傍轴条件: $\rho^2 \ll z_0^2$ $\Delta L=\sqrt{z_0^2+\rho^2} = z_0\sqrt{1+\frac{\rho^2}{z_0^2}} \doteq z_0+\frac{\rho^2}{2z_0}$

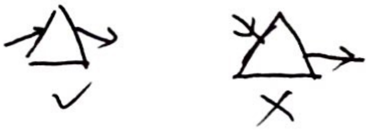
$\Delta\varphi = k\Delta L \doteq \frac{2\pi}{\lambda}\left(z_0+\frac{\rho^2}{2z_0}\right)$

轴外点球面波 $(x_0,y_0,-z)$

远场条件: $z_0 \gg \frac{\rho^2}{\lambda} \Rightarrow \Delta\varphi \doteq \frac{2\pi}{\lambda}z_0$. $\Rightarrow$ 发散: $\varphi = k\left(\frac{x^2+y^2}{2z} - \frac{2(xx_0+yy_0)}{2z}\right)$

$-\varphi$ 表示 (x_0,y_0,z) 汇聚波.

色散棱镜. 两种方式



高斯公式: $\frac{n'}{s'}+\frac{n}{s}=\frac{n'-n}{r}=\Phi$ $\frac{f'}{s'}+\frac{f}{s}=1$

$\beta = -\frac{ns'}{n's}$

光楔: $\Delta h=(n-1)s\alpha$.

球面镜: $f=f'=-\frac{r}{2}$ $\frac{1}{s'}+\frac{1}{s}=-\frac{2}{r}$ $\beta=-\frac{ns'}{n's}\xrightarrow[s'\to -s']{n'\to -n} -\frac{s'}{s}$

逐次成像: $s_2=d-s_1'$

薄透镜: $\frac{n'}{s'}+\frac{n}{s}=\frac{n_L-n}{r_1}+\frac{n'-n_L}{r_2}=\Phi_1+\Phi_2=\Phi$

$\Rightarrow f=\frac{n}{\Phi}$ $f'=\frac{n'}{\Phi}$

$\frac{f'}{s'}+\frac{f}{s}=1$ $xx'=ff'$

虚光线 光程为负值 总光程 $L=L_{实}+L_{虚}$

成像元件: 直接观察、 $2w=\frac{y}{s_0}$ s_0 为明视距离

+目镜 $2w'\approx\frac{y}{s}\approx\frac{y}{f}$ $\Rightarrow M=\frac{w'}{w}=\frac{s_0}{f}$

角放大率.

显微镜. 镜筒长度 $l=f_o'+\Delta+f_e$ $s_1\approx f_o'$ $s_1'\approx f_o'+\Delta\approx\Delta$

则 $y_1'=-\frac{s_1'}{s_1}y\approx-\frac{\Delta}{f_o'}y=\gamma_0 y$

$M_e=\frac{s_0}{f_e}\Rightarrow M=\gamma_0 M_e$.

总角放大率.

望远镜: $w\approx\frac{y_0'}{f_o'}$ $w'=\frac{y_0'}{f_e}\Rightarrow M=\frac{w'}{w}=-\frac{f_o'}{f_e}$.

杨氏干涉 $\Delta L \approx \frac{dx}{D}$

$\Delta x = \frac{D}{d}\lambda$ $\qquad I = \overset{\overset{4A_0^2}{\|}}{I_0}\cos^2\left(\frac{kd}{2D}x\right) = 4A_0^2\cos^2\left(\frac{\Delta\varphi}{2}\right)$

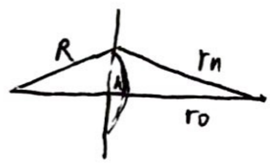
衬比度 $V = \frac{I_{max}-I_{min}}{I_{max}+I_{min}} \Rightarrow I = \overset{\overset{A_1^2+A_2^2}{\uparrow}}{I_0}(1+V\cos\Delta\varphi)$

平面波干涉 $\varphi_1 = \vec{k_1}\cdot\vec{r} + \varphi_{10} = kx\sin\theta_1 + \varphi_{10}$ ……

衍射积分式：$\tilde{U}(p) = K\iint\limits_{\Sigma}\tilde{U}_0(Q)F(\theta_0,\theta)\frac{e^{ikr}}{r}d\Sigma = \frac{e^{-i\frac{\pi}{2}}}{2\lambda}\iint\limits_{\Sigma_0}\tilde{U}_0(Q)(\cos\theta_0+\cos\theta)\frac{e^{ikr}}{r}d\Sigma$

次波不向后传播；各向异性。

菲涅耳衍射



半波带方程：$n = \frac{\rho_n^2}{\lambda}\left(\frac{1}{r_0}+\frac{1}{R}\right)$

$\Downarrow$

$\frac{1}{r_0}+\frac{1}{R} = \frac{n\lambda}{\rho_n^2} \Rightarrow f = \frac{\rho_n^2}{n\lambda}$

全透：$A_t = \frac{A_1}{2}$

$f' = \frac{f}{2m+1}$ $(m=1,2,3\cdots)$ 次焦点

$A = \frac{1}{2}[A_1 + (-1)^{n-1}A_n]$

夫琅禾费衍射 $2u = \Delta\varphi = ka\sin\theta$. $\qquad A = A_0\frac{\sin\frac{\Delta\varphi}{2}}{\frac{\Delta\varphi}{2}} = A_0\frac{\sin u}{u}$

光强极值点：
- 极大值 $\tan u = u \Rightarrow \sin\theta = 0, \pm 1.43\frac{\lambda}{a}$ ……
- 极小值 $u = j\pi \Rightarrow \sin\theta = \pm(j+1)\frac{\lambda}{a}$

角宽度：中央主极大 — $2\frac{\lambda}{a}$ $\qquad$ 次级 — $\frac{\lambda}{a}$

斜入射：~~主~~ 主极大 $\Rightarrow \sin\theta - \sin\theta_0 = 0$.

角宽度：$\sin(\theta_0 \pm \Delta\theta) = \sin\theta_0 \pm \frac{\lambda}{a} \Rightarrow 2\Delta\theta = \frac{2\lambda}{a\cos\theta_0}$

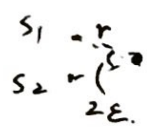
矩孔衍射：$I = I_0\left(\frac{\sin u_1}{u_1}\right)^2\left(\frac{\sin u_2}{u_2}\right)^2$

圆孔衍射. 一 同心圆环 $\qquad$ 艾里斑 $\qquad \Delta\theta_0 = 1.22\frac{\lambda}{D}$ 半角宽度

半径 $\Delta l = f\Delta\theta_0 = 1.22\frac{f\lambda}{D}$

分辨极限：$\delta\theta_{min} = 1.22\frac{\lambda}{D}$

菲涅耳双面镜. $\Delta x = \frac{L+r}{2\varepsilon r}\lambda$.



空间相干性

$$\Delta L = \Delta L_1 + \Delta L_2 = x\beta + \frac{d}{D}x'$$

干涉孔径 $\beta = \frac{d}{l}$ 　　可见度 $V = \frac{\left|\sin\frac{\pi b\beta}{\lambda}\right|}{\frac{\pi b\beta}{\lambda}}$

$\xRightarrow{\text{相干条件}} \frac{b\beta}{\lambda} < 1 \Rightarrow \beta < \frac{\lambda}{b} \Longrightarrow \begin{cases} b\Delta\theta_0 = \lambda \\ \beta < \Delta\theta_0 \end{cases}$

迈克耳孙测星干涉仪：

$\alpha = \frac{b}{L}$ 　　$\beta = \frac{h}{L} < \frac{\lambda}{b} \Rightarrow \frac{b}{L} < \frac{\lambda}{h}$

当 $\frac{\lambda}{h} = \frac{b}{L} = \alpha$ 时，~~干~~ 衬比度为 0.

时间相干性： — 　$j(\lambda+\Delta\lambda) = (j+1)\lambda \Rightarrow j_{max} = \frac{\lambda}{\Delta\lambda}$

$\Delta L_{max} = \underset{(j+1)\lambda}{\cancel{j\lambda}} \approx \frac{\lambda^2}{\Delta\lambda} \longleftarrow$ 相干长度

$I \propto nE_0^2$ 　　半波损失 　　掠入射；垂直入射. 　(判断正负

$n_1 < n_2$. 　　注意. P. S. k 构成右手系.

$\frac{E_{P1}'}{E_{P1}} > 0$ 　P分量反向.

斯托克斯倒逆关系 $\begin{cases} r^2 + \tilde{t}\cdot\tilde{t}' = 1 \\ \tilde{r}\cdot\tilde{t} + \tilde{t}\cdot\tilde{r}' = 0 \end{cases} \Rightarrow \begin{cases} r = -r' \\ t\cdot\tilde{t}' = 1-r^2 \end{cases}$

等倾干涉 $\Delta L = 2n_2 h\cos i_2$ 　　特点：① 同心圆环 ② 无空间相干性问题.

反射光 $\begin{cases} A_n = \underset{\text{半波损}}{-}Ar^{2n-3}(1-r^2), \ n>1 \\ A_1 = Ar. \end{cases}$ 　　$r \ll$ 时，只考虑 $A_1 \cdot A_2$.

透射光 $A_n' = Ar^{2(n-1)}(1-r^2)$

$\Delta L = 2n_2 h\cos i_2 \Longrightarrow$ 圆环角距离 $\Delta i_2 = -\frac{\lambda}{2n_2 h\sin i_2} \Rightarrow \Delta i_1 = \frac{n_2\cos i_2}{n_1\cos i_1}\Delta i_2$

$2n_2 h\cos i_2 = (2j+1)\frac{\lambda}{2}$ 亮纹 $\Rightarrow$ 角宽度. $\delta i_2 = \frac{\lambda}{4n_2 h\sin i_2}$ ~~半角宽度~~ . 半角宽度.

$2n_2 h\cos(i_2+\delta i_2) = j\lambda$ 暗纹.

等厚干涉： $\Delta L = 2n_2 h = (2j+1)\frac{\lambda}{2}$ 亮纹.

迈氏干涉仪　亮纹　$2h\cos i=(j+\frac{1}{2})\lambda$

注：镜子移 ΔL，光程改变 $2\Delta L$.

牛顿环.　$h(2R-h)=r^2 \Rightarrow r\doteq\sqrt{2Rh}=\begin{cases}\sqrt{(j+\frac{1}{2})\lambda R} & （亮纹）\\ \text{半波损．上方看.} & \\ \sqrt{j\lambda R} & \text{下方看.}\\ \text{无半波损} & \end{cases}$

多光束干涉.　半值宽度 $\underset{\substack{\uparrow\\ \text{相位差}}}{\varepsilon}=\frac{2(1-\rho)}{\sqrt{\rho}}$　　$\rho=r^2$（反射率）.

$\delta=k\Delta L=\frac{2\pi}{\lambda}\cdot 2nh\cos i=\frac{4\pi nh\cos i}{\lambda} \Rightarrow d\delta=-\frac{4\pi nh\sin i}{\lambda}di$

$\Rightarrow \underbrace{\Delta i_j}_{\text{半角宽度}}=\frac{\lambda\varepsilon}{4\pi nh\sin i}$

对 λ：
$\varepsilon=d\delta=-\frac{4\pi nh\cos i}{\lambda_j^2}d\lambda_j$

ε所对应波长范围

$\Rightarrow \Delta\lambda_j=\frac{\lambda^2\varepsilon}{4\pi nh\cos i}=\frac{\lambda}{2j\pi}\varepsilon$

$\lambda_j=\frac{2nh\cos i}{j}$　~~$\Rightarrow \Delta\lambda_j=$~~

分辨：　$2nh\cos i_j=j\lambda \Rightarrow -2nh\sin i_j\,di_j=jd\lambda$

$\Rightarrow \delta i=\frac{j}{2nh\sin i_j}\delta\lambda$

$\delta i\geq\Delta i$　时可分辨　$\Rightarrow \delta\lambda\geq\frac{\lambda}{j\pi}\frac{1-\rho}{\sqrt{\rho}}=\frac{\lambda^2}{2\pi nh\cos i}\frac{1-\rho}{\sqrt{\rho}}$

分辨本领：$A=\frac{\lambda}{\delta\lambda}=\frac{\sqrt{\rho}}{1-\rho}j\pi=\frac{2\pi nh\cos i}{\lambda}\frac{\sqrt{\rho}}{1-\rho}$

光栅：　$I(\theta)=I_0\left(\frac{\sin u}{u}\right)^2\left(\frac{\sin N\beta}{\sin\beta}\right)^2$　　$u=\frac{\pi a}{\lambda}\sin\theta$，$\beta=\frac{\pi}{\lambda}d\sin\theta$

双缝衍射：

$I(\theta)=4I_0\cos^2\beta\frac{\sin^2u}{u^2}$

干涉主极大：　$\beta=j\pi \Rightarrow I(\theta)=N^2I_0\left(\frac{\sin u}{u}\right)^2$

极小值 $\begin{cases}\text{衍射：} \begin{cases}\sin u=0\\ u\neq0\end{cases} \Rightarrow u=n\pi\ (n=\pm1,\pm2,\cdots)\\ \text{干涉：} \begin{cases}\sin N\beta=0\\ \sin\beta\neq0\end{cases} \Rightarrow \beta=\frac{j}{N}\pi\ (j=1,2,\cdots N-1,N+1,\cdots)\end{cases}$

谱线缺级 $j = n\frac{d}{a}$

光栅半角宽度 $\sin\beta = 0 \Rightarrow \beta = j\pi \Rightarrow \frac{\pi d\sin\theta_j}{\lambda} = j\pi \Rightarrow \sin\theta_j = \frac{j\lambda}{d}$

$$\sin(\theta_j+\Delta\theta_j) = \left(j+\frac{1}{N}\right)\frac{\lambda}{d} \Rightarrow \boxed{\Delta\theta_j = \frac{\lambda}{Nd\cos\theta_j}}$$

分辨本领 $j\lambda = d\sin\theta_j \Rightarrow j\delta\lambda = d\cos\theta_j\,\delta\theta \Rightarrow \delta\theta = \frac{j\delta\lambda}{d\cos\theta}$

$$\delta\theta_j \geqslant \Delta\theta_j \Rightarrow \frac{j\delta\lambda}{d\cos\theta_j} \geqslant \frac{\lambda}{Nd\cos\theta_j} \Rightarrow \boxed{\begin{aligned}\delta\lambda &\geqslant \frac{\lambda}{jN}\\ A &= jN\end{aligned}}$$

角色散率: $\frac{d\theta}{d\lambda} = \frac{j}{d\cos\theta}$

线色散率: $\frac{dl}{d\lambda} = f\frac{d\theta}{d\lambda}$

量程. $\lambda \leqslant \frac{d}{j} < d$.

自由光谱范围. (不重叠) $j\lambda_M < (j+1)\lambda_m$

$\lambda_M - \lambda_m < \frac{\lambda_m}{j}$

闪耀光栅 垂直闪耀面入射: $\Delta L = 2d\sin\theta_B = -j\lambda$ $j=-1$时.

$\lambda_{1B} = 2d\sin\theta_B$.

沿光栅平面入射: $\Delta L = d\sin 2\theta_B = -j\lambda$ $j=-1$时

$\lambda_{1B} = d\sin 2\theta_B$.

色分辨本领 $A = A_1 + A_2 = j_1N_1 + j_2N_2$

X射线晶体衍射. $2d\sin\theta = j\lambda$

偏振度 $P = \frac{I_{max}-I_{min}}{I_{max}+I_{min}}$.

布儒斯特角. $i_1 = i_B = \arctan\frac{n_2}{n_1}$ $i_1+i_2 = \frac{\pi}{2}$ 反射光只有s分量.

透射光 $\left\{ \begin{array}{l} \text{P分量保持不变.} \\ \underline{(A_{s2})^{(2n)} = A_{s1}\sin^{2n}(2i_2)} \end{array} \right.$ n为玻璃片堆的表面数.

尼科耳棱镜. e光通过.

波片. $\Delta\varphi = \frac{2\pi}{\lambda}(n_e - n_o)d$

	偏振片	本片+偏振片
自然光	×	×
圆偏	×	✓
线偏	✓	
部分偏	✓×	✓×
椭圆偏	✓×	✓

偏振光干涉

$$\begin{cases} I = A_{e2}^2 + A_{o2}^2 + 2A_{e2}A_{o2}\cos\Delta\varphi \\ A_{e2} = A_1\cos\alpha\cos\beta \\ A_{o2} = A_1\sin\alpha\sin\beta \end{cases}$$

克尔效应. $\Delta \underset{n_o - n_e}{\overset{\shortparallel}{n}} = kE^2$ 垂直方向加电场

泡克尔斯效应. $\Delta n = n_o^3 \gamma E$ 平行方向加电场

旋光. $\theta = \alpha l$ 溶液: $\theta = \alpha N l$

右旋晶体 $n_R < n_L$ ....

磁致旋光. $\theta = VBl$ B沿光传播方向为正, 左旋为正.

光的吸收: $I = I_0 e^{-\alpha x} \xlongequal{溶液} I_0 e^{-ACX}$

红外窗口.

光的色散 柯西公式: $n = A + \frac{B}{\lambda^2} + \frac{C}{\lambda^4}$

吸收带 — 反常色散.

散射. $a < 0.3\frac{\lambda}{2\pi}$ 瑞利散射 $I_散 \propto (\frac{1}{\lambda})^4$

$a > 0.3\frac{\lambda}{2\pi}$ 米-德拜散射 对波长依赖性不强

黑体. $\Phi(T) = \sigma T^4$ $T\lambda_m = b$.

瑞利-金斯: $E(\lambda, T) = \frac{4\pi c}{\lambda^4} kT$ — 紫外灾难

光电效应: $E_k = h\nu - W$

康普顿效应. $\begin{cases} h\nu + m_0c^2 = h\nu' + mc^2 \\ \vec{p} = \vec{p}' + m\vec{v} \end{cases}$

$$\Rightarrow \frac{h}{m_0c}(1-\cos\theta) = \frac{c}{\nu'} - \frac{c}{\nu} \Rightarrow \begin{cases} \Delta\lambda = \lambda_c(1-\cos\theta) \\ \lambda_c = \frac{h}{m_0c}. \end{cases}$$

$\lambda = \frac{h}{p}$ $m = \frac{h\nu}{c^2}$