TonyCrane 普通物理学Ⅱ(H)

$e = 1.60217733\times10^{-19}\,C$ 　 质子 $p(+e) = 2\times(\frac{2}{3}e) + (-\frac{1}{3}e)$ 　 $n(0) = 2\times(-\frac{1}{3}e) + \frac{2}{3}e$

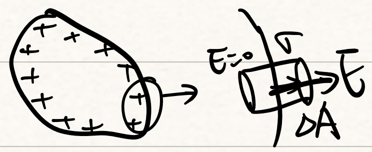
$F = \frac{1}{4\pi\varepsilon_0}\frac{q_1q_2}{r^2}\hat{r}$ 　 $k = \frac{1}{4\pi\varepsilon_0} = 9\times10^9\ Nm^2/C^2$ 　 $1C = 6\times10^{18}e$

$\vec{E} = \lim_{q_0\to0}\frac{\vec{F}}{q_0}$ 　 球坐标系 $\begin{cases} E_x = E_r\sin\theta\cos\varphi \\ E_y = E_r\sin\theta\sin\varphi \\ E_z = E_r\cos\theta \end{cases}$

电偶极矩矢量 $\vec{p} = q\vec{d}$ (负到正)

电通量 $\phi_E = \Sigma\vec{E}\cdot\vec{A}$ 　 $\phi_E = \oiint\vec{E}\cdot d\vec{A}$

高斯定理 $\oiint\vec{E}\cdot d\vec{A} = \phi_E = q_{内部}/\varepsilon_0$ 　 $\nabla\cdot\vec{E} = \frac{\rho_e}{\varepsilon_0}$




$\varepsilon_0\oiint\vec{E}\cdot d\vec{A} = \varepsilon_0 E\Delta A = \sigma\Delta A$

$E = \sigma/\varepsilon_0$

$U_b - U_a = -\int_a^b\vec{F}d\vec{l} = -q\int_a^b\vec{E}d\vec{l}$

静电场环路定理. circuit law of the electrostatic field:

$\oint\vec{E}\cdot d\vec{l} = 0$ 　 $\nabla\times\vec{E} = 0$ 　 $\nabla = (\frac{\partial}{\partial x}, \frac{\partial}{\partial y}, \frac{\partial}{\partial z})$

电势 electric potential 　 $V_p = U_p/q_0$ 　 $V_B - V_A = W_{AB}/q_0 = -\int_A^B\vec{E}\cdot d\vec{l}$

$a\to b$ 　 $\Delta V = V_b - V_a = -W_{ab}/q_0 = -\int_a^b\vec{E}\cdot d\vec{l}$

$r = \infty$ $V_\infty = 0$ 　 $V_p = -\int_\infty^p\vec{E}\cdot d\vec{l} = \int_p^{+\infty}\vec{E}\cdot d\vec{l}$ 　 $\vec{E} = \nabla\cdot V$

$C = q/\Delta V$ 　 平行板 $E = \frac{\sigma}{\varepsilon_0} = \frac{q}{A\varepsilon_0}$ $\Delta V = -\int_B^A\vec{E}d\vec{l} = \frac{q}{A\varepsilon_0}d$ 　 $C = q/\Delta V = \varepsilon_0 A/d$

圆柱电容(内a, 外b) $\Delta V = -\int_b^a E dr = \int_a^b\frac{Q}{2\pi\varepsilon_0 rL}dr$ 　 $C = 2\pi\varepsilon_0 L/\ln\frac{b}{a}$

球形 $\Delta V = \int_a^b q\,dr/4\pi\varepsilon_0 r^2 = \frac{q}{4\pi\varepsilon_0}(\frac{1}{a} - \frac{1}{b})$ 　 $C = 4\pi\varepsilon_0\frac{ab}{b-a}$

并联 $C = C_1 + C_2$ (V相等) 　 串联 $\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2}$ (q相等)

$dW = V\,dq = \frac{q}{C}dq$ 　 $W = \frac{1}{C}\int_0^Q q\,dq = \frac{1}{2}\frac{Q^2}{C} = \frac{1}{2}CV^2$

电场能量密度 $u = \frac{1}{2}\varepsilon_0 E^2$

$C = \kappa_e C_0$ 　 $\kappa_e > 1$ → 介电常数

极化强度矢量 $\vec{P} = \frac{\Sigma p_m}{\Delta V}$ ← volume 　 P在面上法向分量就是束缚电荷密度

电位移矢量（电感应矢量）$\vec{D}=\varepsilon_0\vec{E}+\vec{P}$ $\oiint \vec{D}\cdot d\vec{A}=\sum_{in} q_0$ 自由电荷

各向同性，$\chi_e$ 极化率 $K_e=1+\chi_e$ $\vec{P}=\chi_e\varepsilon_0\vec{E}$ $\vec{D}=K_e\varepsilon_0\vec{E}$

$\oint \vec{E}\cdot d\vec{l}=0$ $\oint \vec{D}\cdot d\vec{l}\neq 0$ 电介质中高斯定理（更普适）

电流强度 $i=\frac{dq}{dt}$ 电流密度 $\vec{j}$ $di=\vec{j}\cdot d\vec{A}$ $i=\iint_A \vec{j}\cdot d\vec{A}=\iint_A j\cos\theta\, dA$

$\oiint_A \vec{j}\cdot d\vec{A}=0$ 恒定电流条件

Ohm law $\Delta V=iR$ 非线性元件 微分电阻 $R=\frac{dU}{dI}$

电导（Conductance）$G=1/R$ 单位 S（西门子）

$R=\rho\frac{l}{A}=\int\rho\, dl/A$ $\rho$: resistivity $\sigma=1/\rho$ conductivity 电导率

$\Delta i=\Delta V/R$ $j\Delta A=\frac{E\Delta l}{\rho\frac{\Delta l}{\Delta A}}$ $j=E/\rho=\sigma\cdot E$ $\vec{j}=\sigma\cdot\vec{E}$ 欧姆定律微分形式

$W=qV_{AB}=i\Delta t V_{AB}$ $P=W/\Delta t=iV_{AB}$ $P=\frac{W}{\Delta t}=iV(=i^2R=V^2/R)$ ←仅R

欧姆定律微观：平均自由程 $\lambda$，平均自由时间 $\tau$，平均热运动速度 $v_t$

平均漂移速度（drift speed）$u$（由于电场作用）

$\vec{a}=-\frac{e}{m}\vec{E}$ $\vec{u}_1=\vec{a}\tau$ $\vec{u}=\frac{\vec{u}_0+\vec{u}_1}{2}=-\frac{e\tau}{2m}\vec{E}=-\frac{e}{2m}\frac{\lambda}{v_t}\vec{E}$

$\Delta q=neu\Delta t\cdot\Delta A$ $\Delta i=\frac{\Delta q}{\Delta t}=neu\Delta A$ $j=\frac{\Delta i}{\Delta A}=neu$

$\vec{j}=-ne\vec{u}=\frac{ne^2}{2m}\frac{\lambda}{v_t}\vec{E}$ $\sigma=\frac{ne^2}{2m}\frac{\lambda}{v_t}$ $\vec{j}=\sigma\vec{E}$ $v_t\propto\sqrt{T}$ $\sigma\propto\frac{1}{\sqrt{T}}$ $\rho\propto\sqrt{T}$

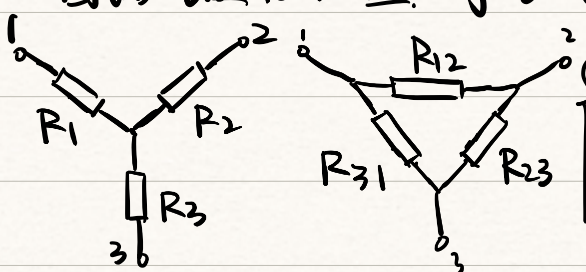
电源中还有非静电力. $\vec{K}=\vec{F}/q_0$ 电源中欧姆定律 $\vec{j}=\sigma(\vec{K}+\vec{E})$

emf 电动势 $\varepsilon=\int_-^+\vec{K}\cdot d\vec{l}$ $\varepsilon=\oint\vec{K}\cdot d\vec{l}$

基尔霍夫方程组（Kirchhoff's equations）

节点电流方程组 −流入电流+流出电流=0

回路电压方程组 $\oint\vec{E}\cdot d\vec{l}=0$ 电势降→正，电势升→负 和为0




$$\begin{cases} R_{12}=\frac{1}{R_3}(R_1R_2+R_2R_3+R_3R_1) \\ R_{23}=\frac{1}{R_1}(R_1R_2+R_2R_3+R_3R_1) \\ R_{31}=\frac{1}{R_2}(R_1R_2+R_2R_3+R_3R_1) \end{cases}$$

$R_1=R_{31}R_{12}/R_{12}+R_{23}+R_{31}$ $R_2=R_{12}R_{23}/\ldots$ $R_3=R_{31}R_{23}/\ldots$

$\oiint \vec{B}\cdot d\vec{A}=0$ $\mu_0 = 4\pi\times10^{-7}\ N/A^2$

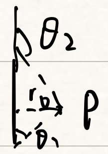
Ampere's law $d\vec{F}_{12} = k\frac{i_2 d\vec{s}_2\times(i_1 d\vec{s}_1\times\hat{r}_{12})}{r_{12}^2}$ $k=\frac{\mu_0}{4\pi}=10^{-7}\ N/A^2$

$d\vec{F}_2 = i_2 d\vec{s}_2 \times \frac{\mu_0}{4\pi}\oint_{L_1}\frac{i_1 d\vec{s}_1\times\hat{r}_{12}}{r_{12}^2}$ 定义 $\vec{B}_1=\frac{\mu_0}{4\pi}\oint_{L_1}\frac{i_1 d\vec{s}_1\times\hat{r}_{12}}{r_{12}^2}$

数值 $B_1=(dF_2)_{max}/i_2 ds_2$ 方向取决于 $i_1 d\vec{s}_1, \hat{r}_{12}$

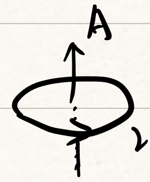
$d\vec{B}=\frac{\mu_0}{4\pi}\frac{i d\vec{s}\times\hat{r}}{r^2}$ 也叫 Biot-Savart Law / Laplace Law

无限长导线 $B=\frac{\mu_0 i}{2\pi r_0}$ $B=\frac{\mu_0 i}{4\pi r_0}(\cos\theta_1-\cos\theta_2)$



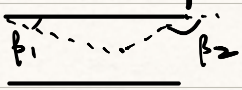

圆环 $B=\frac{\mu_0}{2}\frac{iR^2}{(R^2+r_0^2)^{3/2}}$ 圆心 $B=\frac{\mu_0 i}{2R}$ $r_0>>R$ $B=\frac{\mu_0 i R^2}{2r_0^3}$

$\mu=iA=i\pi R^2$ 磁偶极矩. N圈 $\mu=Ni\pi R^2$ $\vec{\mu}=i\vec{A}$




$B=\frac{\mu_0}{2\pi}\frac{\mu}{r_0^3}$ 宽为a的板 $B_x=\frac{\mu_0 i}{\pi a}\tan^{-1}\frac{a}{2R}$

螺线管内部 $B=\frac{1}{2}\mu_0 n i(\cos\beta_1-\cos\beta_2)$ 无穷长 $B=\mu_0 n i$




两端 $B=\frac{1}{2}\mu_0 n i$

磁通量 $\phi_B=\iint\vec{B}\cdot d\vec{A}=\iint B\cos\theta\, dA$ 单位 $T\cdot m^2=Wb$ $\vec{B}=\frac{d\phi_B}{dA}$

磁场高斯定理 $\oiint \vec{B}\cdot d\vec{A}=0$ $\nabla\cdot\vec{B}=0$

磁场安培环路定理 $\oint\vec{B}\cdot d\vec{l}=\mu_0\sum i$ $\sum i\to$ 环路中包的电流

方向:右手定则


$\cdot\to+$ $\times\to-$

长直导线内 $B=\frac{\mu_0 i r}{2\pi R^2}$ 无限大带电板 $B=\frac{\mu_0 n i}{2}$

螺线环(Toroid) $B=\frac{\mu_0 N i}{2\pi r}$

安培力 $d\vec{F}=i d\vec{s}\times\vec{B}$ 力矩 $\vec{\tau}=\vec{\mu}\times\vec{B}$ $U=-\vec{\mu}\cdot\vec{B}$

Lorentz Force $\vec{F}=q\vec{v}\times\vec{B}$

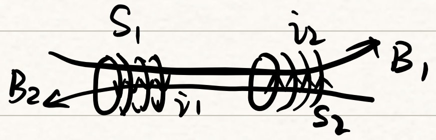
Faraday's Law $\varepsilon=-d\phi_B/dt$

动生电动势 (Motional emf) $\vec{K}=\frac{\vec{F}}{-e}=\vec{v}\times\vec{B}$ $\varepsilon=\int_-^+\vec{K}\cdot d\vec{l}$ $(=BLv)$

感生电动势 (Induced emf) $\varepsilon=\oint\vec{E}\cdot d\vec{l}$

有回路 生 i. $\varepsilon=-\frac{d\phi_B}{dt}$ 无回路 生 ε. E

感应电场 $\oint\vec{E}\cdot d\vec{l}=-d\phi_B/dt$

互感 Mutual inductance 

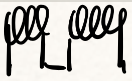
磁通匝链数 $\Psi_{12}=M_{12}i_1\propto N_2A_2B_1\propto N_2\phi_{12}$ (in $S_2$ due to $S_1$)

$M_{12}=M_{21}=M$ 互感系数 $\varepsilon_2=-M\,di_1/dt$ (单位亨利)

自感 Self inductance i变 B变 产生 $\varepsilon_L$

$\psi=Li$ $\varepsilon_L=-\frac{d\psi}{dt}=-L\frac{di}{dt}$

线圈串联 $(L_1, L_2)$ 不漏磁 $M=\sqrt{L_1L_2}$

顺接 $L=L_1+L_2+2M$  反接 $L=L_1+L_2-2M$ 

线圈中插入磁性材料 $L=K_mL_0$ $K_m$ 磁导率

轨道磁矩 $\mu=iA=\frac{e}{T}\cdot A=\frac{e}{2\pi r/v}\cdot\pi r^2=\frac{1}{2}erv$ 角动量 $l=mvr$

$\mu_l=\frac{e}{2m}l$ $\vec{\mu}_l=\frac{e}{2m}\vec{l}$ $\vec{\mu}_L=-\frac{e}{2m}\vec{L}$ 原子中所有电子的磁矩和.

量子力学 $L_z=(0,\pm1,\pm2,\cdots\pm l)\hbar$ 最小 $\mu_B=\frac{e\hbar}{2m}=\frac{eh}{4\pi m}$

自旋角动量 $S=\frac{1}{2}\hbar$ (质,中,电) Fermi子 $^2H$、$s=\hbar$ $^4_2He$ $s=0$ Bose子

$\vec{\mu}_S=-\frac{e}{m}\vec{S}$ $\vec{\mu}_J=\vec{\mu}_L+\vec{\mu}_S$ $\vec{\mu}_J=-\frac{e}{2m}\vec{J}$ $\vec{J}=\vec{L}+2\vec{S}$

质子有轨道磁矩 (中子无) 质子中子都有自旋磁矩. $\vec{\mu}_N\ll\vec{\mu}_A\left(\frac{1}{1800}\right)$ $\vec{\mu}_N=\frac{e}{2M}\vec{J}_N$

磁化强度矢量 $\vec{M}=\sum\vec{\mu}_m/\Delta V$

束缚电流 $\oint\vec{M}\cdot d\vec{l}=\sum i'$ $\vec{M}\times\vec{n}=\vec{j}'$

$\vec{B}=\vec{B}_0+\vec{B}_M$ $\oint\vec{B}\cdot d\vec{l}=\mu_0\sum_{inL}(i_0+i')=\mu_0\sum_{inL}i_0+\mu_0\oint\vec{M}\cdot d\vec{l}$

$\oint\left(\frac{\vec{B}}{\mu_0}-\vec{M}\right)\cdot d\vec{l}=\sum_{inL}i_0$ 磁场强度 $\vec{H}=\frac{\vec{B}}{\mu_0}-\vec{M}$ 安环 $\oint\vec{H}\cdot d\vec{l}=\sum_{inL}i_0$

$\vec{H}=\frac{\vec{B}}{\mu_0}-\vec{M}$ 单位 Os 奥斯特. $1A/m=4\pi\times10^{-3}$ Os

$\vec{M} = \chi_m \vec{H}$ $\chi_m$ 磁化率. $\vec{B} = K_m \mu_0 \vec{H}$ $K_m$ 磁导率. $B = K_m B_0$

$\vec{B} = \mu_0 (\vec{H} + \vec{M}) = \mu_0 (1 + \chi_m) \vec{H} = K_m \mu_0 \vec{H}$ $(K_m = 1 + \chi_m)$

顺磁材料 (Paramagnetic) $\chi_m > 0$ $K_m > 1$ $(\chi_m \approx 10^{-6}, K_m \approx 1)$

抗磁 — (Diamagnetic) $\chi_m < 0$ $K_m < 1$ $(|\chi_m| \ll 1$ $K_m \approx 1)$

铁磁 — (Ferromagnetic) $\chi_m(H)$ $K_m(H)$ $K_m \approx 10^2 \sim 10^3$

RC 电路 $iR + q/C = \varepsilon$ $dq/dt + q/RC = \varepsilon/R$ $q = C\varepsilon(1 - e^{-t/RC})$

$t_c = RC$ 时间常数. (充 63%)

RL 电路 $iR + L\, di/dt = \varepsilon$ $i = \frac{\varepsilon}{R}(1 - e^{-t/\tau_L})$ $\tau_L = L/R$ ← 时间常数.

L 上电压 $V_L = -L\, di/dt = -\varepsilon e^{-t/\tau_L}$

无电源. 放电 $iR + L\, di/dt = 0$ $i = \frac{\varepsilon}{R} e^{-t/\tau_L}$ $V_L = -\varepsilon e^{-t/\tau}$

L 存储的磁场能量 $dW = -\varepsilon_L dq = -\varepsilon_L i\, dt$ $\varepsilon_L = -L\, di/dt$.

$dW = Li\,di$ $W = \int_0^{i_m} Li\,di = \frac{1}{2} L i_{max}^2 = \frac{1}{2} L I^2$

K 个线圈总能量 $U = \frac{1}{2} \sum_{i=1}^{k} L_i I_i^2 + \frac{1}{2} \sum_{i,j=1}^{k} M_{ij} I_i I_j$

磁场能量密度 $u_B = B^2/2\mu_0 = \frac{1}{2} \vec{B} \cdot \vec{H}$ $u_E = \frac{1}{2}\varepsilon_0 E^2 = \frac{1}{2} \vec{D} \cdot \vec{E}$

静电场高斯 $\oiint \vec{E} \cdot d\vec{A} = \Sigma q_内 / \varepsilon_0$ 电介质: $\oiint \vec{D} \cdot d\vec{A} = q_内$

环路 $\oint \vec{E} \cdot d\vec{l} = 0 \rightarrow \oint \vec{E} \cdot d\vec{l} = -\frac{d\phi_B}{dt}$ $\vec{D} = \varepsilon_0 \vec{E} + \vec{P}$

磁场高斯 $\oiint \vec{B} \cdot d\vec{A} = 0$ $\vec{H} = \vec{B}/\mu_0 - \vec{M}$

环路 $\oint \vec{B} \cdot d\vec{l} = \mu_0 \Sigma i_内$ $\oint \vec{H} \cdot d\vec{l} = \Sigma i_内$

欧姆定律. $\Delta V = iR$ $\vec{j} = \sigma \cdot \vec{E}$

电场高斯 $\Rightarrow \nabla \cdot \vec{E} = \rho_e / \varepsilon_0$

柱坐标系 梯度 $\nabla f = \frac{\partial f}{\partial \rho} \vec{e}_\rho + \frac{1}{\rho} \frac{\partial f}{\partial \theta} \vec{e}_\theta + \frac{\partial f}{\partial z} \vec{e}_z$ 散度 $\nabla \cdot f = \frac{1}{\rho} \frac{\partial}{\partial \rho}(\rho f_\rho) + \frac{1}{\rho} \frac{\partial f_\varphi}{\partial \varphi} + \frac{\partial f_z}{\partial z}$

球— —: $\nabla f = \frac{\partial f}{\partial r} \vec{e}_r + \frac{1}{r} \frac{\partial f}{\partial \theta} \vec{e}_\theta + \frac{1}{r\sin\theta} \frac{\partial f}{\partial \varphi} \vec{e}_\varphi$ $\nabla \cdot f = \frac{1}{r^2} \frac{\partial}{\partial r}(r^2 f_r) + \frac{1}{r\sin\theta} \frac{\partial}{\partial \theta}(\sin\theta f_\theta) + \frac{1}{r\sin\theta} \frac{\partial f_\varphi}{\partial \varphi}$

束缚电荷 $\sigma_e' = \vec{P} \cdot \vec{n}$

$V_p = \int_p^{+\infty} \vec{E}\cdot d\vec{l}$ $\vec{E} = \nabla V$ $C = \frac{\varepsilon_0 A}{d}$ $\frac{2\pi\varepsilon_0 L}{\ln b/a}$ $4\pi\varepsilon_0 \frac{ab}{b-a}$

$dB = \frac{\mu_0}{4\pi}\frac{id\vec{s}\times\hat{r}}{r^2}$ $\vec{\tau} = \vec{\mu}\times\vec{B}$

电磁波性质. 横波 $\vec{E}\perp\vec{k}$ $\vec{H}\perp\vec{k}$, $\vec{E}\perp\vec{H}$, EH同相.

右手定则. $\sqrt{K_e\varepsilon_0}E_0 = \sqrt{K_m\mu_0}H_0$ 速度 $v = \frac{1}{\sqrt{K_e\varepsilon_0 K_m\mu_0}} = \frac{1}{\sqrt{\varepsilon_0\mu_0}} = 3\times10^8 m/s = c$

球面镜成像. 傍轴: $\frac{n'}{i} + \frac{n}{o} = \frac{n'-n}{r}$ o物距. i像距. r球半径 n内

$i\to+\infty$ $o = f = \frac{n}{n'-n}r$ 第一焦点 $\frac{f}{f'} = \frac{n}{n'}$ $\frac{f}{o}+\frac{f'}{i} = 1$

$o\to+\infty$ $i = f' = \frac{n'}{n'-n}r$ 第二 ...

球面反射成像. $n = -n'$ 证负反向 $\Rightarrow f = -\frac{r}{2}$, $f' = \frac{r}{2}$, $\frac{1}{o}+\frac{1}{i} = -\frac{2}{r}$

横向放大率 $m = \frac{y'}{y} = -\frac{i\theta'}{o\theta} = -ni/n'o$ 反射: $m = -i/o$

薄透镜 $f' = f_1'f_2'/(f_1'+f_2)$ $f = f_1f_2/(f_1'+f_2)$

磨镜者公式 $n = n' = 1$ $f = f' = 1/(n_L-1)(\frac{1}{r_1}-\frac{1}{r_2})$

$m = -\frac{f}{x} = -x'/f'$ $x, x'$为物/像到各自焦点距离

屈光度 $P = 1/f$ $f = -0.5m$ $P = -2.00D \to 200$度.

定态波. $U(P,t) = A(P)\cos(\omega t - \varphi(P))$

平面波. $A(P) = \text{const}$. $\varphi(P) = \vec{k}\cdot\vec{r}+\varphi_0$ $k = \frac{2\pi}{\lambda}$ $\vec{r} = x\vec{i}+y\vec{j}+z\vec{k}$

球面波 $A(P) = a/r$ $\varphi(P) = kr+\varphi_0$

电磁波. $\vec{E}(P,t) = \vec{E_0}(P)\cos(\omega t - \varphi(P))$

$\vec{H}(P,t) = \vec{H_0}(P)\cos(\omega t - \varphi(P))$

$\tilde{U}(P,t) = A(P)e^{\pm i(\omega t - \varphi(P))} \to \underbrace{A(P)e^{i\varphi(P)}}_{\tilde{U}(P)\text{ 复振幅}} e^{-i\omega t}$

平面波 $\tilde{U}(P) = Ae^{i(\vec{k}\cdot\vec{r}+\varphi_0)}$

球面波 $\tilde{U}(P) = \frac{a}{r}e^{i(kr+\varphi_0)}$

强度 $I(P) = (A(P)^2) = \tilde{U}^*(P)\cdot\tilde{U}(P)$

干涉. $\tilde{U}_1(P,t) = A_1e^{i\varphi_1(P)}e^{-i\omega t}$ $\tilde{U}_2(P,t) = \cdots$

$\tilde{U}(P,t) = \tilde{U}_1(P,t)+\tilde{U}_2(P,t)$ $I(P) = A_1^2+A_2^2+2A_1A_2\cos(\varphi_1-\varphi_2)$

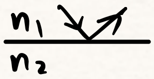
$I(P) = I_1(P) + I_2(P) = 2\sqrt{I_1(P)I_2(P)}\cos(\varphi_1-\varphi_2)$

干涉条件: $\omega_1=\omega_2=\omega$ $\vec{U_1}\parallel\vec{U_2}$ $\varphi_1(P)-\varphi_2(P)$ 稳定.

$I_1(P)=(A_1(P))^2$ $A_1(P)\propto\frac{1}{r_1}$ $r_1>>d$ $r_2>>d \Rightarrow A_1(P)=A_2(P)=A$.

$I(P)=4A^2\cos^2\delta(P)/2$. $\delta(P)=\varphi_{10}-\varphi_{20}+\frac{2\pi}{\lambda}(r_1-r_2)$

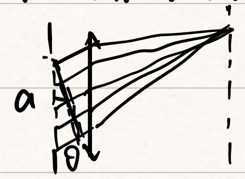
if $\varphi_{10}-\varphi_{20}=0$ $\Delta L=r_1-r_2=m\lambda$, 大 $(m+\frac{1}{2})\lambda$ 小 $m=0,\pm1,\pm2\cdots$

半波损失 

$n_1<n_2$ 则反射时多走 $\frac{\lambda}{2}$ (相位变180°)

$n_1>n_2$ 则无变化

弗朗和大衍射.




$E_\theta=E_m\frac{\sin\alpha}{\alpha}$ $\alpha=\frac{\pi a}{\lambda}\sin\theta$

$I_\theta=E_\theta^2=I_m^2\left(\frac{\sin\alpha}{\alpha}\right)^2$

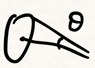
条纹宽

中心零级最大. $a\sin\theta=\lambda$ $\sin\theta=\Delta\theta=\frac{\lambda}{a}$ $\Delta y_m=2f\Delta\theta=2f\frac{\lambda}{a}$.

m级最大. $a\sin\theta=(m+\frac{1}{2})\lambda$ 附近. (小一点)

a 圆孔半径

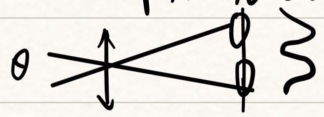
~ 圆孔衍射. $I_\theta=I_0\left(\frac{2J_1(x)}{x}\right)^2$ $x=\frac{2\pi a}{\lambda}\sin\theta$ $J_1(x)$ 一阶贝塞尔

中心亮斑 

$\Delta\theta=0.61\frac{\lambda}{a}=1.22\frac{\lambda}{D}\approx\sin\theta$

光栅常数

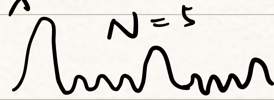
缝间距.




$\theta_R=\theta_{min}=1.22\frac{\lambda}{D}$ $R=\frac{1}{\theta_R}$ 分辨能力

N个单缝 $I_\theta=I_m\left(\frac{\sin\alpha}{\alpha}\right)^2\left(\frac{\sin N\beta}{\sin\beta}\right)^2$ $\alpha=\frac{\pi a}{\lambda}\sin\theta$ $\beta=\frac{\pi d}{\lambda}\sin\theta$

在2个主极大间有 N-1个极小、N-2个次极大




$\beta=m\pi$ $d\sin\theta=m\lambda$ 主极大 $\beta=(m+\frac{n}{N})\pi$ 零点位置.

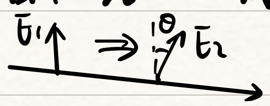
主极大半角宽度. $\theta_m\approx\sin\theta_m=\frac{m\lambda}{d}$ $\theta_m+\Delta\theta\approx(m+\frac{1}{N})\frac{\lambda}{d}$ $\Delta\theta=\frac{\lambda}{Nd\cos\theta}$

光栅色散本领 $D=\Delta\theta/\Delta\lambda=m/d\cos\theta$ $(d\sin\theta=m\lambda$ $d\cos\theta\,\Delta\theta=m\Delta\lambda)$

半角宽

分辨本领 $\Delta\lambda=\Delta\theta_w/D=\lambda/Nm$ $R=\lambda/\Delta\lambda=Nm$

自然光 → 线偏振光. 光强减半




$I_2=I_1\cos^2\theta$ 马吕斯定律

$E_x=E_{x0}\sin(kz-\omega t+\varphi_x)$ $E_y=E_{y0}\sin(kz-\omega t+\varphi_y)$

$\varphi_x-\varphi_y=0$ $E_{y0}/E_{x0}=\tan\theta$ 线偏振.

$\varphi_x-\varphi_y=\pm\frac{\pi}{2}$ $E_{y0}=E_{x0}$ 圆偏振.

无偏振 线偏振 ↕ 部分偏振 $E_{max}$ $E_{min}$ 偏振度 $P=\frac{I_{max}-I_{min}}{I_{max}+I_{min}}$

圆偏振 $E_x=E_0\sin(kz-\omega t\pm\frac{\pi}{2})$ (+右旋. −左旋.) $E_y=E_0\sin(kz-\omega t)$

椭圆偏振光. $E_x=E_1\sin(kz-\omega t+\delta)$ $E_y=E_2\sin(kz-\omega t)$ 且 $E_1\neq E_2$ 或 $\delta\neq\pm\frac{\pi}{2}$

反射偏振. 布儒斯特角：反射光线与折射光线垂直时. 反射光线变成线偏振

此时入射角称为：$\theta_p$ 只有垂直光线方向

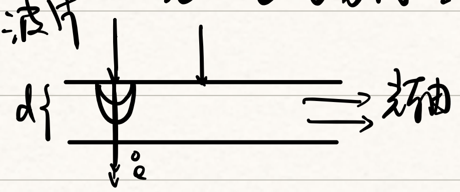
双折射. o光寻常光 和正常折射一样 e光非~ 在不同方向上 $v$ 不同

e光速度在 $v_o$ $v_e$ 间变化. $n_o$ . $n_e$：主折射率

$n_e<n_o$ 负晶体. $n_e>n_o$ 正晶体. 沿光轴方向. o.e 速度相同.

o光：电场方向垂直于传播方向与光轴所成平面 e光：在……内.

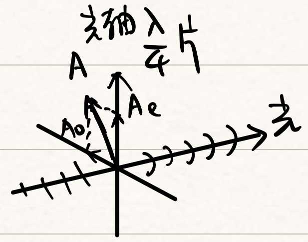
波片

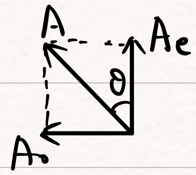



光程 $L_o=n_od$ $L_e=n_ed$ $\Delta\varphi=\frac{2\pi}{\lambda}(n_o-n_e)d$

$(n_o-n_e)d=\pm\frac{1}{4}\lambda$ $\Delta\varphi=\pm\frac{\pi}{2}$ $\frac{1}{4}\lambda$片. 线偏振→圆偏振

$(n_o-n_e)d=\pm\frac{1}{2}\lambda$ $\Delta\varphi=\pm\pi$或$2\pi$ $\frac{1}{2}\lambda$片




$\theta=45°$ 线→圆 —.

光出来转了 有角动量. 守恒 ⇒ 晶体转了

电磁波能流密度. 动量. $\vec{D}=K_e\varepsilon_0\vec{E}$ $\vec{B}=K_m\mu_0\vec{H}$

$$U=\iiint\left(\frac{1}{2}\varepsilon_0E^2+\frac{1}{2}\frac{B^2}{\mu_0}\right)dv \quad / \quad U=\iiint\left(\frac{1}{2}\vec{D}\cdot\vec{E}+\frac{1}{2}\vec{B}\cdot\vec{H}\right)dv$$

$$\frac{dU}{dt}=-\iiint\nabla\cdot(\vec{E}\times\vec{H})dv-\iiint(\vec{j}_0\times\vec{E})dv=-\oiint(\vec{E}\times\vec{H})\cdot d\vec{A}-\iiint(\vec{j}_0\times\vec{E})dv$$

$$\iiint(\vec{j}_0\times\vec{E})dv=i_0^2R-i_0\varepsilon=Q-P$$

$\oiint(\vec{E}\times\vec{H})\cdot d\vec{A}$ ⇒ $\vec{S}=\vec{E}\times\vec{H}$ 坡印廷矢量

电磁场能量通量

$$\frac{dU}{dt} = -\underbrace{\oiint \vec{S}\cdot d\vec{A}} - Q + P$$

$$\vec{S} = \vec{E}\times\vec{H} = \frac{1}{\mu_0}\vec{E}\times\vec{B}$$ 数值 $S = \frac{EB}{\mu_0} = \frac{E^2}{\mu_0 c}$ $Z_0 = \mu_0 c = 377\Omega$

$$I = \langle S\rangle = \frac{\langle E^2\rangle}{Z_0} = \frac{E_{max}^2}{377\Omega}\langle \sin^2(kz-\omega t)\rangle = \frac{1}{2}\frac{E_{max}^2}{377\Omega} \quad \text{Watts}/m^2$$

E-M wave : $B = E/c$ $u_B = \frac{1}{2}\varepsilon_0 E^2 = \frac{1}{2}\frac{B^2}{\mu_0} = u_E$

$u = u_B + u_E = \varepsilon_0 E^2$ $\langle u\rangle = \varepsilon_0\langle E^2\rangle = \frac{1}{2}\varepsilon_0 E_{max}^2$

$E_{rms} = E_{max}/\sqrt{2}$ $\langle u\rangle = \varepsilon_0 E_{rms}^2$ $I = c\langle u\rangle = E_{rms}^2/377\Omega$

动量密度 $\vec{g} = \frac{1}{c^2}\vec{S} = \frac{1}{c^2}(\vec{E}\times\vec{H})$

光压 100%反射 $P = \frac{2}{c}|\vec{S}_{in}| = \frac{2}{c}EH$ 黑体 $P = \frac{1}{c}|\vec{S}_{in}| = \frac{1}{c}EH$