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Sheet 7

P19)

a) From the Q-switch master equation we obtain the transcendent relation

$$r = -\frac{\ln(1-\eta_e)}{\eta_e}$$

Inserting $\eta_e = 0.94$ results in $r = -\frac{\ln 0.06}{0.94} = 2.993 \approx \underline{\underline{3}}$.

b) $$\tau_c = -\frac{2L}{c\ln[R_{oc}(1-\Lambda)]} = -\frac{2\cdot 250\,mm}{3\cdot 10^8 \frac{m}{s} \ln(0.85\cdot 0.98)} = \underline{\underline{9.12\,ns}}$$

the approximative Q-switch pulse width is given by

$$\Delta t_p = \frac{r\,\eta_e(r)}{r-1-\ln r}\cdot \tau_c = \frac{3\cdot 0.94}{2-\ln 3}\cdot 9.12\,ns \approx \underline{\underline{28.5\,ns}}$$

c) $$G = \frac{1}{\sqrt{R_{oc}(1-\Lambda)}} = 1.097$$

$$\Rightarrow g_{th} = \frac{\ln G}{L} = \frac{\ln 1.097}{0.25\,m} = 0.37\,m^{-1}$$

$$\Rightarrow g_i = r\cdot g_{th} = \underline{\underline{1.111\,m^{-1}}}$$

as $g_i = \frac{1}{2}\left[(\sigma_a+\sigma_e)\langle\Delta N\rangle_i - (\sigma_a-\sigma_e)\langle N\rangle\right]$ we find

$$\frac{2g_i}{\sigma_a+\sigma_e} = \langle\Delta N\rangle_i - \frac{\sigma_a-\sigma_e}{\sigma_a+\sigma_e}\langle N\rangle = \langle\Delta N\rangle_i' = 9.01\cdot 10^{23}\,m^{-3}$$

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From the extraction efficiency we have

$$\eta_e = 1 - \frac{\langle \Delta N \rangle_f'}{\langle \Delta N \rangle_i'}$$

$$\Rightarrow \quad \langle \Delta N \rangle_f' = 0.06 \cdot \langle \Delta N \rangle_i' = 5.404 \cdot 10^{22}\, m^{-3}$$

$$\Rightarrow \quad \langle \Delta N \rangle_f = \langle \Delta N \rangle_f' + \frac{\sigma_a - \sigma_e}{\sigma_a + \sigma_e} \langle N \rangle = \underline{\underline{-1.21 \cdot 10^{26}\, m^{-3}}}$$

$\Rightarrow$

$$\langle N_2 \rangle_f = \frac{\langle N \rangle + \langle \Delta N \rangle_f}{2} = 8.5 \cdot 10^{24}\, m^{-3}$$

$$\langle N_1 \rangle_f = \frac{\langle N \rangle - \langle \Delta N \rangle_f}{2} = \underline{\underline{1,285 \cdot 10^{26}\, m^{-3}}}$$

P 20

a) The sound frequency is 50 MHz

$$\Rightarrow \quad \lambda_a = \frac{v_a}{\nu_a} = \frac{3700\ m/s}{50\ MHz} = 75.2\ \mu m$$

$$\frac{\lambda_s \cdot L_m}{\lambda_a^2} = \frac{1064\ nm \times 50\ mm}{(75.2\ \mu m)^2} = 9.4$$

$\Rightarrow \quad \lambda_s L_m \gg \lambda_a^2$: The modulator operates in the Bragg regime.

b) $$\sin\Theta_B = \frac{\lambda_s}{2n\lambda_a} \Rightarrow \Theta_B = \arcsin\frac{\lambda_s}{2n\lambda_a} = \underline{\underline{0.28^\circ}}$$

The external diffraction angle is

$$\Theta' = 2n\Theta_B = \underline{\underline{0.81^\circ}}$$

c) $$\Delta\phi = \pi \cdot \sqrt{\frac{2L_m}{\lambda_s^2} M_2 \cdot \frac{P_a}{b}} = \pi \cdot \sqrt{\frac{2.50\,mm}{(1064\,nm)^2} \cdot 0.47 \cdot 10^{-15} \frac{s^3}{kg} \cdot \frac{30W}{5mm}}$$

$$= 1.568$$

$$\Rightarrow \quad \eta_d = \frac{I_1}{I_0} = \sin^2\left(\frac{\Delta\phi}{2}\right) = \underline{\underline{50\%}}$$

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P21

a) The total refractive index difference is

$$\Delta n = n_o^3 r_{63} E_z$$

resulting in an optical path length difference of

$$\Delta l = \Delta n \cdot L_m$$

$\Rightarrow$ phase difference $\delta = 2\pi \cdot \frac{\Delta l}{\lambda} = \frac{2\pi}{\lambda} \cdot n_o^3 r_{63} \underbrace{E_z \cdot L_m}_{U_z}$

$$= \frac{2\pi}{\lambda} \cdot n_o^3 r_{63} U_z$$

qed.

b) To obtain circular output polarization, we need

$$\delta = \frac{\pi}{2}$$

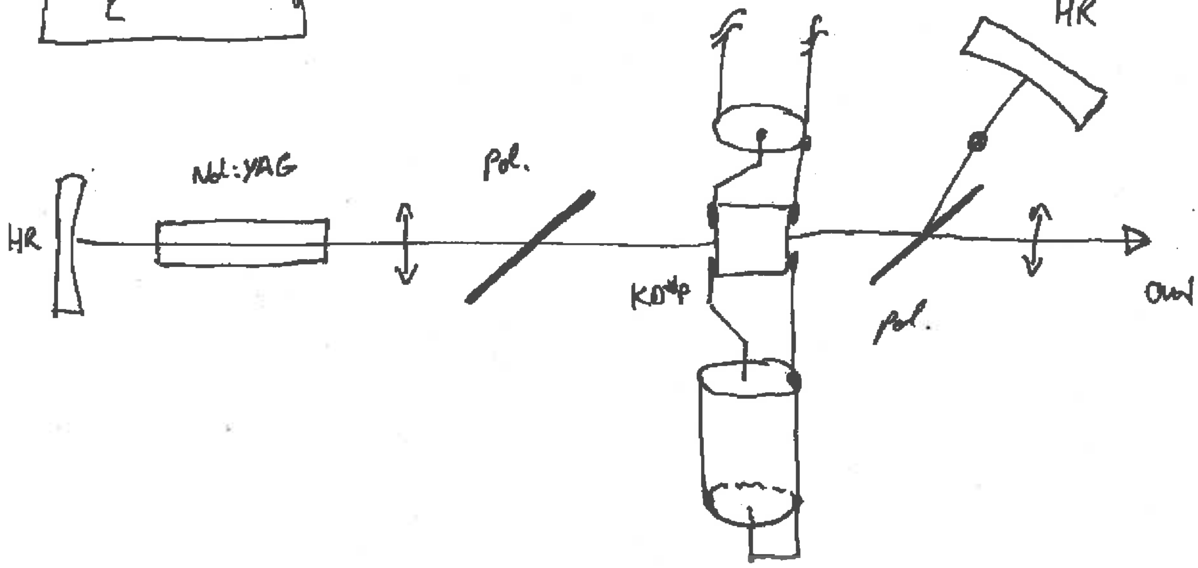
$\Rightarrow \frac{\pi}{2} = \frac{2\pi}{\lambda} n_o^3 r_{63} U_{\frac{\lambda}{4}} \Rightarrow U_{\frac{\lambda}{4}} = \frac{\lambda}{4 n_o^3 r_{63}}$

To rotate the polarization by 90°, we need

$\delta = \pi \Rightarrow U_{\frac{\lambda}{2}} = \frac{\lambda}{2 n_o^3 r_{63}}$ qed.

c) $U_{\frac{\lambda}{2}} = \frac{\lambda_s}{2 n_o^3 r_{63}} = \underline{\underline{5.97\ kV}}$

$\boxed{U_{\frac{\lambda}{2}} - \text{setup.}}$



or $\boxed{U_{\frac{\lambda}{4}} - \text{setup.}}$