第 5 章（1） 振 动

一、简谐振动方程及 A 、ω、 φ 的计算

$$x = A\cos(\omega t + \varphi) \qquad T = 1/\nu = 2\pi/\omega \qquad \omega = 2\pi\nu$$

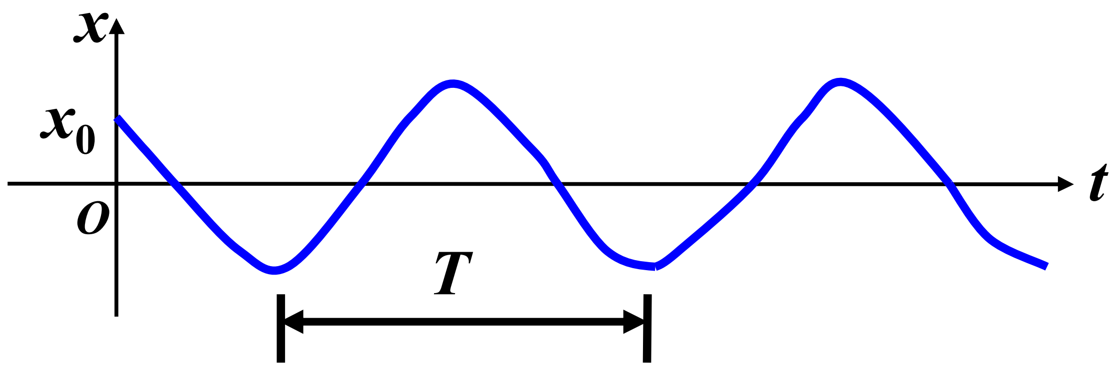
$$v = -\omega A\sin(\omega t + \varphi) = \omega A\cos(\omega t + \varphi + \pi/2)$$

$$a = -\omega^2 A\cos(\omega t + \varphi) = \omega^2 A\cos(\omega t + \varphi + \pi)$$

$$A = \sqrt{x_0^2 + \left(\frac{v_0}{\omega}\right)^2} \qquad \tan\varphi = -\frac{v_0}{\omega x_0} \qquad \varphi = \tan^{-1}\left(-\frac{v_0}{\omega x_0}\right)$$

弹簧振子 $\omega = \sqrt{\frac{k}{m}}$ 单摆 $\omega = \sqrt{\frac{g}{l}}$ 复摆 $\omega = \sqrt{\frac{mgb}{J}}$

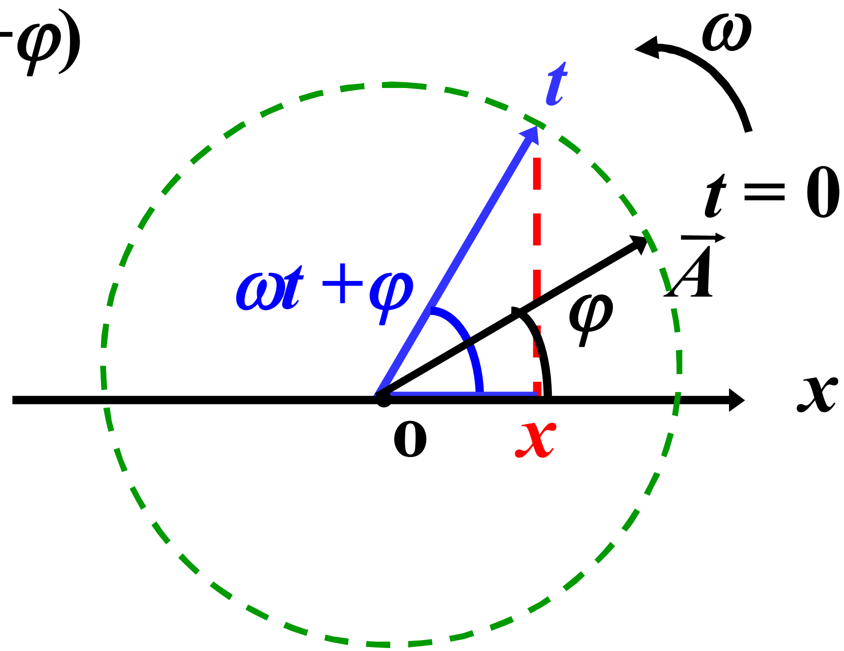
二、振动曲线$(x-t)$ $\rightarrow$ A、φ、T



三、旋转矢量法

求φ_0， 两状态之间的时间 Δt ……

$$x = A\cos(\omega t + \varphi)$$



四、振动能量

$$E_k = \frac{1}{2} m v^2 \qquad E_p = \frac{1}{2} k x^2$$

$$E_{总} = \frac{1}{2} k A^2 = \frac{1}{2} m \omega^2 A^2 \qquad \overline{E}_{\mathrm{p}} = \overline{E}_{\mathrm{k}} = \frac{1}{2} E_{总}$$

动能、势能相互转换，总能量守恒

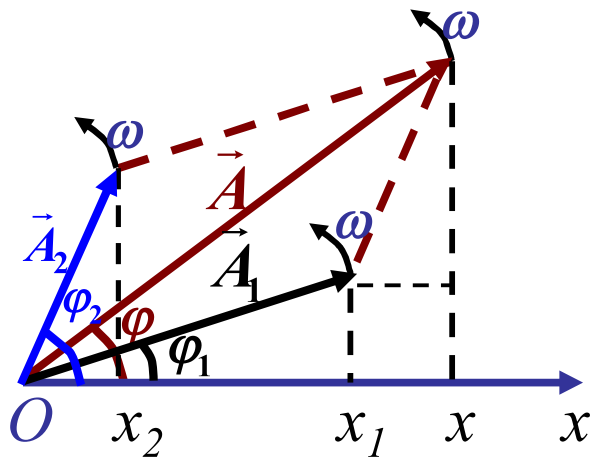
五、振动合成

$$x = x_1 + x_2 = A\cos(\omega t + \varphi)$$

同方向同频率

$$A = \sqrt{A_1^2 + A_2^2 + 2A_1A_2\cos(\varphi_2 - \varphi_1)}$$

$$\tan\varphi = \frac{A_1\sin\varphi_1 + A_2\sin\varphi_2}{A_1\cos\varphi_1 + A_2\cos\varphi_2}$$



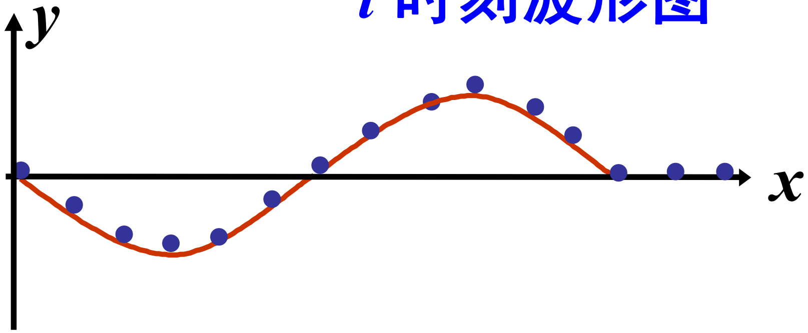
$$\begin{cases} \varphi_2 - \varphi_1 = \pm 2k\pi & k = 0,1,2\ldots. \quad A = A_1 + A_2 \\ \varphi_2 - \varphi_1 = \pm(2k+1)\pi & k = 0,1,2\ldots. \quad A = |A_1 - A_2| \end{cases}$$

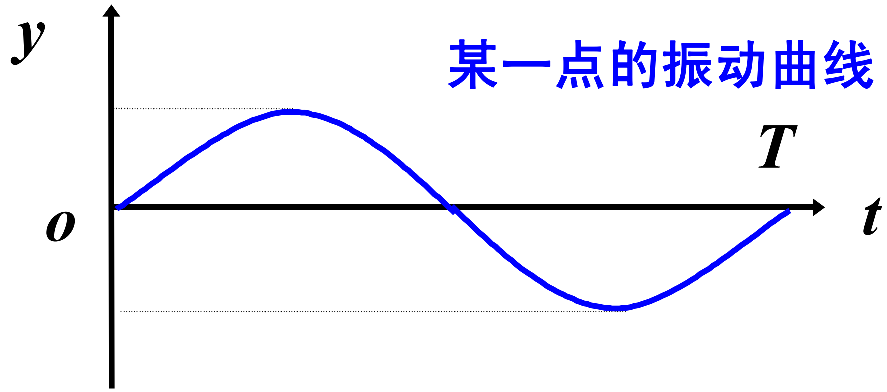
第 5 章（2） 波 动

一、波的性质

波是振动状态、相位、波形的传播。

t 时刻波形图





波速 u： 振动状态或相位传播的速度

机械波u由媒质的性质决定

$$u = \frac{\lambda}{T} = \nu\lambda$$

沿着波线相距 Δx的两点位相差

$$\Delta\varphi = \frac{2\pi}{\lambda}\Delta x$$

同一质点时间差为Δt的两振动状态的位相差 $\Delta\varphi = \omega\Delta t$

二、波函数

1、由已知条件确定基准点的基准方程

2、求任意 x 与基准点的位相差

3、将任意 x 的位相差代入基准方程

如：已知基准点（x=0）的振动方程（基准方程）

$$y = A\cos[\omega t + \varphi]$$

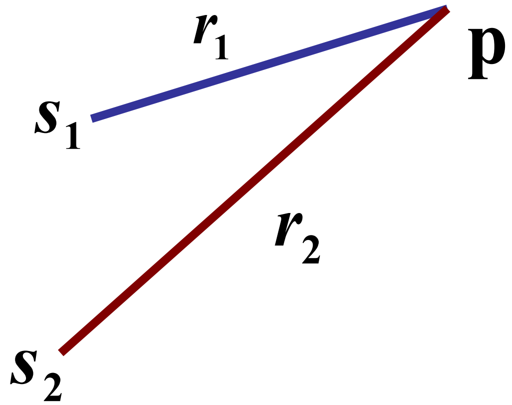
波函数（沿 $+x$）

$$y = A\cos\left[\omega t - \frac{2\pi x}{\lambda} + \varphi\right] = A\cos\left[\omega\left(t - \frac{x}{u}\right) + \varphi\right]$$

$$= A\cos\left[2\pi\left(\frac{t}{T} - \frac{x}{\lambda}\right) + \varphi\right]$$

三、波的干涉

$$y_1 = A_1\cos\left(\omega t - \frac{2\pi}{\lambda} r_1 + \varphi_1\right), \quad y_2 = A_2\cos\left(\omega t - \frac{2\pi}{\lambda} r_2 + \varphi_2\right)$$



$$A = \sqrt{A_1^2 + A_2^2 + 2A_1A_2\cos\Delta\varphi}$$

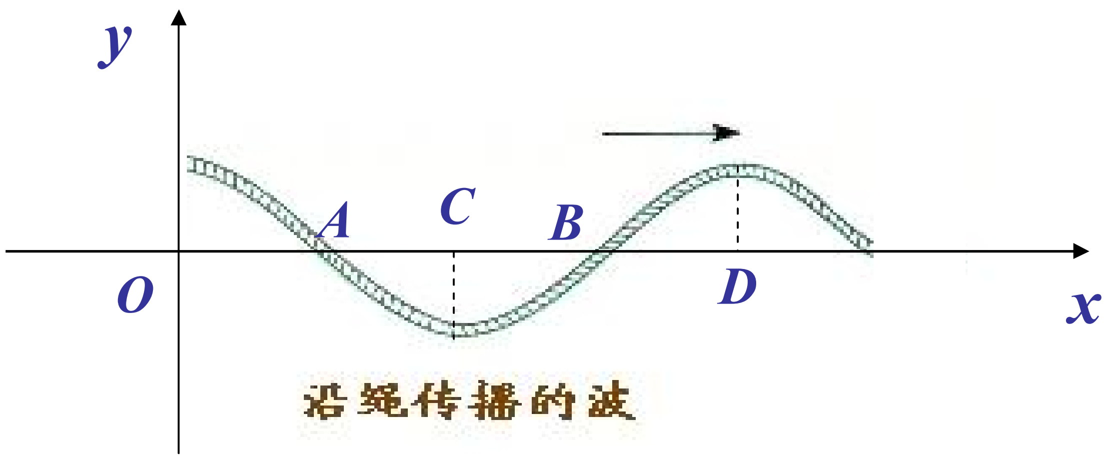
$$\Delta\varphi = \varphi_2 - \varphi_1 - \frac{2\pi}{\lambda}(r_2 - r_1) = \begin{cases} \pm 2k\pi & \text{加强} \\ \pm(2k+1)\pi & \text{减弱} \end{cases}$$

若 $\varphi_1 = \varphi_2$， $\delta = r_2 - r_1 = \begin{cases} \pm k\lambda, & \text{加强} \\ \pm(2k+1)\dfrac{\lambda}{2}, & \text{减弱} \end{cases}$ $k = 0, 1, 2, \ldots$

四、波动能量

质元的弹性势能与动能同步变化, 两者同时达到最大（平衡位置），同时等于零（最大位移），任一质元的总能量不守恒，以波速 u 传播。

平均能流密度（波的强度） $I=\overline{w}_{能}u=\frac{1}{2}\rho u\omega^2A^2$



第 6 章 （1） 光的干涉

一、相干光的叠加

$$A^2 = A_1^{\ 2} + A_2^{\ 2} + 2A_1A_2\cos(\Delta\varphi)$$

$$I = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos(\Delta\varphi)$$

其中 $\Delta\varphi = \varphi_{20} - \varphi_{10} - 2\pi\dfrac{\text{光程差}}{\lambda}$

$$\varphi_{20} = \varphi_{10}, \quad \Delta\varphi = \frac{\text{光程差}}{\lambda}2\pi$$

- 非相干光：

$$I = I_1 + I_2$$

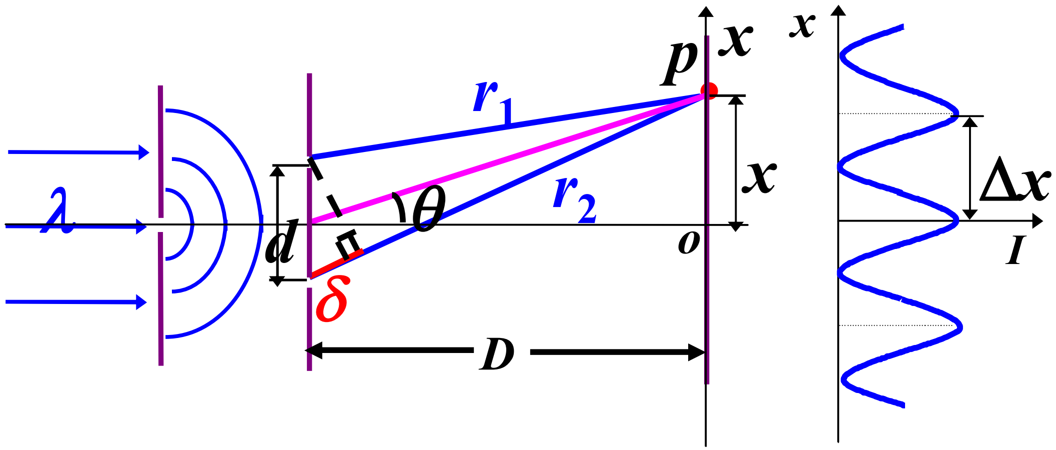
光程 $L = n\,d$

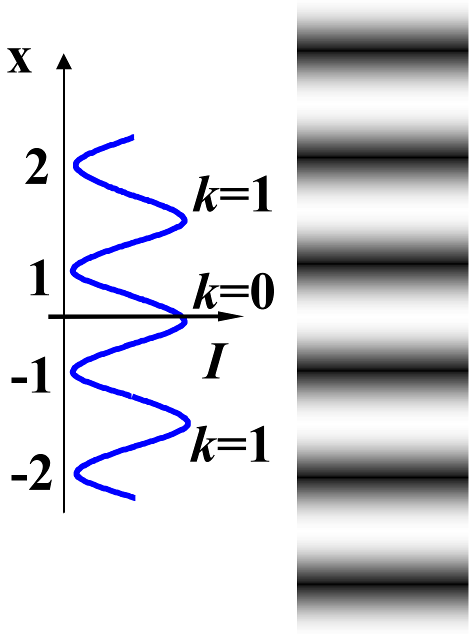
光程差 $\delta = \begin{cases} \pm k\lambda \\ \pm(2k+1)\dfrac{\lambda}{2} \end{cases}$

$k = 0,1,2,\cdots$ 明纹

$k = 0,1,2\cdots$ 暗纹

二、杨氏双缝干涉





$$\delta = r_2 - r_1 \approx d\sin\theta \approx \frac{d}{D}x = \begin{cases} \pm k\lambda & k = 0,1,2,\cdots \text{明纹} \\ \pm(2k-1)\dfrac{\lambda}{2} & k = 1,2,\cdots \quad \text{暗纹} \end{cases}$$

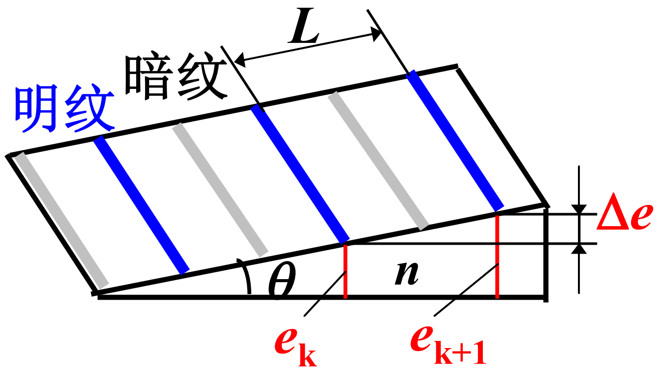
$$x = \begin{cases} \pm k\lambda \dfrac{D}{d} & \text{明纹中心} \quad k = 0,1,2,\cdots \\ \pm(2k-1)\dfrac{\lambda}{2}\dfrac{D}{d} & \text{暗纹中心} \quad k = 1,2,3,\cdots \end{cases}$$

两相邻明纹或暗纹的间距 $\boxed{\Delta x = \dfrac{D}{d}\lambda}$

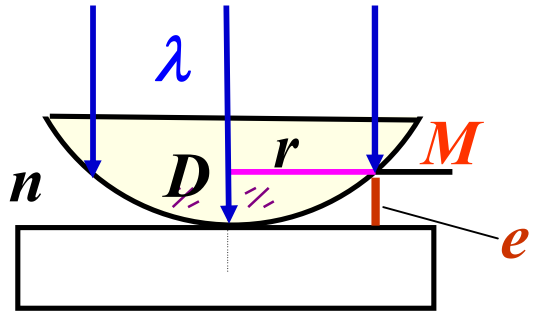
三、 薄膜干涉 等厚条纹

$$\delta = 2ne + (\frac{\lambda}{2}) = \begin{cases} k\lambda, & k = 1,2,\cdots \quad \text{明纹} \\ (2k+1)\frac{\lambda}{2}, & k = 0,1,2, \quad \text{暗纹} \end{cases}$$

$$\Delta e = \frac{\lambda}{2n}$$



$$L \approx \frac{\lambda}{2n\theta}$$



$$e = \frac{r^2}{2R}$$

$$r = \sqrt{\frac{(2k-1)R\lambda}{2n}} \quad k = 1,2,\cdots \text{明}$$

$$r = \sqrt{\frac{kR\lambda}{n}} \quad k = 0,1,2,\cdots \text{暗}$$

四、迈克耳逊干涉仪

$$\Delta d = N \cdot \frac{\lambda}{2} \qquad \Delta\delta = 2(n-1)l = \Delta k\lambda$$

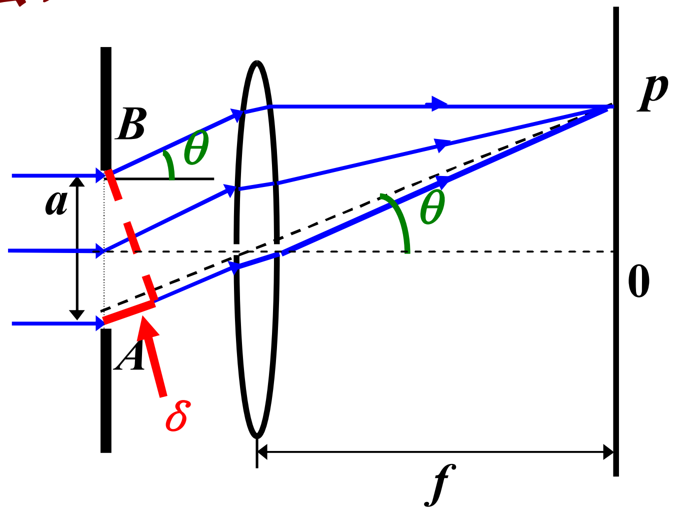
第 6 章（2） 光的衍射

一、单缝的夫琅禾费衍射（半波带法）

$$a\sin\theta = \pm 2k\frac{\lambda}{2} = \pm k\lambda,\quad k = 1,2,3\cdots$$ 暗纹

$$a\sin\theta = \pm(2k+1)\frac{\lambda}{2},\quad k = 1,2,3\cdots$$ 明纹

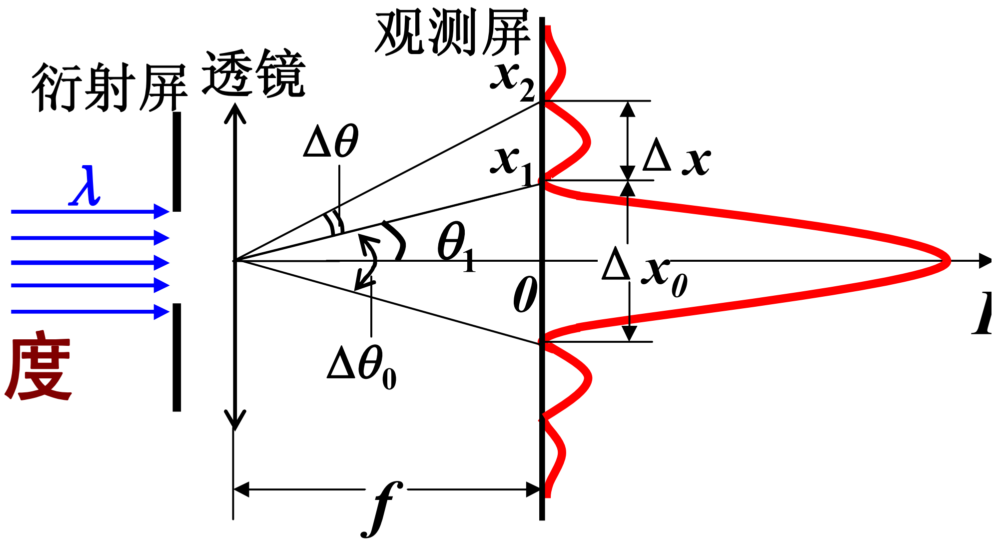
$$a\sin\theta = 0$$ —— 中央明纹（中心）



1、中央明纹的宽度：

$$\Delta\theta_0 = 2\theta_1 \approx 2\frac{\lambda}{a}$$

$$\Delta x_0 = 2f\cdot\tan\theta_1 \approx 2f\frac{\lambda}{a}$$



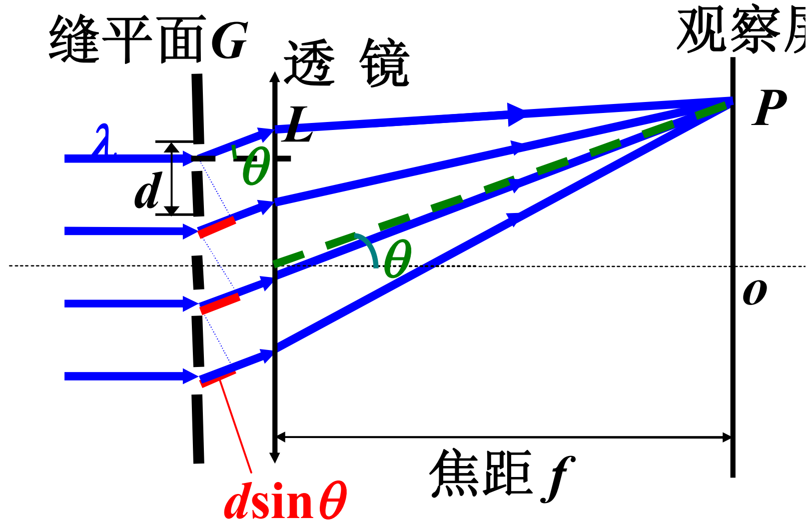
2、其他明纹(次极大)的宽度

$$\Delta x \approx \frac{f\lambda}{a} = \frac{1}{2}\Delta x_0$$

二、光栅衍射

光栅公式　明纹（k 级主极大）

$$\delta = d\sin\theta = \pm k\lambda, \quad k = 0,1....$$

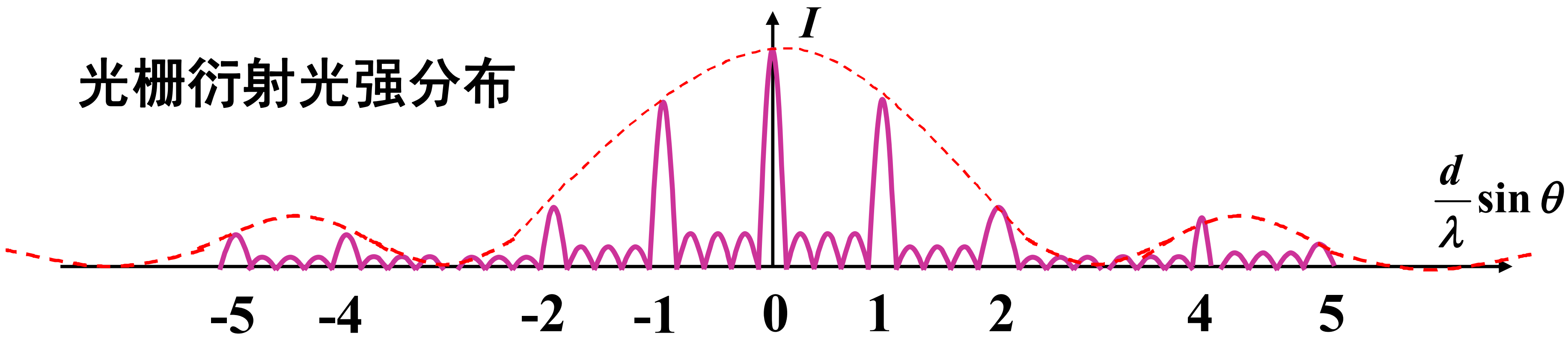


光栅常数　$d = a + b$

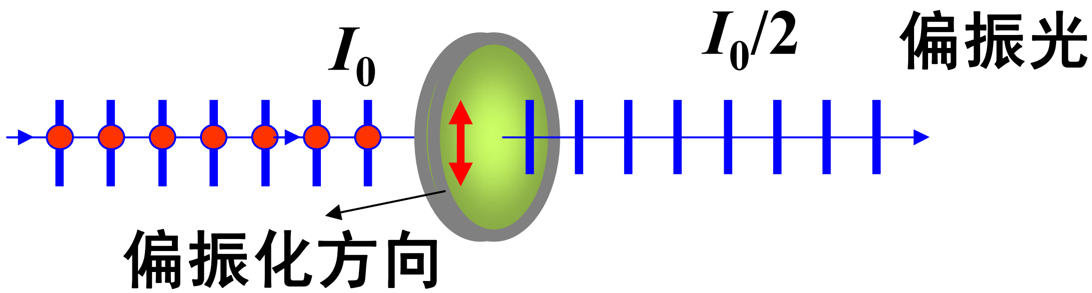
当　$a\sin\theta = \pm k'\lambda, \quad k' = 1,2...$　　**衍射暗纹**

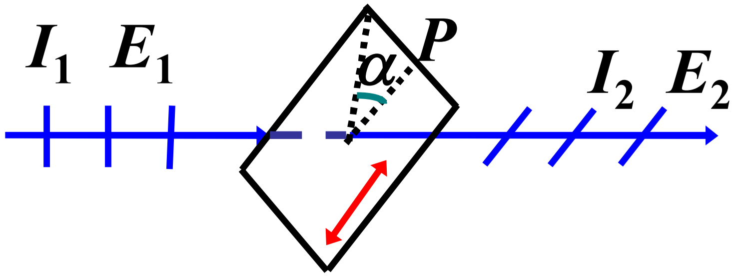
缺级级次　$k = \dfrac{d}{a}k'$　　k 级主极大缺级

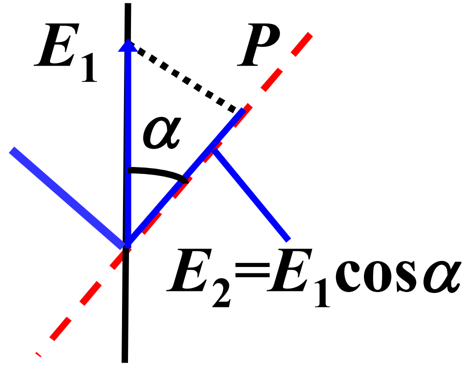
光栅衍射光强分布



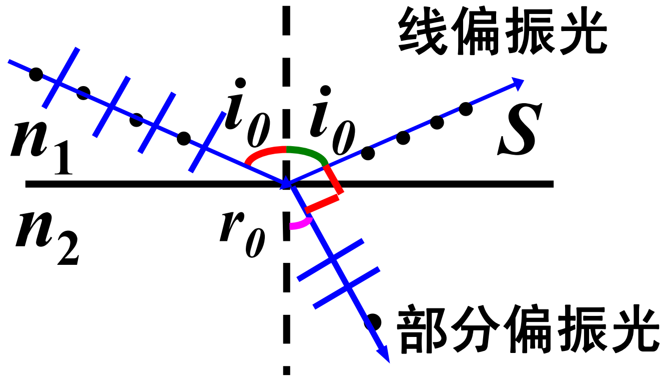
第 6 章（3）光的偏振







马吕斯定律 $$I_2 = I_1\cos^2\alpha$$



布儒斯特定律

$$\tan i_0 = \frac{n_2}{n_1}$$

$$i_0 + r_0 = 90^{\circ}$$