§17. 电磁场与电磁波

1. 位移电流

$$\vec{j}_d = \frac{\partial \vec{D}}{\partial t}. \quad I_d = \frac{d\phi_d}{dt} = \int_S \frac{\partial \vec{D}}{\partial t} d\vec{S}.$$

全电流. $I_全 = \sum I + I_d$.

全电流环路定律

$$\oint_L \vec{H} d\vec{l} = I + \int_S \frac{\partial \vec{D}}{\partial t} d\vec{S}.$$

性质.

$$\vec{j}_D = \frac{\partial \vec{D}}{\partial t} = \varepsilon_0 \frac{\partial \vec{E}}{\partial t} + \frac{\partial \vec{P}}{\partial t}.$$

$\vec{D}$ $\frac{\partial \vec{D}}{\partial t} = \vec{j}_d$.

H_d.

2. 电磁场.

Maxwell 方程组. ($\vec{D} = \varepsilon\vec{E}$. $\vec{B} = \mu\vec{H}$. $\vec{j} = \gamma\vec{E}$).

(微分形式).

电场的性质

$$\oint_S \vec{D}\cdot d\vec{S} = q \qquad \nabla\cdot\vec{D} = \rho.$$

磁场的性质

$$\oint_S \vec{B}\cdot d\vec{S} = 0 \qquad \nabla\cdot\vec{B} = 0$$

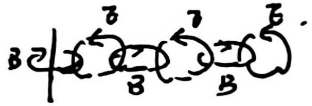
变化电场激发磁场.

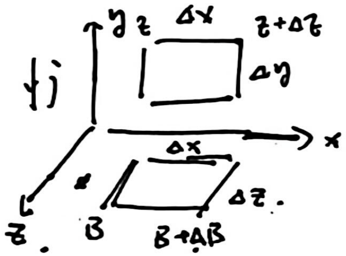
$$\oint_L \vec{H}\cdot d\vec{l} = I + \iint_S \frac{\partial \vec{D}}{\partial t} d\vec{S}. \qquad \nabla\times\vec{H} = \vec{j} + \frac{\partial \vec{D}}{\partial t}.$$

变化磁场激发电场.

$$\oint_L \vec{E}\cdot d\vec{l} = -\iint_S \frac{\partial \vec{B}}{\partial t} d\vec{S}. \qquad \nabla\times\vec{E} = -\frac{\partial \vec{B}}{\partial t}.$$

3. 电磁波.





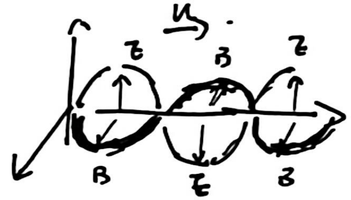
$$\Delta E\Delta y = -\frac{\partial B}{\partial t} dS. \qquad \frac{\partial E}{\partial x} = -\frac{\partial B}{\partial t}$$

$$\Delta H\Delta z = \frac{\partial D}{\partial t} dS$$

$$\Rightarrow \begin{cases} \frac{\partial^2 E}{\partial x^2} = \varepsilon_0\mu_0 \frac{\partial^2 E}{\partial t^2} \\ \frac{\partial^2 H}{\partial x^2} = \varepsilon_0\mu_0 \frac{\partial^2 H}{\partial t^2}. \end{cases}$$

$c = \frac{1}{\sqrt{\mu_0\varepsilon_0}}$, $\sqrt{\varepsilon_0} E = \sqrt{\mu_0} H$.

$u = \frac{1}{\sqrt{\mu\varepsilon}}$. 折射率: $n = \sqrt{\mu_r\varepsilon_r}$.



电磁波的能量.

$$\vec{S} = \frac{w\, dA\, dl}{dA\, dt} = \vec{E}\times\vec{H}.$$

$$\bar{S} = \frac{1}{2}E_0H_0.$$

电磁波的动量.

$$\frac{dmv}{dm} = \frac{w}{c^2}\cdot c = \frac{w}{c}. \qquad S = wc. \Rightarrow g = \frac{w}{c} = \frac{S}{c^2}$$

动量流密度 (作用在表面的压强)、光压.

$$P = \frac{S}{c}.$$

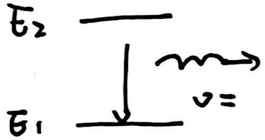
(反射: $P = 2\frac{S}{c}$).

§19. 光的干涉.

微粒说 → 经典波动说 → 波粒二象性.

1. 光源

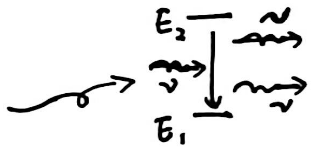
热辐射光源
冷光源



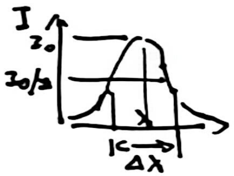
$\nu = \dfrac{E_2 - E_1}{h}$.

波列长 $L = \tau c$.

普通光源：自发辐射. 独立随机
激光光源：受激辐射 相干. →



单色性.



干涉：相干光波. { 分波阵面. 分振幅.

相干条件：频率相同. 振动方向相同. 有固定位相差.

$$E_1 = E_{10}\cos(\omega t + \varphi_{10}).$$

$$E_2 = E_{20}\cos(\omega t + \varphi_{20}).$$

$$E = E_1 + E_2 = E_0\cos(\omega t + \varphi_0).$$

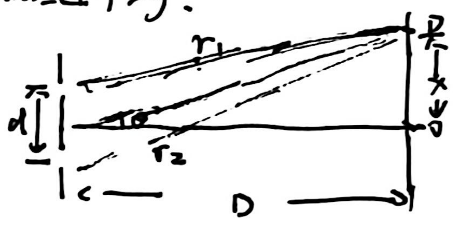
其中：$E_0 = \sqrt{E_{10}^2 + E_{20}^2 + 2E_{10}E_{20}\cos(\varphi_{20} - \varphi_{10})}$.

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

相长：$I = I_1 + I_2 + 2\sqrt{I_1 I_2}$ $(\Delta\varphi = \pm 2k\pi)$.

相消：$I = I_1 + I_2 - 2\sqrt{I_1 I_2}$ $(\Delta\varphi = \pm(2k+1)\pi)$

2. 双缝干涉.



$\Delta\varphi = \dfrac{2\pi}{\lambda}(r_2 - r_1)$.

$r_2 - r_1 = d\sin\theta = d\dfrac{x}{D}$. $(D \to +\infty)$

$k\lambda\dfrac{D}{d}$ 相长 $(k+\frac{1}{2})\lambda\dfrac{D}{d}$ 相消.

$I_P = 2I(1+\cos\Delta\varphi)$.

洛埃镜. 菲涅耳双镜.

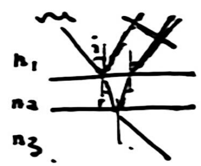
3. 薄膜干涉.

$\dfrac{c_0}{c} = n$. $\lambda_n = \dfrac{\lambda}{n}$. ν (ν不变).

光程 $\delta = nx$. $\Delta\varphi = \dfrac{2\pi}{\lambda}\delta$. → { 相长 $\delta = k\lambda$; $\delta = (k+\frac{1}{2})\lambda$ 相消.

$= \sum n_i x_i$.

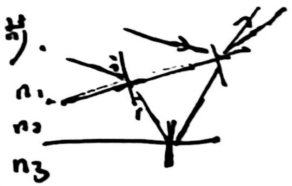
① 等倾干涉. →



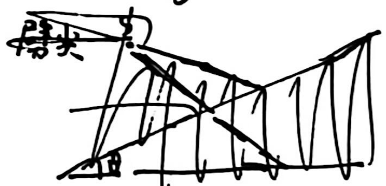
$\delta = 2en_2\cos r + \delta'$.

半波损失 光疏→光密. 反射.

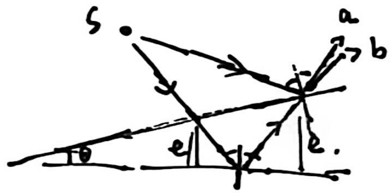
② 等厚干涉.



$\delta = 2en_2\cos r + \delta'$.

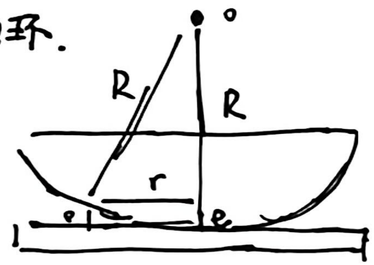


劈尖膜干涉



$$\delta = 2en + \frac{\lambda}{2}.$$

牛顿环.



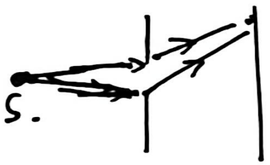
$$\delta = 2en + \frac{\lambda}{2}.$$

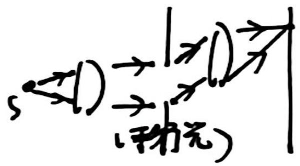
$$r^2 = 2Re.$$

§20. 光的衍射.

绕过障碍物边缘偏离直线传播. $\lambda \approx a$ 时明显.

菲涅耳衍射　　　夫琅禾费衍射

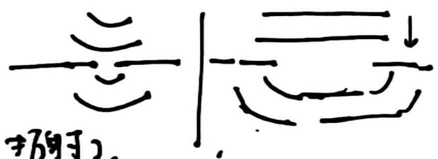




惠更斯原理.

波阵面上的各点是子波源.

(衍射、反射、折射).



菲涅耳原理.

$$dE_p = C\frac{dS}{r}k(\theta)\cos(\omega t - \frac{2\pi}{\lambda}r + \varphi_0).$$

$$E_p = \int_S C\frac{a(s)}{r}k(\theta)\cos(\omega t - \frac{2\pi}{\lambda}r + \varphi_0)dS.$$

$(k(\theta) = \cos^2\frac{\theta}{2})$

单缝夫琅禾费衍射光路图.

菲涅耳半波带法.

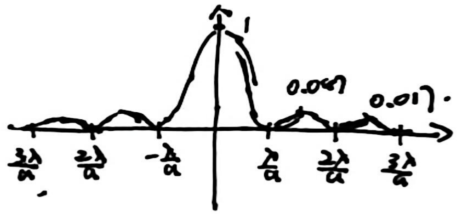
$a\sin\theta = \lambda$. (暗).

(明) $a\sin\theta = \frac{3}{2}\lambda$.

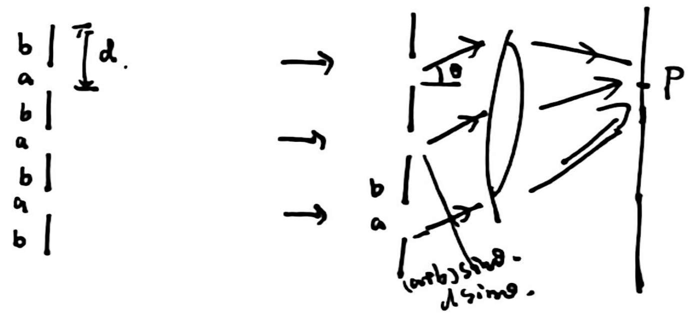
暗纹. $a\sin\theta = \pm k\lambda$.　　$\pm k = 1, 2, 3, \ldots$

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

中央明纹. $a\sin\theta = 0$



光栅衍射.



光栅方程. $d\sin\theta = k\lambda$.　$\pm k = 0, 1, 2, \ldots$.

主极大明纹. 个数有限.

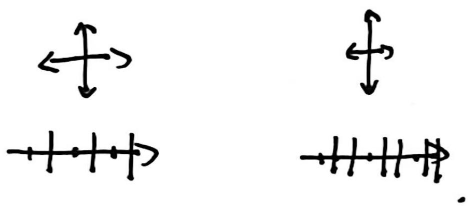
缺级: $\begin{cases} a\sin\theta = k_1\lambda \\ d\sin\theta = k_2\lambda \end{cases} \Rightarrow k_2 = \frac{d}{a}k_1.$

光栅分辨本领 R.

$$R = \frac{\bar{\lambda}}{\Delta\lambda} = kN.$$

§21. 光的偏振.

自然光　　部分偏振光



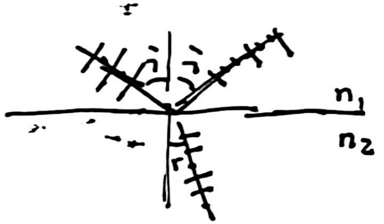
2. 起偏. 检偏. 马吕斯定律.

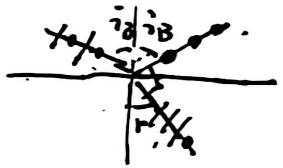
偏振片.

$I=\frac{1}{2}I_0$.

$I = I_0\cos^2\alpha$.

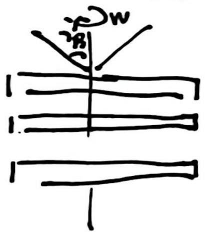
3. 反射折射致偏振.





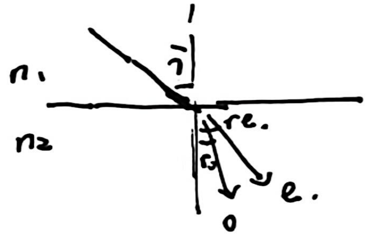
$\tan i_B = \frac{n_2}{n_1}$

玻璃片堆检偏.



4. 双折射.

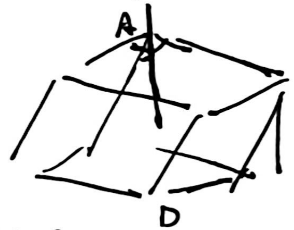
寻常光 (Ordinary)　异常光 (Exceptional)



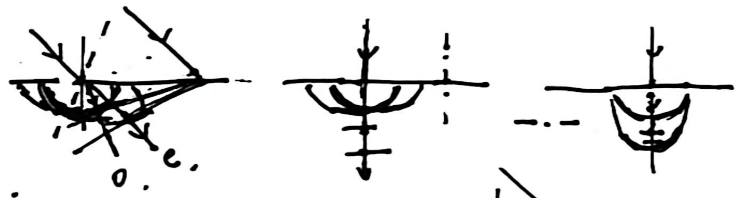
$n_1\sin i = n_2 r_o$.

$\frac{\sin i}{\sin r_e} \neq C$.

光轴　　单轴、双轴.



光轴位于入射面时 oe重合于平面.

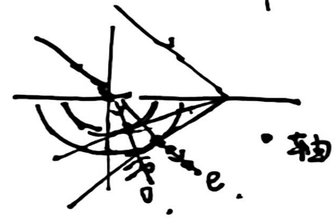


解释: 波阵面为旋转椭球面.

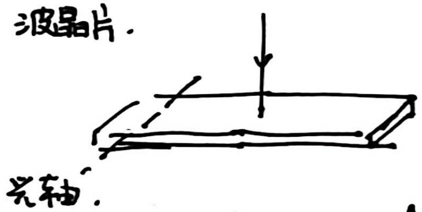
$n_e = \frac{c}{v_e}$. $n_o = \frac{c}{v_o}$.

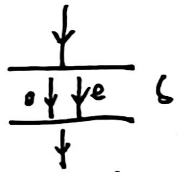
正晶体 $n_e > n_o$.

负晶体 $n_e < n_o$.



波晶片.





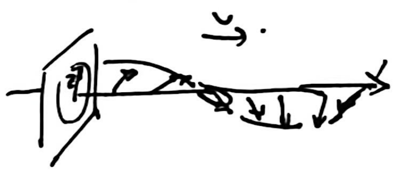
$\Delta\delta = |n_o - n_e|d$.

$\Delta\varphi = \frac{2\pi}{\lambda}\delta = \frac{2\pi}{\lambda}|n_o - n_e|d$.

四分之一波片. $\delta = \frac{\lambda}{4}$. $\Delta\varphi = \frac{\pi}{2}$.

二分之一波片. $\delta = \frac{\lambda}{2}$. $\Delta\varphi = \pi$.

5. 椭圆偏振光. 圆偏振光.



合成特殊偏振光.