perpendicularly to the beam path into one of the two arms without changing the optical alignment. What are the output intensities $I_{\text{out},1}$ and $I_{\text{out},2}$ now?

5.1.9 A waveguide Mach–Zehnder interferometer uses Y-junction couplers for its input and output ports, as shown in Fig. 5.9(a). It has a symmetric structure with an equal length of $l_a = l_b = l$ for the two arms. The two Y-junctions are both 3-dB couplers. Thus, $\Delta\varphi = 0$, and the transmittance is $T = 1$. By changing the refractive index of the medium in one arm with respect to the other through the Pockels effect, for example, the phase shifts through the two arms can be made different for $\Delta\varphi \neq 0$ so that $T \neq 1$. Find the minimum necessary index difference Δn between the two arms for $T = 0$ at an optical wavelength of λ. At $\lambda = 1$ μm, what is the minimum value of Δn for an equal arm length of $l = 1$ mm? If the Mach–Zehnder interferometer has a symmetric structure with $l_a = l_b = l$ using two 3-dB directional couplers, as shown in Fig. 5.9(b), the transmittance is $T = 0$ with $\Delta\varphi = 0$. Then, what is the minimum necessary index difference Δn between the two arms for $T = 1$ at an optical wavelength of λ? At $\lambda = 1$ μm, what is the minimum value of Δn for an equal arm length of $l = 1$ mm?

5.2.1 Identical slits in an array are equally spaced at $\Lambda = 20$ μm. A plane wave at the $\lambda = 532$ nm wavelength is normally incident on the slits. How many diffraction peaks can be found in transmission within the range of angles between $-30°$ and $30°$? If the wave is obliquely incident at an angle of $\theta_\text{i} = -15°$, how many diffraction peaks can be found in transmission within the range of angles between $-30°$ and $30°$?

5.2.2 Three perfectly aligned plane optical waves at $\lambda_1 = 450$ nm, $\lambda_2 = 550$ nm, and $\lambda_3 = 650$ nm are normally incident at the same time on an array of identical slits that are equally spaced at Λ. The diffraction peaks in transmission are examined. It is clear that the zeroth-order peaks for all three wavelengths completely overlap at $\theta_q = 0°$ for $q_1 = q_2 = q_3 = 0$.

(a) What are the lowest nonzero diffraction orders q_1 and q_2 for λ_1 and λ_2, respectively, that have exactly overlapped peaks? What is the minimum slit spacing Λ for this to be possible?

(b) Answer the questions in (a) for λ_2 and λ_3.

(c) Answer the questions in (a) for λ_1 and λ_3.

(d) What are the nonzero diffraction orders q_1, q_2, q_3 for λ_1, λ_2, λ_3, respectively, that have exactly overlapped peaks? What is the smallest slit spacing Λ for this to be possible?

5.2.3 A grating on the surface of a glass plate has a period of $\Lambda = 800$ nm. The glass plate has a refractive index of 1.5. A laser beam is normally incident on the grating from the air. Only two nonzero diffraction orders, for $q = -1$ and $q = 1$, are allowed on the glass side, but no nonzero diffraction orders are allowed on the air side. What is the possible wavelength of the incident laser light?

5.2.4 A collimated laser beam at $\lambda = 800$ nm is incident on a grating at an air–glass interface from the air side. The refractive index of this glass is 1.5. At normal incidence, three diffraction peaks for $q = -1$, 0, and 1 are found on the glass side. By carefully varying the incident angle of the laser beam, it is found that the $q = 1$ diffraction peak just disappears when the incident angle is $\theta_\text{i} = 12.1°$. Find the grating period. How many