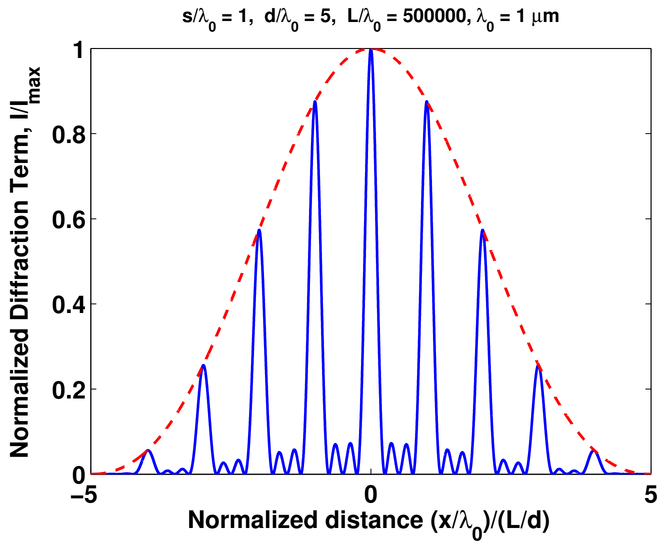

Figure 8: Normalized combined diffraction-interference term as a function of the normalized distance $(x/\lambda_0)/(L/d)$ for $\lambda_0 = 1\,\mu$m, $s = \lambda_0$, $d = 5\lambda_0$, and $L = 500000\lambda_0$. It is obvious that the fifth main maximum is zeroed due to the $s/d = 1/5$.