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百度贴吧 中国……学近代光学基础

老师说话相当慢．前言 了光是什么　上帝说，要有光于是就有了光．

光学的历史发展．钻木取火　铜镜　阳燧取火　主表《墨子》小孔成像

欧几里得：光反射定律　Plato 光在水面折射

（看过一个节目实地演示，点不着）　透镜的发明

一　部分相干光理论

1. 几个概念　角频率　$\omega = 2\pi\nu = \frac{2\pi}{\lambda}c = kc$

准单色光　$\frac{\Delta\lambda}{\lambda} \ll 1$ 或 $\frac{\Delta\omega}{\omega} \ll 1$

可见度　$V(x) = \frac{I_{max} - I_{min}}{I_{max} + I_{min}}$

完全相干　$V(x) = 1$

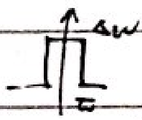
部分相干　$V(x) \in (0,1)$

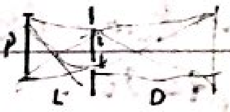
完全非相干　$V(x) = 0$

严格单色光点 → 平顶型 —— 一般线型 → 非单色扩展

严格单色光点 → 均匀扩展 —— 非均匀扩展 → 非单色扩展

2. 理想杨氏干涉

平顶型　　$dI(x) = 2I_0\left[1+\cos\frac{k}{D}(dx)\right]d\omega$　$I = 2I_0\Delta\omega\left[1+\frac{\sin\frac{\Delta\omega\, xd}{Dc}}{\frac{\Delta\omega\, xd}{Dc}}\cos\frac{\bar{\omega}\, xd}{Dc}\right]$

扩展均匀　　$dI(x) = 2I_0\left[1+\cos\left[k\left(\frac{dx}{D}+\frac{dx_0}{L}\right)\right]\right]dx = 2I_0 p\left[1+\frac{\sin k\frac{dp}{2L}}{k\frac{dp}{2L}}\cos\frac{2\pi dx}{D}\right]$

$\boxed{2.26}$ 5月份开卷考试．两小时

3. 一般性型　对于光谱成分较宽的光引入 $y = \omega - \bar{\omega}$，$I(x) = 2\int I(y)\left[1+\cos\frac{2xd}{Dc}(\bar{\omega}+y)\right]dy$ 展开

$= 2\int I_1(y)dy + 2\int I_1(y)\cos\bar{\omega}\frac{2xd}{Dc}\cos y\frac{2xd}{Dc}dy - 2\int I_1(y)\sin\bar{\omega}\frac{2xd}{Dc}\sin y\frac{2xd}{Dc}dy$

记为　$P + C(x)\cos\bar{\omega}\frac{2xd}{Dc} - S(x)\sin\bar{\omega}\frac{2xd}{Dc}$．　P 平均值　S C 包络　sin cos 一起 条纹位置

$I \in [P \pm \sqrt{C^2+S^2}]$

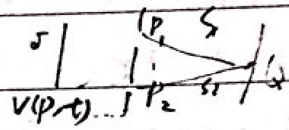
非均匀光源　$I(x) = 2\int_{-\frac{p}{2}}^{\frac{p}{2}} I_0(x_0)\left\{1+\cos\left[2k\left(\frac{dx}{D}+\frac{dx_0}{L}\right)\right]\right\}dx_0$　$C(L,x) = 2\int_{-\frac{p}{2}}^{\frac{p}{2}} I_0(x_0)\cos\frac{2kdx_0}{L}dx_0$

$= P + C(L,x)\cos\left[2k\frac{dx}{D}\right] - S(L,x)\sin\left(2k\frac{dx}{D}\right)$

偏振态

4. 互相干函数

稳态光场，标量处理　时间间隔



$$V(Q,t)=K_1V(P_1,t-t_1)+K_2V(P_2,t-t_2)$$

K依倾斜因子 $\propto \frac{1}{s}$ 与孔大小与光路有关，次波超前入射光 $\frac{\pi}{2}$

$$I(Q)=\langle I(Q,t)\rangle=\langle V(Q,t)V^*(Q,t)\rangle$$

$$=|K_1|^2I_1+|K_2|^2I_2+2\mathrm{Re}[K_1K_2^*\langle V_1(t-t_1)V_2^*(t-t_2)\rangle]$$

$t-t_2=t'$　$t-t_1=t'+\tau$　$\tau=\frac{s_2-s_1}{c}$ 为延迟时间

$$\to \mathrm{Re}[\langle V_1(t+\tau)V_2^*(t)\rangle]$$

$\boxed{3.2}$ def $\Gamma_{12}(\tau)=\frac{1}{2T}\int_{-T}^{T}V_1(t+\tau)V_2^*(t)dt$

自相干函数 $\Gamma_{11}(\tau)$　$\Gamma_{11}(0)=I_1$　$\Gamma_{22}(0)=I_2$　(时间相干性)

归一化 $\Gamma_{12}(\tau)$　复相干度 $\gamma_{12}(\tau)\triangleq\frac{\Gamma_{12}(\tau)}{\sqrt{\Gamma_{11}(0)\Gamma_{22}(0)}}=\frac{\Gamma_{12}(\tau)}{\sqrt{I_1I_2}}$

$$I(Q)=I^1(Q)+I^2(Q)+2\mathrm{Re}\left[\sqrt{I^1(Q)I^2(Q_2)}\,\gamma_{12}\left(\frac{s_2-s_1}{c}\right)\right]$$

$|\gamma_{12}(\tau)|$ 调制度　$\arg\gamma_{12}(\tau)$ 干涉级的位置　$\alpha_{12}(\tau)$：光源的性质带来的相位

$$\arg\gamma_{12}(\tau)=\alpha_{12}(\tau)-\delta=\alpha_{12}(\tau)-\frac{2\pi}{\bar\lambda}(s_2-s_1)=\alpha_{12}(\tau)-2\pi\bar\nu\tau$$

$$\gamma_{12}^{(r)}(\tau)=|\gamma_{12}(\tau)|\cos[\alpha_{12}(\tau)-2\pi\bar\nu\tau]$$

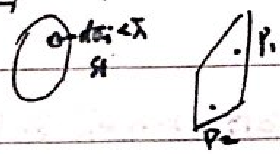
5. 准单色光的干涉

互强度 $J_{12}\triangleq\Gamma_{12}(0)$　互相干因子 $\mu_{12}=\gamma_{12}(0)$　有效位相差 $\beta_{12}=\arg\gamma_{12}(0)$

$$\gamma_{12}(\tau)=|\gamma_{12}(\tau)|e^{i[\alpha_{12}(\tau)-2\pi\bar\nu\tau]}\to\mu_{12}e^{-i2\pi\bar\nu\tau}$$

$$\Gamma_{12}(\tau)\leftrightarrow J_{12}e^{-i2\pi\bar\nu\tau}$$

$\boxed{3.4}$ 扩展准单色光场的互强度和相干度



$V_1(t)=\sum V_{m1}(t)$　$V_2(t)=\sum V_{m2}(t)$

$$J_{12}(P_1,P_2)=\langle V_1(t)^*V_2(t)\rangle=\sum_m\langle V_{m1}(t)V_{m2}^*(t)\rangle+\underbrace{\sum\sum\langle V_{m1}(t)V_{n2}^*(t)\rangle}_{0}$$

$$V_{m1}(t)=A\left(t-\frac{R_{m1}}{v}\right)\frac{e^{-j2\pi\bar\nu(t-\frac{R_{m1}}{v})}}{R_{m1}}\qquad V_{m2}(t)=\ldots$$

$$J(P_1,P_2)=\sum_m\left\langle A_{m1}(t)A_{m2}^*\left(t-\frac{R_{m1}-R_{m2}}{v}\right)\right\rangle\frac{e^{j2\pi\bar\nu(R_{m1}-R_{m2})/v}}{R_{m1}R_{m2}}$$

$$=\sum_m I(S_m)\Delta\sigma_i\frac{e^{j\bar k(R_{m1}-R_{m2})}}{R_{m1}R_{m2}}=\int I(S)\frac{e^{j\bar k(R_1-R_2)}}{R_1R_2}d\sigma$$

$$I(P_1) = J(P_1,P_1) = \int I(s)\frac{1}{R_1^2}ds \qquad \mu(P_1,P_2) = \frac{J(P_1,P_2)}{\sqrt{I(P_1)}\sqrt{I(P_2)}}$$

$$R_2 = R + \frac{(x_1-\xi)^2+(y_1-\eta)^2}{2R}$$

$$\frac{x_1-x_2}{R}=p \qquad \frac{y_1-y_2}{R}=q$$

$$R_1-R_2 = \frac{1}{2R}[(x_1^2+x_2^2)+(y_1^2+y_2^2)] - \frac{1}{R}[(x_1-x_2)\xi+(y_1-y_2)\eta] \qquad \psi = \frac{k[(x_1^2+y_1^2)-(x_2^2+y_2^2)]}{2R}$$

$$J = e^{j\psi}\iint I(\xi,\eta)\frac{e^{-jk(p\xi+q\eta)}}{R^2}d\xi d\eta \qquad \mu(P_1,P_2) = \frac{e^{j\psi}\iint I(\xi,\eta)e^{-jk(p\xi+q\eta)}d\xi d\eta}{\iint I(\xi,\eta)d\xi d\eta}$$

相干面积 $\int|\mu_{12}|ds$ A_c 角直径 $\theta = A\frac{\lambda}{2L}$ 缝 晶体 圆盘

7. 互相干函数的传播

霍普金斯公式：$J(P_1,P_2) = \int U(s,P_1)U^*(s,P_2)ds$

$$U(s,Q_1) = \int_A U(s,P_1)\frac{e^{jks_1}}{s_1}\Lambda_1 dP_1$$

$$J(Q_1,Q_2) = \iint_{AA} J(P_1,P_2)\frac{e^{jk(s_1-s_2)}}{s_1 s_2}\Lambda_1\Lambda_2^* dP_1 dP_2$$

非相干光的互相干计算

$$\Gamma(P_1,P_2,\tau) = \sqrt{I(P_1)}\sqrt{I(P_2)}\,\gamma(P_1,P_2,\tau) = J_{12}e^{-i2\pi\nu t} = \int_0^\infty d\nu e^{-i2\pi\nu t}\int I(s,\nu)\frac{e^{ik(R_1-R_2)}}{R_1R_2}ds$$

$\boxed{3.19}$ 8. 互相干函数的测量

*杨氏干涉法 调制盘

算出后焦面的光场分布

两层光栅剪切干涉仪 像面法

9. 强度干涉仪

10. 偏振

$$E(\theta,\delta,t) = E_x\cos\theta + E_y\sin\theta\, e^{i\delta} \qquad \delta = \phi_x-\phi_y$$

$$I(\theta,\delta) = \langle EE^*\rangle = J_{xx}\cos^2\theta + J_{yy}\sin^2\theta + J_{xy}e^{-i\delta}\sin\theta\cos\theta + J_{yx}e^{i\delta}\sin\theta\cos\theta$$

看作矩阵 的矩阵元

a_x a_y φ_x φ_y 随时间变化 $\frac{\Delta\lambda}{\lambda}$ << 1 时 $\frac{a_x(t)}{a_y(t)} = r$ $\delta = \varphi_x(t) - \varphi_y(t)$ 与

斯托克斯矢量 邦加球

非单色偏振光

[3.11] 二 标量场衍射理论 傅立叶光学

惠更斯—菲涅耳原理

$$U(P) = \iint_{\sigma_1} U(r_1)\frac{e^{ikr_0}}{r_0}\iint_{s} k(x)\frac{e^{ikx}}{s}\,ds\,d\sigma_1$$

基尔霍夫衍射理论

$$U(P_0) = \frac{1}{4\pi}\iint_{s_0+s_1+s_2}\left\{\frac{\partial U}{\partial n}\left[\frac{\exp(ikr_{01})}{r_{01}}\right] - U\frac{\partial}{\partial n}\frac{\exp(ikr_{01})}{r_{01}}\right\}ds$$

瑞利—索末菲衍射理论

$$U(P_0) = \frac{A}{i\lambda}\iint_{\Sigma}\frac{e^{ik(r_{01}+r_{21})}}{r_{01}r_{21}}\frac{\cos(n,r_{01})-\cos(n,r_{21})}{2}ds$$

近似

$$= \iint\left(\frac{Ae^{ikr_{21}}}{r_{21}}\frac{1}{i\lambda}\right)\left(\frac{e^{ikr_{01}}}{r_{01}}\frac{\cos-\cos}{2}\right)ds$$

$$= \iint U(x_1,y_1)h(x_0,y_0;x_1,y_1)\,dx_1dy_1$$

近似条件 $z \gg \Sigma$ $z \gg x_0$

$$h = \frac{1}{i\lambda}\frac{Ae^{ikz}}{z}$$

菲涅耳近似 $r_{01} \simeq z\left[1+\frac{1}{2}\left(\frac{x_0-x_1}{z}\right)^2+\frac{1}{2}\left(\frac{y_0-y_1}{z}\right)^2\right]$

[3.15]

$$U(x_0,y_0) = \frac{e^{jkz}}{j\lambda z}e^{j\frac{k}{2z}(x_0^2+y_0^2)}$$

$$U(x_0,y_0) = \iint U(x_1,y_1)e^{j\frac{k}{2z}(x_1^2+y_1^2)}e^{-j\frac{2\pi}{\lambda z}(x_0x_1+y_0y_1)}dx_1dy_1$$

$$= \frac{e^{jkz}}{j\lambda z}e^{j\frac{k}{2z}(x_0^2+y_0^2)}F\{U(x_1,y_1)\}$$

夫朗和费近似

$$= \frac{e^{jkz}}{j\lambda z}e^{j\frac{k}{2z}(x_0^2+y_0^2)}F\{U(x_1,y_1)\}$$

棒透镜的FT性质

空间频率

3.17 夫朗和费衍射光场的计算

1.选择函数 $t(x_1,y_1)$

2. 平面波，单色振幅 $U_0(x_1,y_1)=t(x_1,y_1)$

$$U(x_0,y_0)=\frac{e^{jkz}}{j\lambda z}e^{j\frac{k}{2z}(x_0^2+y_0^2)}F\{U_0(x_1,y_1)\}$$

$$I(x_0,y_0)=U^*U(x_0,y_0)$$

角谱衍射理论

3-23 角谱的传播

5.3 物 $U_O(x,y)=A_O(x,y)e^{-j\varphi_O(x,y)}$

$U_R(x,y)=A_R(x,y)e^{-j\varphi_R(x,y)}$

$I(x,y)=|U_O+U_R|^2=|A_O|^2+|A_R|^2+2A_OA_R\cos[\varphi_O-\varphi_R]\quad(x,y)$

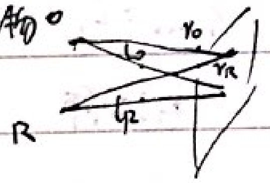
τ 曝光时间 $E=I\cdot\tau$ 底片能量

$t(x,y)=t_0+\beta(|U_O|^2+U_R^*U_O+U_RU_O^*)$ $\beta=$曲线斜率 $\times\tau$

再现 $U_B(x,y)=A_Be^{j\varphi_B}$

$U_Bt=t_0U_B+\beta|U_O|^2U_B+\beta U_R^*U_BU_O+\beta U_RU_BU_O^*$

8.1 物 o



菲涅耳近似 $\varphi_O=\frac{k_1}{l_0}[x^2+y^2-2(xx_0+yy_0)]$

4.6 全息记录介质 $Q=\frac{\nu\cdot\eta}{W}$ $\left(\frac{\text{分辨率 . 衍射效率}}{\text{能量}}\right)$

4.13 晶体光学

线性 $D=\varepsilon E$ $D=\alpha E+\beta E^2+\gamma E^3$ 非线性 ε张量

双折射 e光可能不在入射平面内

波法线折射 n_o n_e $v=\sqrt{\frac{1}{\varepsilon\mu}}=\frac{c}{n}$

《光学原理》14章

一. 折射率张量　　各向同性 $D=\varepsilon E$

$D=\begin{pmatrix}D_1\\D_2\\D_3\end{pmatrix}$　$E=\begin{pmatrix}E_1\\E_2\\E_3\end{pmatrix}$　由 $\varepsilon=\begin{pmatrix}\varepsilon_{11}&\varepsilon_{12}&\varepsilon_{13}\\\varepsilon_{21}&\varepsilon_{22}&\varepsilon_{23}\\\varepsilon_{31}&\varepsilon_{32}&\varepsilon_{33}\end{pmatrix}$　　ε对称

由电能密度 w_e　$\frac{\partial w_e}{\partial t}$ 与表示方程 ? 求 $\frac{\partial w_e}{\partial t}$

$w_e=\frac{1}{2}\vec{D}\cdot\vec{E}=\frac{1}{2}\sum\varepsilon_{ik}E_kE_i$

$\nabla\times\vec{E}=-\frac{\partial B}{\partial t}$　$\nabla\times H=\frac{\partial D}{\partial t}$

由 $\nabla(E\times H)=-E\cdot\nabla\times H+H\cdot\nabla\times E$

...

$\rightarrow\nabla\cdot S=-\left(\frac{\partial w_e}{\partial t}+\frac{\partial w_m}{\partial t}\right)$　…　$\Rightarrow\sum\varepsilon_{ik}E_k'E_i=\sum\varepsilon_{ik}E_kE_i'$

$\rightarrow\varepsilon_{ki}=\varepsilon_{ik}$

w_e 为常量时　$E\varepsilon E=\varepsilon_{11}x_1^2+\varepsilon_{22}x_2^2+\varepsilon_{33}x_3^2+2\varepsilon_{12}x_1x_2+2\varepsilon_{23}x_2x_3+2\varepsilon_{31}x_3x_1=\text{const}$

菲涅耳椭球　光线椭球　$\vec{R}$ ~ ε 相联系

介质坐标系　$\varepsilon_1x_1^2+\varepsilon_2x_2^2+\varepsilon_3x_3^2=\text{const}$

主介电常数　$\varepsilon_1=n_1^2$　$\varepsilon_2=n_2^2$　$\varepsilon_3=n_3^2$　主折射率

~~$D=\eta E_i$~~　$E=\eta D$　$\eta_{mn}=\frac{(\varepsilon_{ik})_{mn}}{\text{Det}(\varepsilon_{ik})}$ 代数余子式　$\eta=\varepsilon^{-1}$

主轴方向

$D\propto n$　$E\propto u$　$u=\frac{1}{n_i}$.

$\varepsilon_1\neq\varepsilon_2\neq\varepsilon_3$ 双轴　　$\varepsilon_1=\varepsilon_2\neq\varepsilon_3$ 单轴　　$\varepsilon_1=\varepsilon_2=\varepsilon_3$

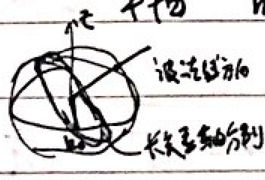
三斜 单斜 斜方　　三方 四方 六方　　立方晶体

波面　$R-v_g-n_g$　群

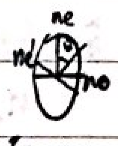
波法线面　$S-v_p-n$　相

折射率求法　$\frac{x^2}{n_x^2}+\frac{y^2}{n_y^2}+\frac{z^2}{n_z^2}=1$

单轴　$\frac{x^2}{n_o^2}+\frac{y^2}{n_o^2}+\frac{z^2}{n_e^2}=1$　　正 $n_e>n_o$　$v_e<v_o$

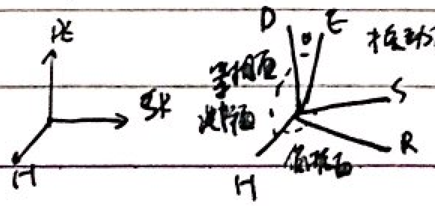


e 振动方向



$n_e'=\frac{1}{\sqrt{\frac{\cos^2\theta}{n_o^2}+\frac{\sin^2\theta}{n_e^2}}}$

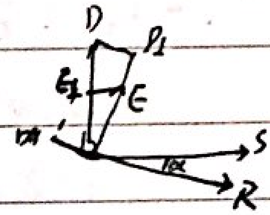
DESR 各向同性



o/e光轴 在晶体传播方向不变

5.17考试

波法线 折射率 n 光线折射率 n_g



$V_p = \frac{c}{n}$ n-D方向 $V_g = \frac{c}{n_g}$ n_g-E方向

$D = \varepsilon_0 n^2 E_\perp = \varepsilon_0 n^2 |E| \cos\alpha$ $n^2 = \frac{D^2}{\varepsilon_0 E \cdot D}$

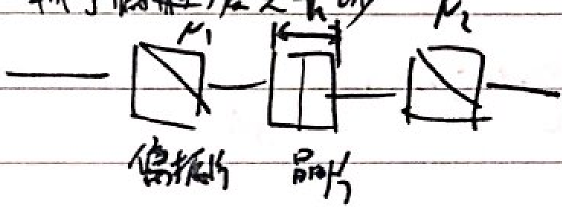
$D_\perp = \varepsilon_0 n_g^2 E$ $n_g^2 = \frac{D \cdot E}{\varepsilon_0 E^2}$ …

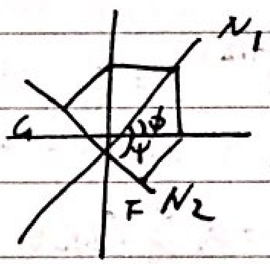
$\Rightarrow n_g = n\cos\alpha$ o光 $n_{go} = n_o$ e光 $n_{ge} < n_e$

$V_{ge} > V_{pe}$ $v_{pe} = v_{ge}\cos\alpha$

偏振光干涉

平行偏振光干涉





$OF = E\cos\phi\cos(\phi-\psi)$

$OG = E\sin\phi\sin(\phi-\psi)$

晶片: $\frac{2\pi}{\lambda}(n''-n')h$

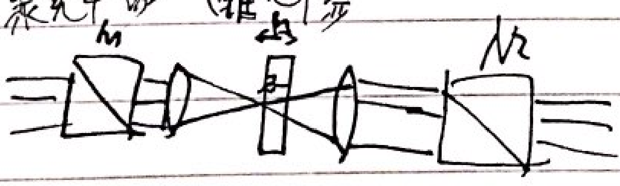
$I = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\delta = E^2[\cos^2\psi - \sin 2\phi\sin 2(\phi-\psi)\sin^2\frac{\delta}{2}]$

$h=0$时 $I = E^2\cos^2\psi$

$N_1 \parallel N_2$ $\psi = 0$ $I = E^2[1-\sin^2 2\phi\sin^2\frac{\delta}{2}]$

$N_1 \perp N_2$ $\psi = \frac{\pi}{2}$ $I = E^2\sin^2 2\phi\sin^2\frac{\delta}{2}$

会聚光干涉 (锥光干涉



$n_1 = n_o$

$n_e' = \frac{n_o n_e}{\sqrt{n_e^2\cos^2\theta + n_o^2\sin^2\theta}}$

$\approx n_o - \frac{1}{2}n_o^3\sin^2\theta\left(\frac{1}{n_e^2} - \frac{1}{n_o^2}\right)$

$\frac{2\pi}{\lambda}(n_2-n_1)\frac{h}{\cos\theta}$

5.18考试 开卷 前三章例题

一. 互相干函数 $\Gamma_{12}(\tau) = \langle V_1(t+\tau) V_2^*(t) \rangle$

$$I(Q) = I_1(Q) + I_2(Q) + 2\sqrt{I_1 I_2}\,|\gamma_{12}(\tau)|\cos(\alpha_{12}(\tau) - \delta)$$

$$\gamma_{12}(\tau) = \frac{\Gamma_{12}(\tau)}{\sqrt{\Gamma_{11}(0)\Gamma_{22}(0)}}$$

自相干函数 $\Gamma_{11}(\tau)$ $\gamma_{11}(\tau)$

准单色近似 $J_{12} = \langle U(P_1) U^*(P_2) \rangle$ 互相干性

$$\mu_{12} = \frac{J_{12}}{\sqrt{J_{11}J_{22}}} = \gamma_{12}(0) \qquad \beta_{12} = \alpha_{12}(0)$$

~~互相干时间~~

相干时间 $\tau_c = \int |\gamma_{11}(\tau)|^2 d\tau$ 矩形 $\frac{1}{\Delta\nu}$ 高斯 $\sqrt{\frac{2\ln 2}{\pi}} \cdot \frac{1}{\Delta\nu} = \frac{2.664}{\Delta\nu}$

$$\Gamma_{12}(\tau) = \Gamma_{12}(0)e^{-i2\pi\bar{\nu}\tau} = J_{12}e^{-i2\pi\bar{\nu}\tau}$$

$$J_{12} = \langle V_1(t) V_2^*(t) \rangle = e^{j\psi}\iint I(\xi,\eta)e^{-j\frac{2\pi}{\lambda z}(\Delta x\xi + \Delta y\eta)}d\xi d\eta$$

$$\nabla_1^2 \Gamma(P_1, P_2, \tau) = \frac{1}{c^2}\frac{\partial^2}{\partial\tau^2}\Gamma(P_1, P_2, \tau)$$

x 夫朗和费衍射

(1) ~~t(x)~~ $t(x_1, y_1)$ (2) 求 $\vec{U}(x_1, y_1) = t(x_1, y_1)$

(3) $F\{U(x_1, y_1)\}$ (4) $U(x_2, y_2) = \frac{e^{jkz}}{j\lambda z} e^{j\frac{k}{2z}(x_2^2+y_2^2)} \left\{F\left(U(x_1,y_1)e^{j\frac{k}{2z}(x_1^2+y_1^2)}\right)\right\}$

(5) $I = U(x_2,y_2)U^*(x_2,y_2)$

~~边界衍射波~~