21. 波动光学(一)

1. ?

$n_1 < n_2 > n_3$, $\Delta_0 = \frac{\lambda_0}{2}$, λ_0: 真空中波长

$\Delta_r = 2n_2 d + \Delta_0 = 2n_2 e + \frac{\lambda_0}{2}$,

n_1 介质中: $\lambda = \frac{\lambda_0}{n_1} \Rightarrow \lambda_0 = n_1 \lambda$

$\Rightarrow \Delta_r = 2n_2 e + \frac{n_1 \lambda_1}{2}$

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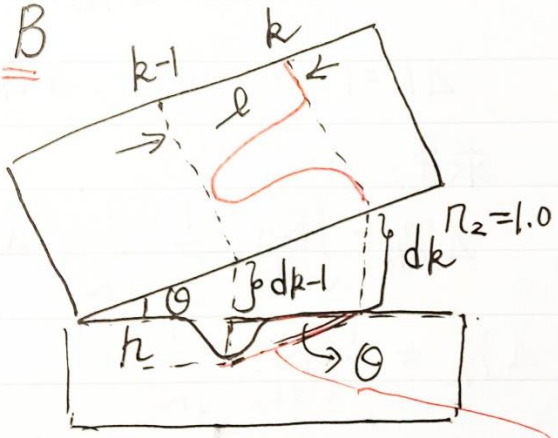
2. B



$l \sin\theta = \frac{\lambda}{2n_2} = \frac{\lambda}{2}$

$l \sin\theta = h$

$\Rightarrow h = \frac{\lambda}{2}$

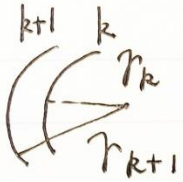
3. A

$$\Delta x = \frac{d'\lambda}{d} = \frac{1.2\,m \times 500\,nm}{0.5\,mm} = 1.2\,mm$$

4. C

① 中心：$d=0$，$\Delta_r = 2n_2 d + \frac{\lambda}{2} = \frac{\lambda}{2}$，暗，不变.

② 间距：以暗环为例：



暗环半径：$r_k = \sqrt{\frac{kR\lambda}{n_2}}$

$\Delta k = 1$，$\Rightarrow$ 间距：Δr_k

求导：

$$\Delta r_k = \sqrt{\frac{R\lambda}{n_2}} \cdot \frac{1}{2} \frac{1}{\sqrt{k}} \cdot \Delta k$$

$$\Delta k = 1,\ \Delta r_k = \frac{1}{2}\sqrt{\frac{R\lambda}{n_2}} \cdot \frac{1}{\sqrt{k}}$$

空气中：$n_2 = 1$，$\Delta r_k = \frac{1}{2}\sqrt{R\lambda} \cdot \frac{1}{\sqrt{k}}$

水中：$n_2 > 1$，$\Delta r_k' = \frac{1}{2}\sqrt{\frac{R\lambda}{n_2}} \cdot \frac{1}{\sqrt{k}}$

$\Rightarrow \Delta r_k' < \Delta r_k$

5. $d = N\cdot\frac{\lambda}{2} \Rightarrow \lambda = 500\,nm$

6. $n_小$, $n_大$, π (或 $(2k+1)\pi$)

9. $l\sin\theta = \frac{\lambda}{2n_2}$, $\sin\theta \approx \theta$, $n_2 = 1.0$

$\Rightarrow l\cdot\theta = \frac{\lambda}{2} \Rightarrow l = \frac{\lambda}{2\theta}$

$l = \frac{600\times10^{-9}}{2\times2\times10^{-4}} = 1.5\times10^{-3}\ m = 1.5\ mm$

$l' = l - \Delta l = 0.5\ mm$

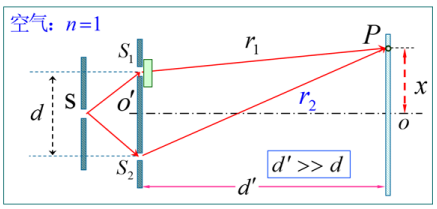
$\theta' = \frac{\lambda}{2l'} = \frac{600\times10^{-9}}{2\times0.5\times10^{-3}} = 6\times10^{-4}\ rad$

$\Delta\theta = \theta' - \theta = 4\times10^{-4}\ rad$.

7、

解：1) 光程差：$\Delta = (\overline{SS_2} + r_2) - [(\overline{SS_1} + r_1 - e) + ne]$

$\Delta = (r_2 - r_1) + (1-n)e \approx d\frac{x}{d'} + (1-n)e$



明条纹：$\Delta = \pm 2k\frac{\lambda}{2},\ k = 0, 1, 2, \cdots$

0级明纹：$k = 0,\ \Delta = 0,\ x_0,\ d\frac{x_0}{d'} + (1-n)e = 0,\ \Rightarrow x_0 = (n-1)e\frac{d'}{d} > 0,$

条纹上移

2） 第7级明纹：

$k = 7,\quad x_7 = 0,$

$0 + (1-n)e = -7\lambda$

玻璃薄片折射率：

$n = 1 + \frac{7\lambda}{e} = 1.58$

8、

解：　反射光：$\Delta_r = 2n_2 d + \Delta_0 = 2n_2 e + \dfrac{\lambda}{2}$

干涉加强（明）：$\Delta_r = 2k\dfrac{\lambda}{2},\ k = 1, 2, \cdots$

$$\lambda = \frac{4n_2 e}{2k-1} = \frac{2128\text{nm}}{2k-1},\quad k = 1, 2, \cdots$$

$k = 1,\quad \lambda = 2128\text{nm}$ ✗

$k = 2,\quad \lambda = 709\text{nm}$ ✓

$k = 3,\quad \lambda = 425.6\text{nm}$ ✓

$k = 4,\quad \lambda = 304\text{nm}$ ✗

10、

解：　暗环半径：$r_k = \sqrt{\dfrac{kR\lambda}{n_2}} = \sqrt{kR\lambda}$

$r_k = \sqrt{kR\lambda}$，　$r_{k+15} = \sqrt{(k+15)R\lambda}$，

$$\Rightarrow r_{k+5}^2 - r_k^2 = 15R\lambda \Rightarrow \lambda = \frac{r_{k+15}^2 - r_k^2}{15R} = 400\text{nm}$$

22. 波动光学(二)

1. C.

$$N = \frac{b\sin\theta}{\frac{\lambda}{2}} = \frac{4\lambda \times \sin 30°}{\frac{\lambda}{2}} = 4$$

2. B.

$$-\frac{d}{\lambda} < k < +\frac{d}{\lambda} \Rightarrow -3.3 < k < 3.3$$

$$k_{max} = 3$$

3. A

2级缺, $\frac{b+b'}{b} = 2$

4. D.

5. 明: $N = \frac{b\sin\theta}{\frac{\lambda}{2}} = 2k$, $k = 1, 2, \cdots$

① $k = 2$, $N = \frac{b\sin\theta}{\frac{\lambda}{2}} = 2 \times 2 = 4$

② $b_2 = \frac{1}{2}b$, $N' = \frac{\frac{1}{2}b\sin\theta}{\frac{\lambda}{2}} = \frac{1}{2}N = 2$

$k' = 1$, 1级明.

6. 不要求. (布拉格公式: $2d\sin\theta = k\lambda$)

7. 1) 单缝：明：$b\sin\theta = (2k+1)\cdot\frac{\lambda}{2}$

$\tan\theta = \frac{x}{f}$，θ 很小

$\Rightarrow x_k = (2k+1)\cdot\frac{f\lambda}{2b}$

$\Delta x = x_3 - x_2 = \frac{f\lambda}{b} = 1.25\times10^{-3}\ mm$

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2) 光栅：主极大：$d\sin\theta = (b+b')\sin\theta = k\lambda$

$k=2$，$\sin\theta_2 = \frac{2\lambda}{b+b'} = 5\times10^{-2}$ ↑ 很小 $\rightarrow \theta_2 \approx 0.05$

$\tan\theta_2 = \frac{x_2}{f}$

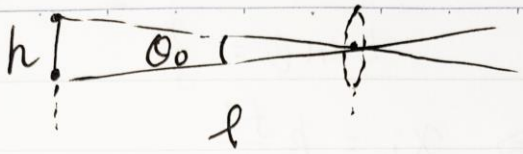
$x_2 = f\tan\theta_2 \approx f\sin\theta_2 = 2.5\ cm$

$k=3$，$\sin\theta_3 = \frac{3\lambda}{b+b'} = 0.075$ ↑ 很小

$x_3 = f\tan\theta_3 \approx f\sin\theta_3 = 3.75cm$

$\Delta x = x_3 - x_2 = 1.25cm$

8.



$$\theta_0 = 1.22\frac{\lambda}{D}$$

$$\frac{h}{\ell} \geq \theta_0 = 1.22\frac{\lambda}{D},\quad h \geq 1.22\frac{\ell\lambda}{D} = 1.21\,m$$

9. 光栅方程：$d\sin\theta = k\lambda$，

1) λ_1，$k_1 = 3$，$d\sin\theta_3 = 3\lambda_1$

$$\Rightarrow d = \frac{3\lambda_1}{\sin 30^\circ} = 3.36\times10^{-6}\,m$$

2). λ_2，$k_2 = 4$，$d\sin\theta_4 = 4\lambda_2$

$$\Rightarrow \lambda_2 = \frac{d\sin 30^\circ}{4} = 420\,nm.$$

或：

$$\left.\begin{aligned} d\sin\theta_3 &= k_1\lambda_1 \\ d\sin\theta_4 &= k_2\lambda_2 \\ \theta_3 &= \theta_4 \end{aligned}\right\} \Rightarrow k_1\lambda_1 = k_2\lambda_2$$

$$\Rightarrow \lambda_2 = \frac{k_1}{k_2}\lambda_1 = \frac{3}{4}\times 560\,nm = 420\,nm$$

10. 1) 暗纹：$b\sin\theta = 2k\cdot\frac{\lambda}{2} = k\lambda$

$$\tan\theta = \frac{x}{f}$$

$$\Rightarrow x_k = k\frac{f\lambda}{b}$$

1级暗：$x_1 = \frac{f\lambda}{b}$

中央明纹宽度：$\Delta x_0 = 2x_1 = 2\frac{f\lambda}{b}$

$$\Rightarrow \Delta x_0 = 2.9465\times10^{-3}\ m$$

2级暗：$x_2 = 2\frac{f\lambda}{b} = 2.9465\times10^{-3}\ m$

2) 明：$b\sin\theta = (2k+1)\frac{\lambda}{2}$

$$b\tan\theta = \frac{x}{f}$$

$$\Rightarrow x_k = (2k+1)\frac{f\lambda}{2b}$$

$k=2$，$x_2 = 5\frac{f\lambda}{2b} = 3.68\times10^{-3}\ m$

23. 波动光学（三）

1. C　2. C　3. B　（$I=\frac{1}{2}I_0\cos^2 45^0=\frac{1}{4}I_0$）

4. 不要求

5、6、10.

2) $I=\frac{1}{2}I_0\cos^2 45^0\cos^2 45^0=\frac{1}{8}I_0$

7. $I=\frac{1}{2}I_0\cos^2\alpha=\frac{1}{8}I_0 \Rightarrow \cos\alpha=\frac{1}{2} \Rightarrow$ 取 $\alpha=60^0$

8. 1) $\tan i_0=\frac{n_2}{n_1}=\frac{n}{1}=n \Rightarrow n=\tan 60^0=\sqrt{3}$

$n=1.732$

2) $\gamma=90^0-i_0=30^0$

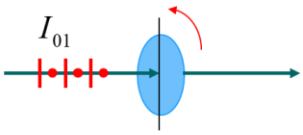
10. 1) $I=I_0\cos^2 30^0\cos^2 60^0=\frac{3}{16}I_0$

2) $I=\frac{1}{2}I_0\cos^2 60^0=\frac{1}{8}I_0$

2、4、5、8 题，不要求

9、

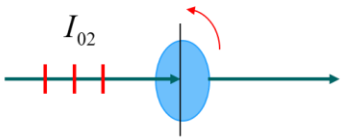
自然光



$\frac{1}{2}I_{01}$

$I_{max}=\frac{1}{2}I_{01}+I_{02}$

线偏振光



$\begin{cases} I_{02} \\ 0 \end{cases}$

$I_{min}=\frac{1}{2}I_{01}+0$

$$\Rightarrow I_{max}=4I_{min} \Rightarrow \frac{I_{01}}{I_{02}}=\frac{2}{3} \Rightarrow \begin{cases} \frac{I_{01}}{I_{01}+I_{02}}=\frac{2}{5} \\ \frac{I_{02}}{I_{01}+I_{02}}=\frac{3}{5} \end{cases}$$