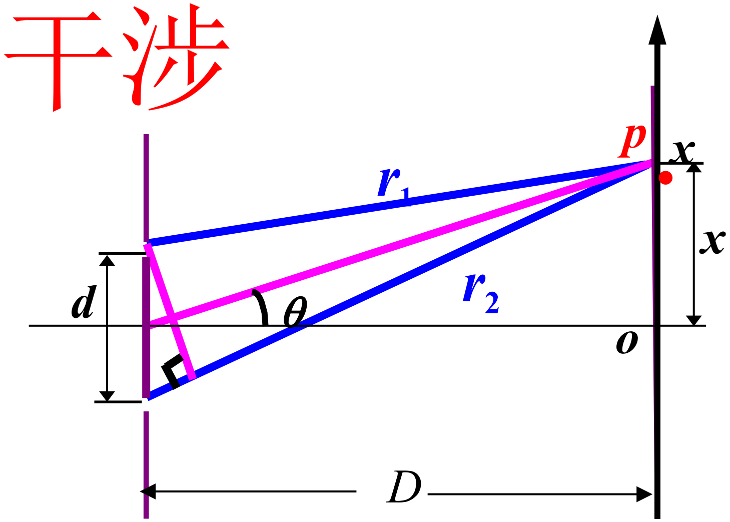
第6章　光的干涉

一　基本概念

1. 光程　　$D=nr$

2. 干涉加强与减弱的条件

$$\delta=\begin{cases}\pm k\lambda, & k=0,1,2,\mathrm{L} \quad \text{明纹} \\ \pm(2k+1)\dfrac{\lambda}{2}, & k=0,1,2,\mathrm{L} \quad \text{暗纹}\end{cases}$$



$$\delta \approx d\sin\theta$$

$$=\frac{xd}{D}$$

二　注意问题

1. 理解相干光的条件，是哪两束光产生干涉，正确计算两条相干光线的光程差。

用折射率n、厚度a的云母片盖住一缝，明纹移动7条。

2. 光程差的变化导致屏上条纹的移动。

$$\therefore \Delta\delta=(n-1)a=7\lambda$$

3. 在涉及到反射光线时，必须考虑有无半波损失。

三　题型分析

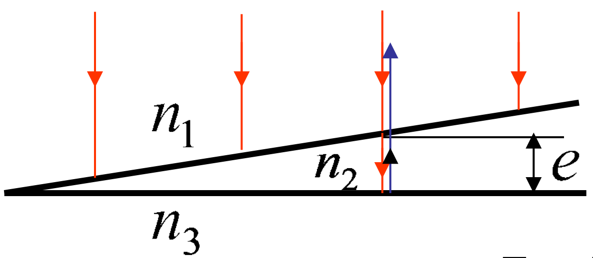
1. 杨氏双缝干涉

各级明条纹位置： $x_k = \pm k\dfrac{D\lambda}{d},\quad k = 0,1,2,L$

各级暗条纹位置： $x_k = \pm\dfrac{D\lambda}{2d}(2k-1),\quad k = 1,2,L$

2. 薄膜干涉

劈尖



$$\delta = 2en_2 + \frac{\lambda}{2}$$

$n_1 < n_2 < n_3$　　或$n_1 > n_2 > n_3$

$n_1 > n_2$且$n_2 < n_3$

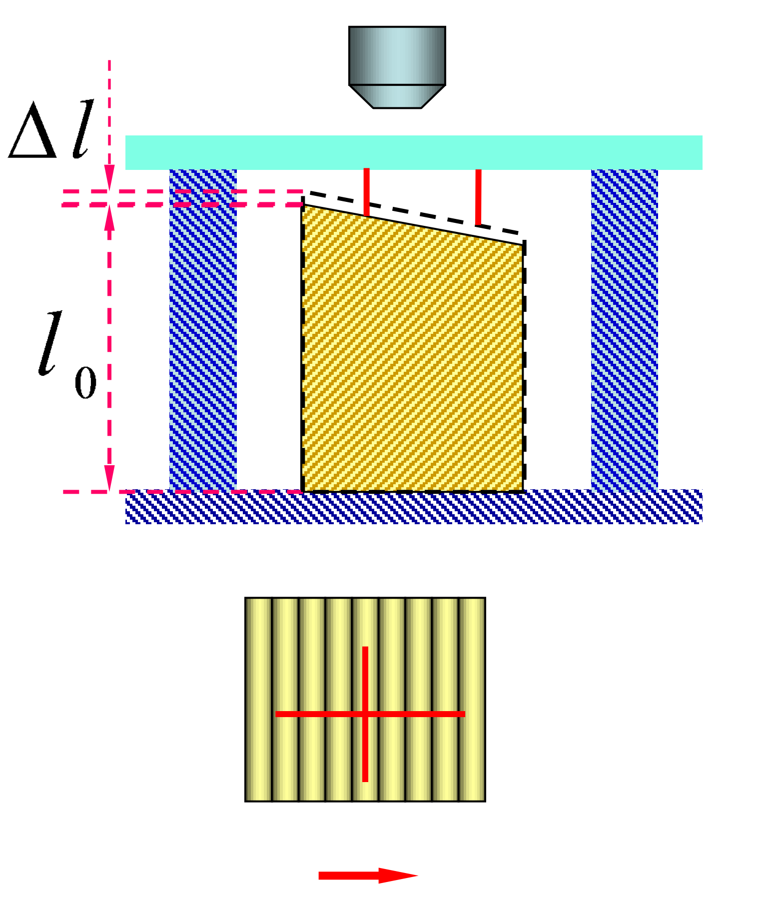
或$n_1 < n_2$且$n_2 > n_3$

$$\delta = 2ne + \left[\frac{\lambda}{2}\right] = \begin{cases} = k\lambda, (k = 1,2,3\ldots) & \text{明纹} \\ = (2k+1)\dfrac{\lambda}{2}, (k = 0,1,2\ldots) & \text{暗纹} \end{cases}$$

相邻明（暗）纹的间距　$\Delta L = \dfrac{\lambda}{2n\sin\theta} = \dfrac{\lambda}{2n\theta}.$

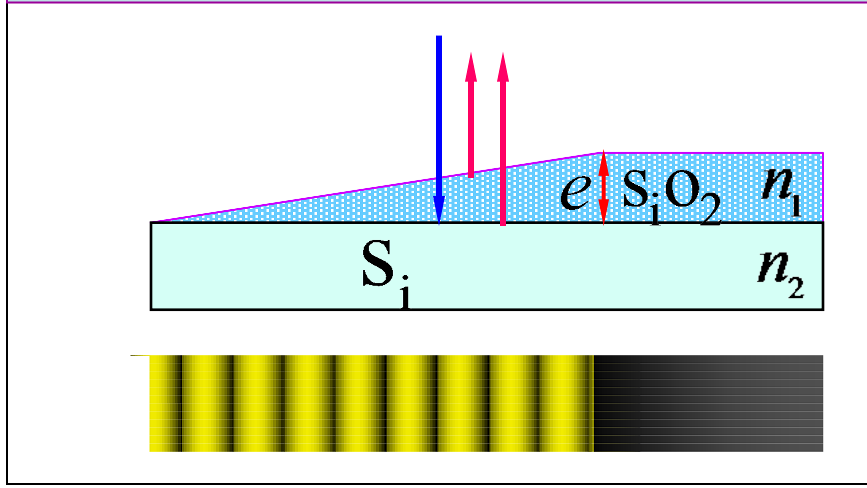
劈尖干涉的应用

1）干涉膨胀仪



$$\Delta l = \Delta N \frac{\lambda}{2}$$

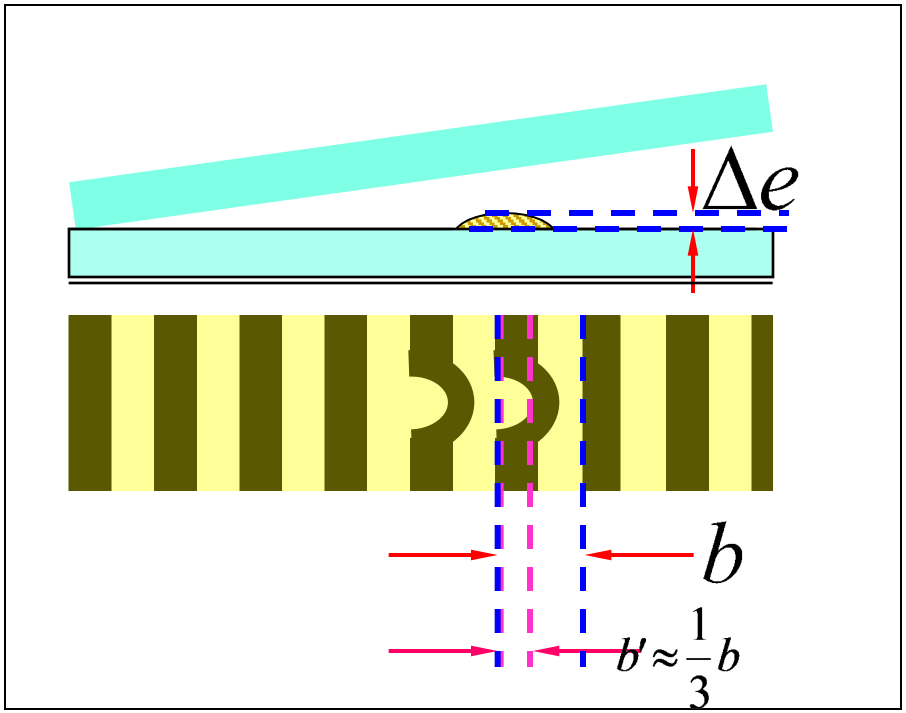
2）测膜厚

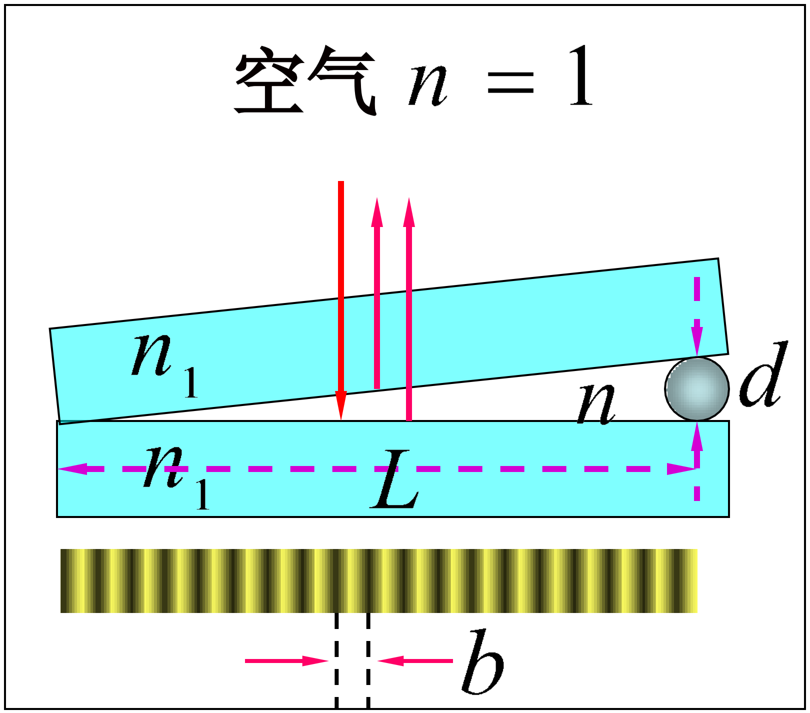


$$e = (N-1)\Delta e = (N-1)\frac{\lambda}{2n_1}$$

$$2n_1 e = k\lambda, \quad k = N - 1$$

3）检验光学元件表面的平整度　　4）测细丝的直径



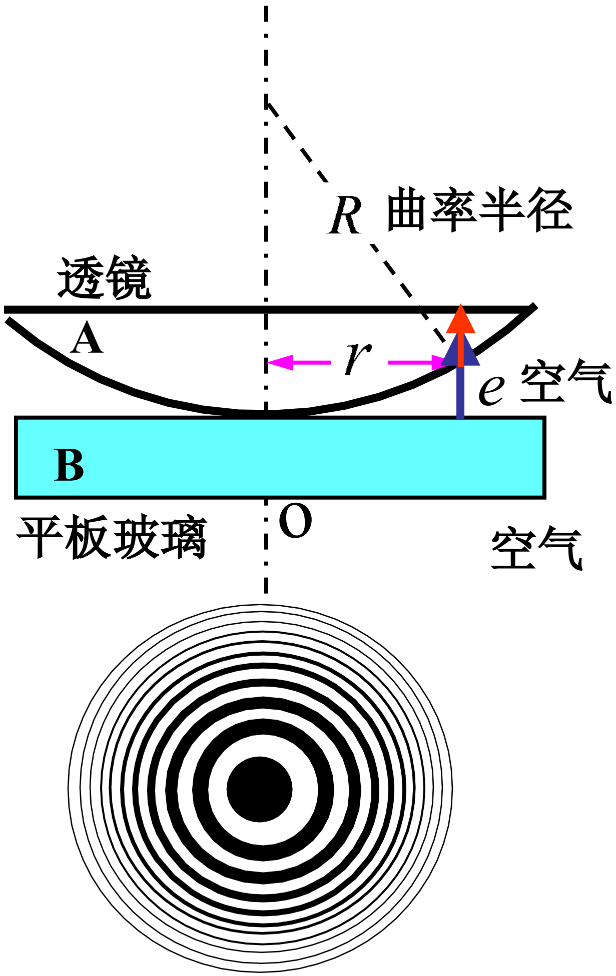


$$\Delta e = \frac{b'}{b}\frac{\lambda}{2} \approx \frac{1}{3} \cdot \frac{\lambda}{2} = \frac{\lambda}{6}$$

$$d = L\theta = \frac{\lambda}{2n} \cdot \frac{L}{b}$$

3.牛顿环

$$\delta = 2e + \frac{\lambda}{2} = \begin{cases} k\lambda, (k=0,1,2\ldots) & \text{明} \\ (2k+1)\frac{\lambda}{2}, (k=0,1,2\ldots) & \text{暗} \end{cases}$$

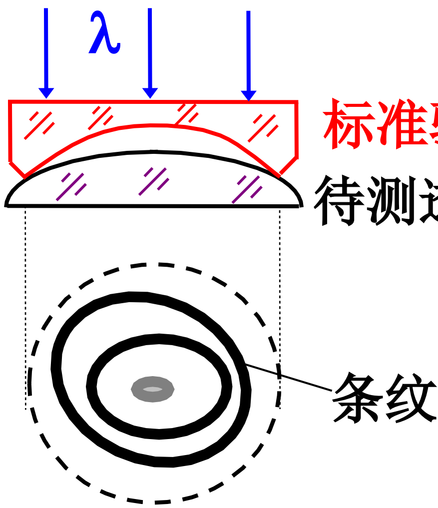


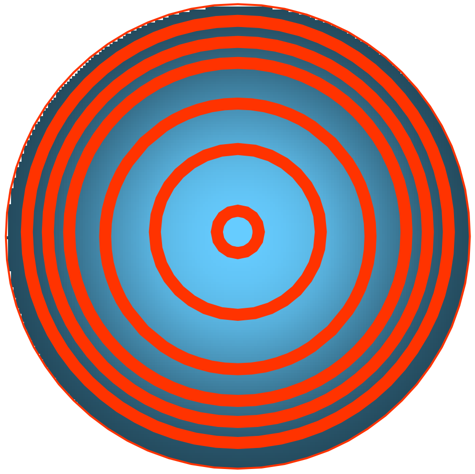
$$r^2 = R^2 - (R-e)^2 = 2Re - e^2$$

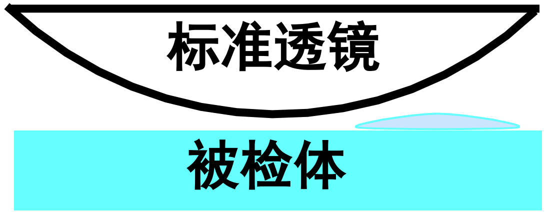
$R \gg e$ $\therefore$ 略去 e^2

$$\begin{cases} r_{明} = \sqrt{\frac{(2k-1)R\lambda}{2}}, (k=1,2\ldots) \\ r_{暗} = \sqrt{Rk\lambda}, (k=0,1,2\ldots) \end{cases}$$

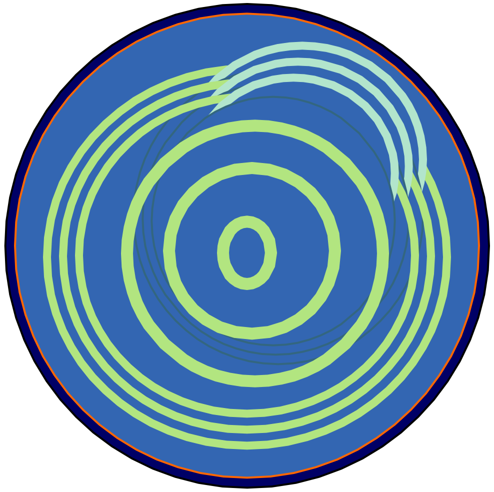
检验透镜球表面质量







检验平板玻璃表面质量



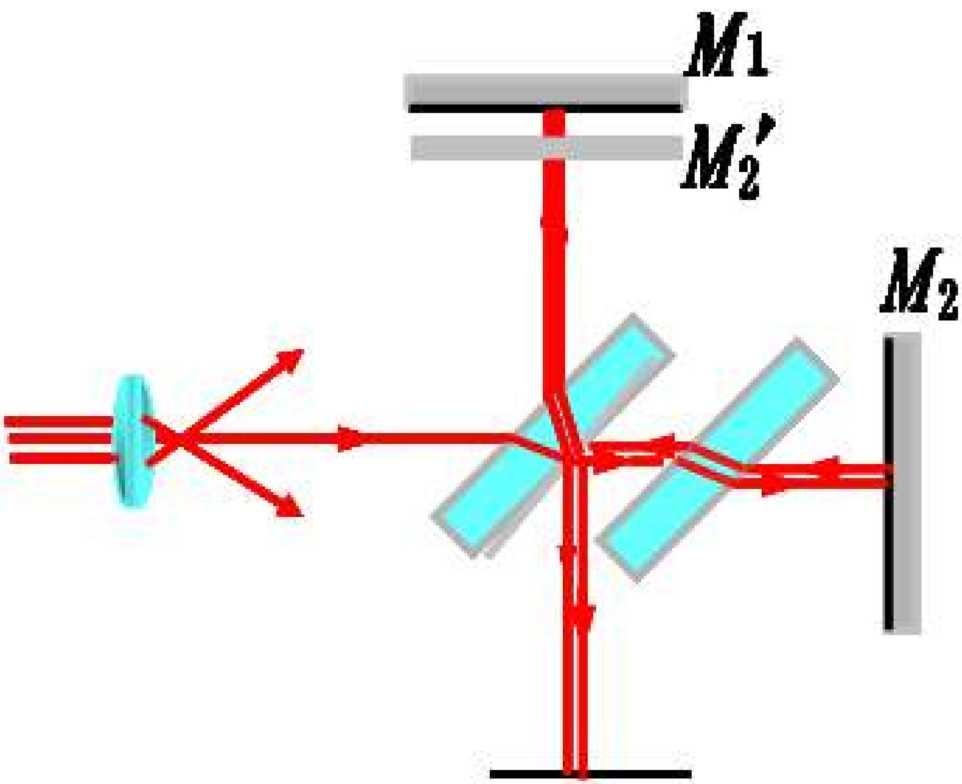
4.迈克耳逊干涉仪

$$\delta = 2d\cos\gamma = \begin{cases} k\lambda & \boxed{\text{明}} \\ (2k+1)\dfrac{\lambda}{2} & \boxed{\text{暗}} \end{cases} \quad \boxed{k = 0,1,2\ldots}$$

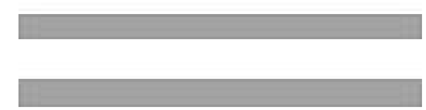
$$k_m = \frac{2d}{\lambda}$$

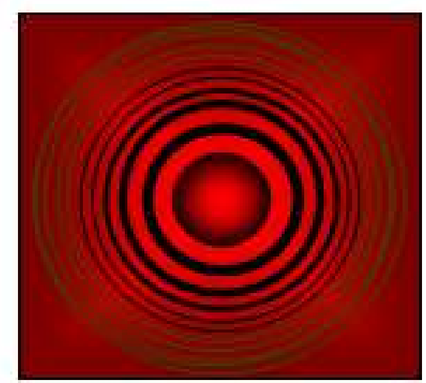
d 增大时有条纹冒出

$$\Delta d = m\frac{\lambda}{2}$$



相当于平行平面空气膜干涉





四　例题

1. 用白光作双缝干涉实验时，能观察到几级清晰可辨的彩色光谱？

解：用白光照射时，除中央明纹为白光外，两侧形成内紫外红的对称彩色光谱. 当k 级红色明纹位置$x_{k红}$大于k+1级紫色明纹位置$x_{(k+1)紫}$时，光谱就发生重叠。

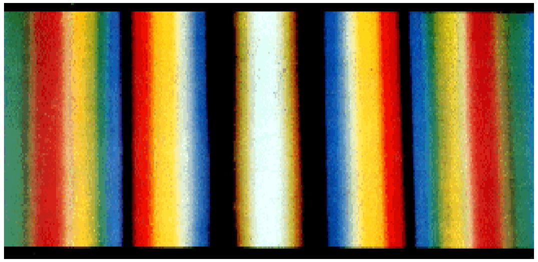
$$x_{k红}=k\frac{D}{d}\lambda_{红} \qquad x_{(k+1)紫}=(k+1)\frac{D}{d}\lambda_{紫}$$

由 $x_{k红} > x_{(k+1)紫}$ 可得 $$k\lambda_{红}>(k+1)\lambda_{紫}$$

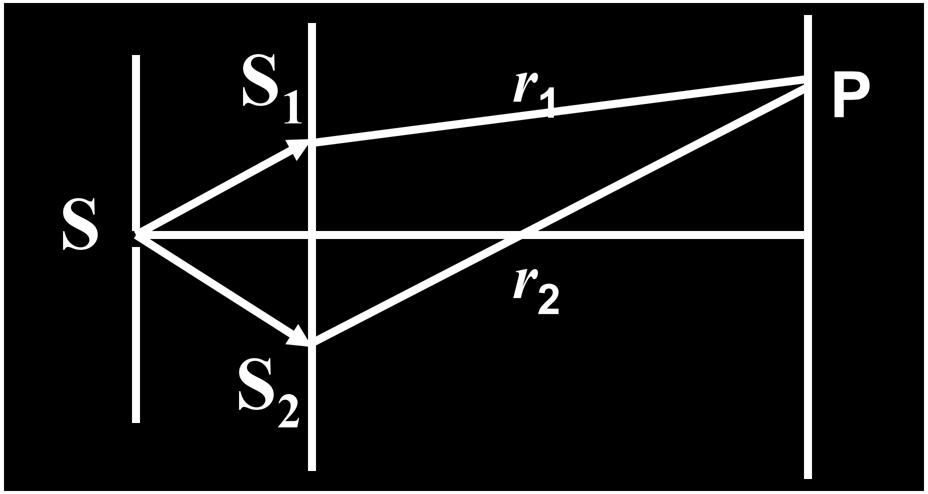
将 $\lambda_{红}$ = 7600Å， $\lambda_{紫}$ = 4000Å　代入得 $k>1.1$

因为k只能取整数，所以应取 $k=2$

这一结果表明：在中央白色明纹两侧，只有第一级彩色光谱是清晰可辨的。



2.如图所示，在双缝干涉实验中 $SS_1 = SS_2$，用波长为λ 的光照射双缝 S_1和 S_2，通过空气后在屏幕E上形成干涉条纹，已知 P 点处为第三级明条纹，则 S_1 和 S_2 到 P 点的光程差为__**3λ**__，若将整个装置放在某种透明液体中，P 点为第四级明条纹，则该液体的折射率 n =______**1.33**



$$\delta = r_2 - r_1 = k\lambda, (k = 3)$$

$$n(r_2 - r_1) = 4\lambda,$$

$$3n\lambda = 4\lambda$$

$$n = 4/3 = 1.33$$

3. 如图a所示，一光学平板玻璃A与待测工件B之间形成空气劈尖，用波长λ＝500 nm (1 nm=10^{-9} m)的单色光垂直照射．看到的反射光的干涉条纹如图b所示．有些条纹弯曲部分的顶点恰好与其右边条纹的直线部分的连线相切．则工件的上表面缺陷是

(A) 不平处为凸起纹，最大高度为500 nm．

(B) 不平处为凸起纹，最大高度为250 nm．

(C) 不平处为凹槽，最大深度为500 nm．

(D) 不平处为凹槽，最大深度为250 nm．

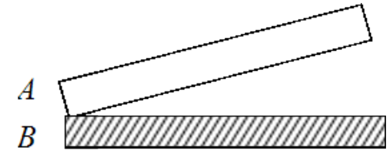


图 a

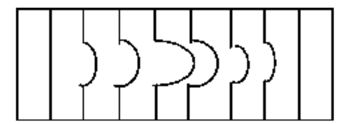


图 b

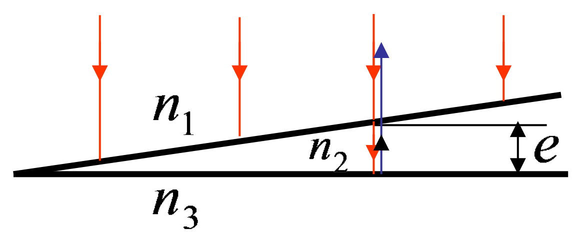
$$e_{k+1}-e_k=\frac{\lambda}{2},$$

[B

4. 用波长为λ_1的单色光照射空气劈形膜，从反射光干涉条纹中观察到劈形膜装置的A点处是暗条纹．若连续改变入射光波长，直到波长变为λ_2 ($\lambda_2>\lambda_1$)时，A点再次变为暗条纹．求A点的空气薄膜厚度．

解：设 A 点处空气薄膜的厚度为 e，则有

$$2e+\frac{1}{2}\lambda_1=\frac{1}{2}(2k+1)\lambda_1,\ \text{即}\ 2e=k\lambda_1$$



改变波长后有 $2e=(k-1)\lambda_2$

$$\therefore\ k\lambda_1=k\lambda_2-\lambda_2,\ k=\lambda_2/(\lambda_2-\lambda_1)$$

$$e=\frac{1}{2}k\lambda_1=\frac{1}{2}\lambda_1\lambda_2/(\lambda_2-\lambda_1)$$