一 光程

光在真空中的速度 $c = 1/\sqrt{\varepsilon_0 \mu_0}$

光在介质中的速度 $u = 1/\sqrt{\varepsilon \mu}$

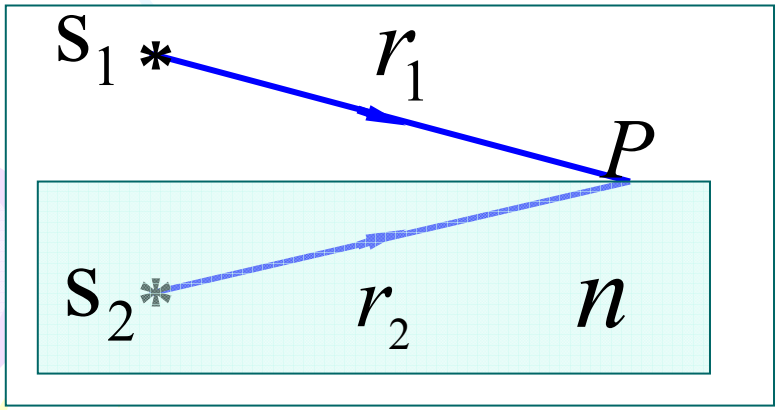
$$\frac{u}{c} = \frac{1}{n}$$

$$u = \lambda' \nu \qquad c = \lambda \nu$$

介质中的波长 $\lambda' = \dfrac{\lambda}{n}$

λ：真空中的波长

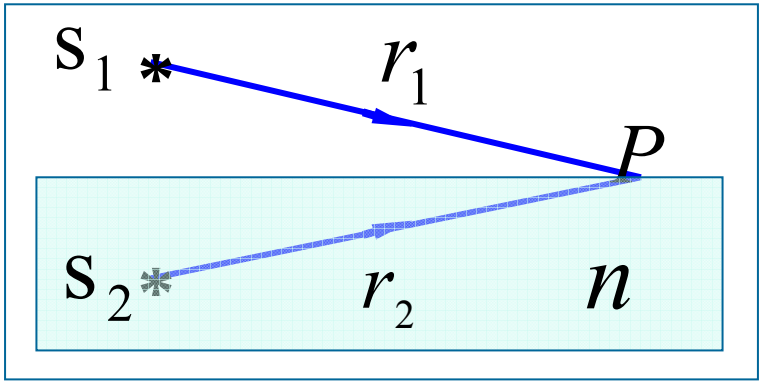
n：介质的折射率



$$E_1 = E_{10}\cos 2\pi\left(\frac{t}{T} - \frac{r_1}{\lambda}\right)$$

$$E_2 = E_{20}\cos 2\pi\left(\frac{t}{T} - \frac{r_2}{\lambda'}\right)$$

介质中的波长 $\lambda' = \dfrac{\lambda}{n}$



- 波程差　$\Delta r = r_2 - r_1$

- 相位差　$\Delta\varphi = 2\pi\left(\dfrac{t}{T} - \dfrac{r_2}{\lambda'}\right) - 2\pi\left(\dfrac{t}{T} - \dfrac{r_1}{\lambda}\right)$

$$= -2\pi\left(\frac{r_2}{\lambda'} - \frac{r_1}{\lambda}\right) = -2\pi\left(\frac{nr_2 - r_1}{\lambda}\right)$$

1) 光程：媒质折射率与光的几何路程之积 = nr

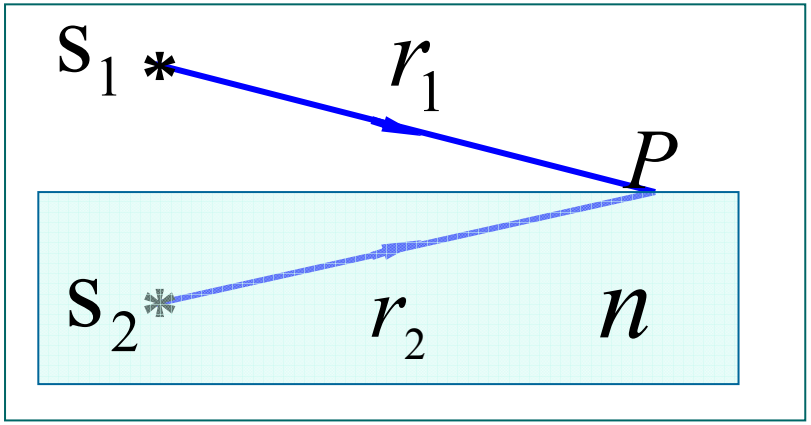
物理意义：光程就是光在媒质中通过的几何路程，按波数相等折合到真空中的路程.

$$\frac{r}{\lambda'} = \frac{nr}{\lambda}$$

2）光程差 (两光程之差)

光程差 $\Delta = nr_2 - r_1$

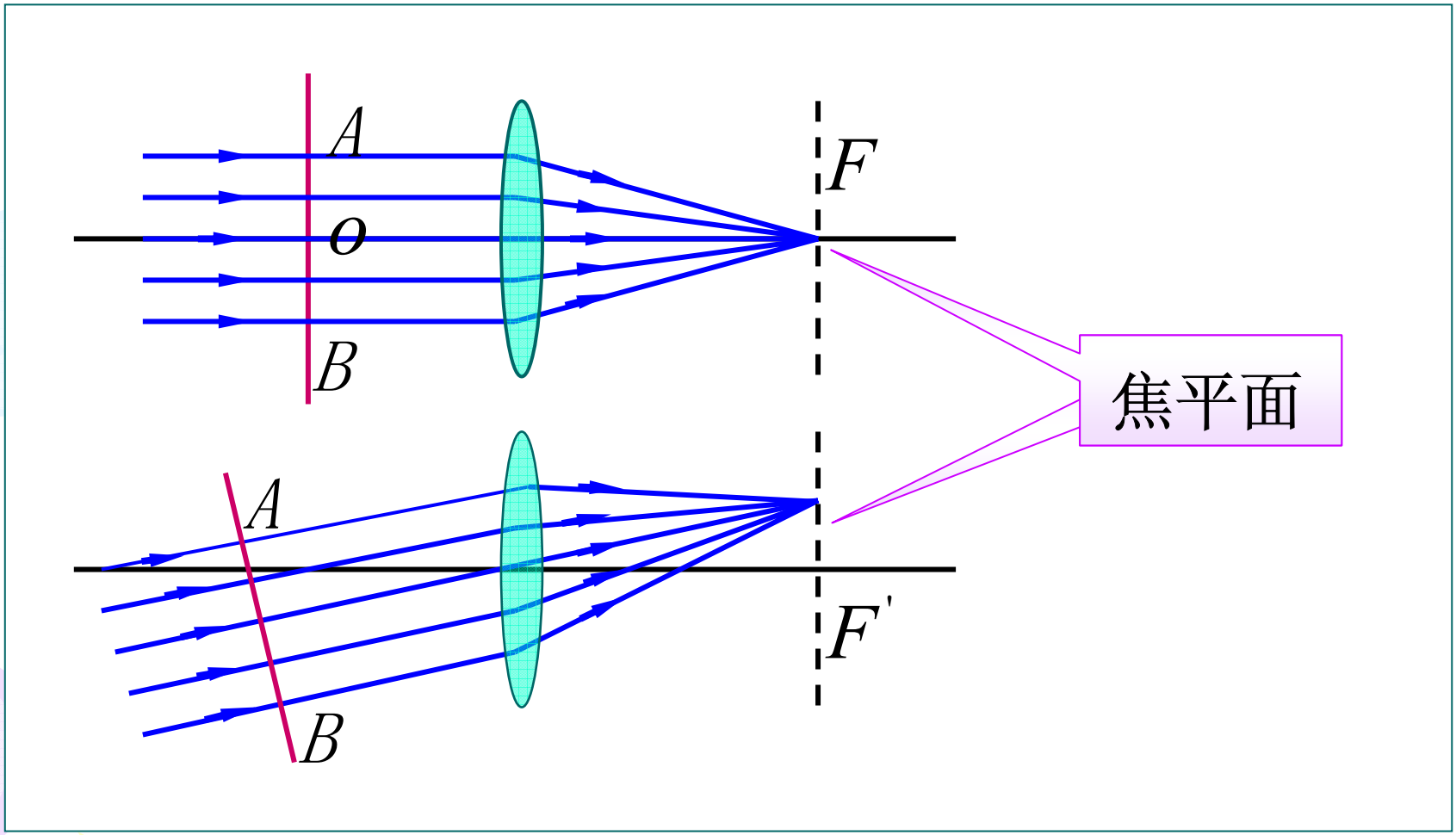
相位差 $\Delta\varphi = 2\pi\dfrac{\Delta}{\lambda}$



- 干涉加强
$$\begin{cases} \Delta = \pm k\lambda, \quad k = 0,1,2,\cdots \\ \Delta\varphi = \pm 2k\pi \ , k = 0,1,2,\cdots \end{cases}$$

- 干涉减弱
$$\begin{cases} \Delta = \pm(2k+1)\dfrac{\lambda}{2}, \quad k = 0,1,2,\cdots \\ \Delta\varphi = \pm(2k+1)\pi \ , k = 0,1,2,\cdots \end{cases}$$

二 透镜不引起附加的光程差

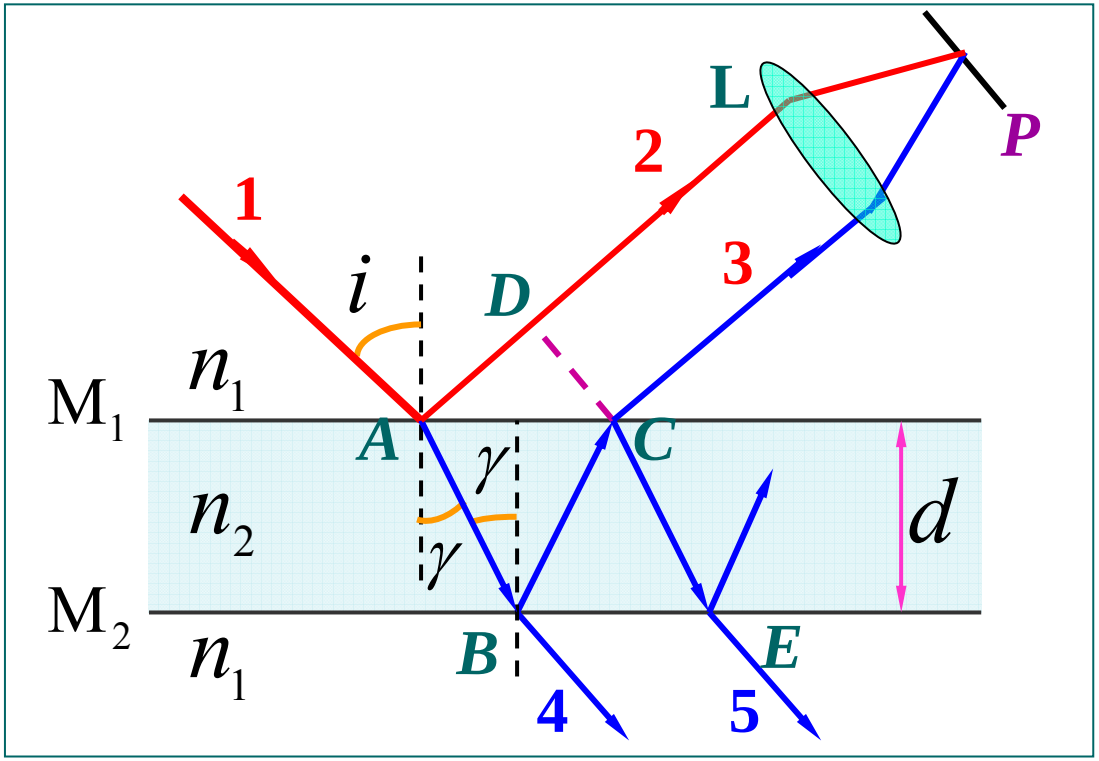


三　薄膜干涉

$$n_2 > n_1$$

$$CD \perp AD$$

$$\frac{\sin i}{\sin\gamma} = \frac{n_2}{n_1}$$



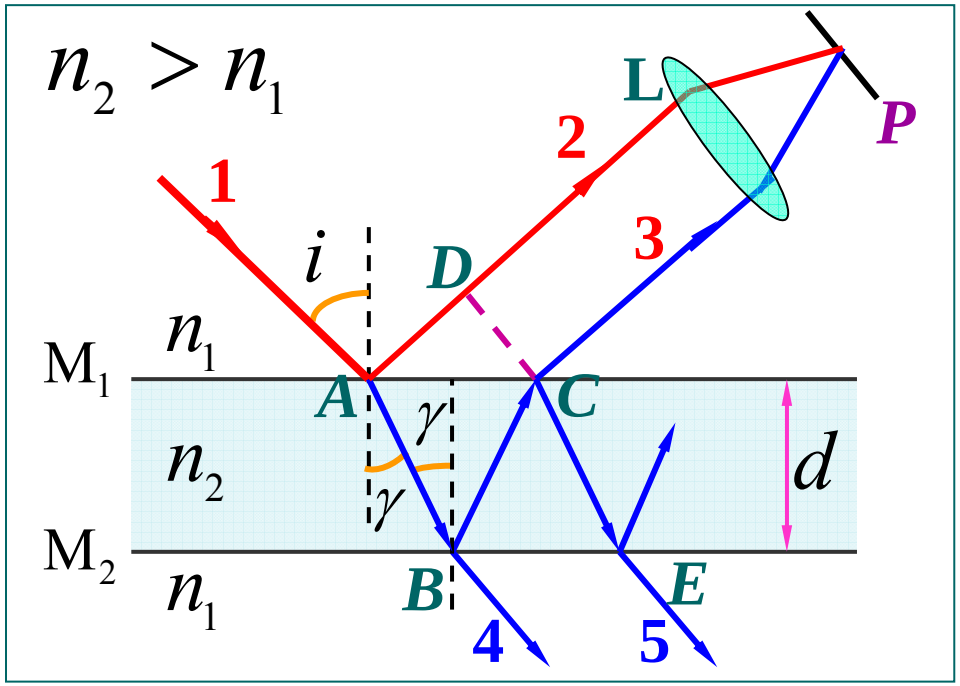
$$\Delta_{32} = n_2(AB + BC) - n_1 AD + \frac{\lambda}{2}$$

$$AB = BC = d/\cos\gamma \qquad AD = AC\sin i = 2d \cdot \tan\gamma \cdot \sin i$$

$$\Delta_{32}=\frac{2d}{\cos r}n_2\left(1-\sin^2 r\right)+\frac{\lambda}{2}=2n_2 d\cos r+\frac{\lambda}{2}$$

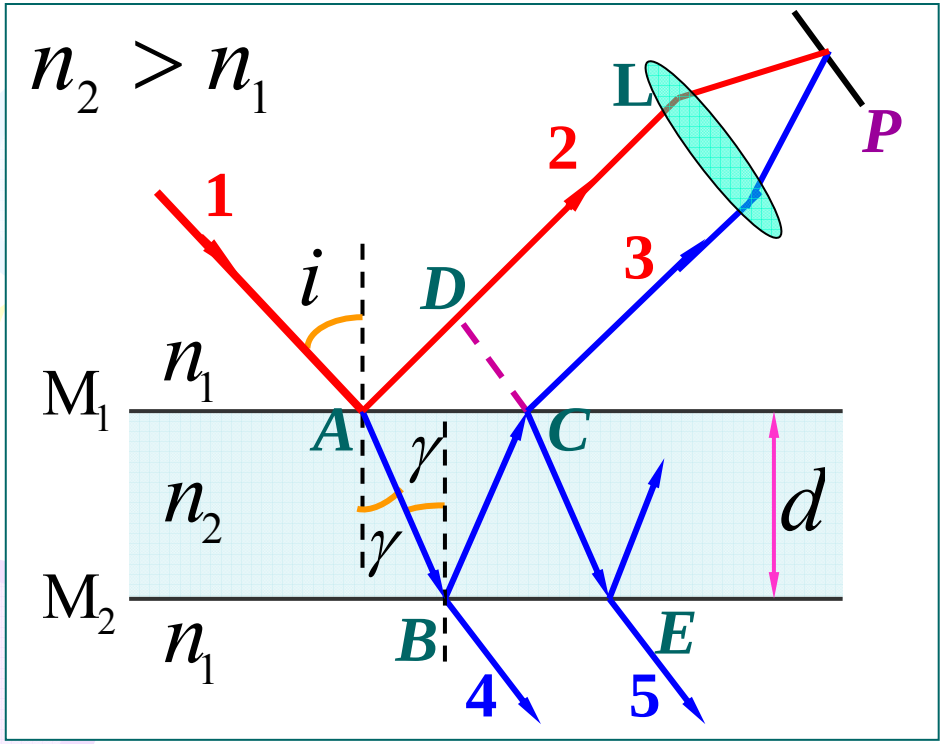
➢ 反射光的光程差 $\Delta_{\mathrm{r}}=2d\sqrt{n_2^2-n_1^2\sin^2 i}+\dfrac{\lambda}{2}$

$$\Delta_{\mathrm{r}}=\begin{cases}k\lambda & \text{加强}\\ (k=1,2,\cdots)\\ (2k+1)\dfrac{\lambda}{2} & \text{减弱}\\ (k=0,1,2,\cdots)\end{cases}$$



$$\Delta_{反}=2d\sqrt{n_2^2-n_1^2\sin^2 i}+\lambda/2$$

根据具体情况而定



➢ 透射光的光程差

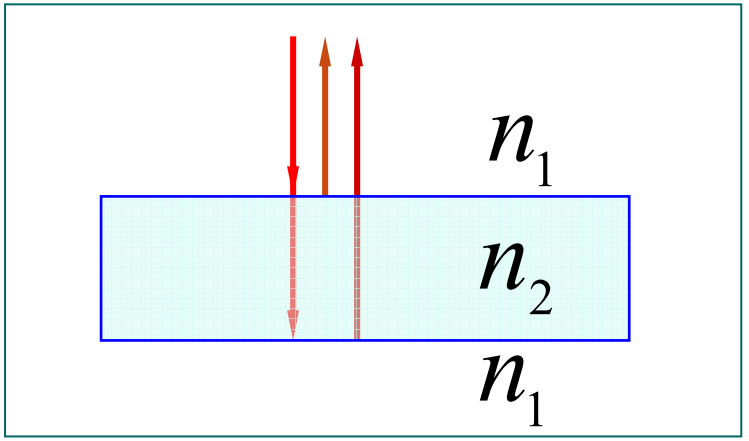
$$\Delta_t=2d\sqrt{n_2^2-n_1^2\sin^2 i}$$

注意：透射光和反射光干涉具有互 补 性，符合能量守恒定律.

- 当光线垂直入射时 $i = 0^\circ$

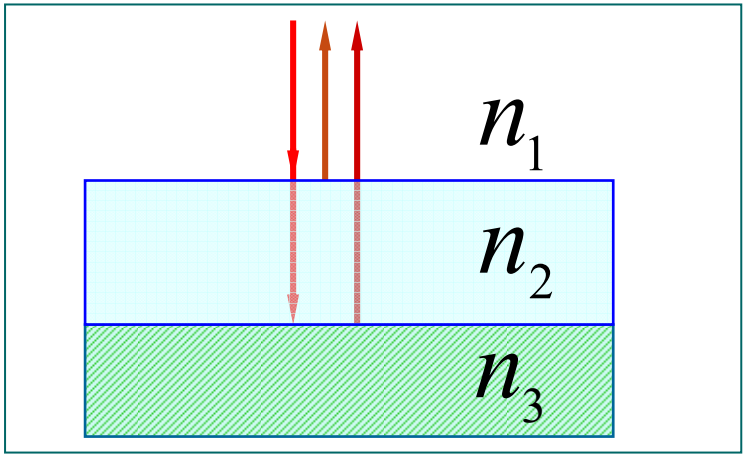
当 $n_2 > n_1$ 时

$$\Delta_r = 2dn_2 + \frac{\lambda}{2}$$



当 $n_3 > n_2 > n_1$ 时

$$\Delta_r = 2dn_2$$



例　一油轮漏出的油(折射率 $n_1=1.20$)污染了某海域, 在海水($n_2=1.30$)表面形成一层薄薄的油污.

(1) 如果太阳正位于海域上空,一直升飞机的驾驶员从机上向下观察,他所正对的油层厚度为460nm, 则他将观察到油层呈什么颜色?

(2) 如果一潜水员潜入该区域水下,又将看到油层呈什么颜色?

解 **(1)** $\Delta_r = 2dn_1 = k\lambda \quad \lambda = \dfrac{2n_1 d}{k}, \quad k = 1,2,\cdots$

$k=1, \quad \lambda = 2n_1 d = 1104\text{nm}$

$k=2, \quad \lambda = n_1 d = 552\text{nm}$　绿色

$k=3, \quad \lambda = \dfrac{2}{3} n_1 d = 368\,\text{nm}$

(2) 透射光的光程差 $\Delta_t = 2dn_1 + \lambda/2$

$$k=1,\quad \lambda=\frac{2n_1d}{1-1/2}=2208\,\text{nm}$$

紫红色

$$k=2,\quad \lambda=\frac{2n_1d}{2-1/2}=736\,\text{nm}$$ 红光

$$k=3,\quad \lambda=\frac{2n_1d}{3-1/2}=441.6\text{nm}$$ 紫光

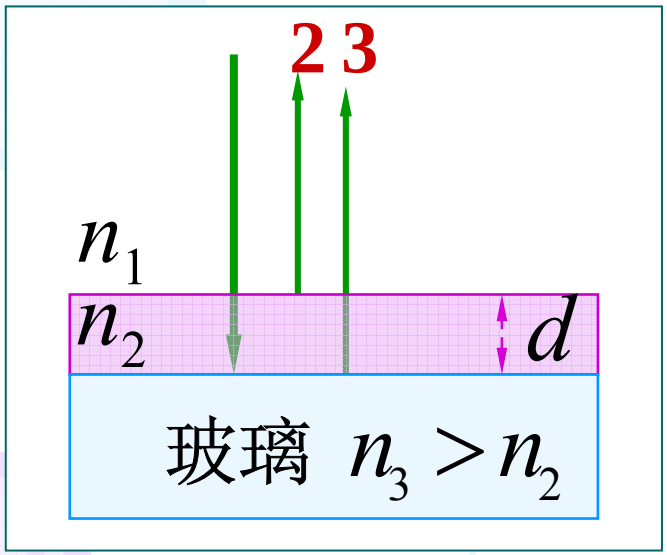
$$k=4,\quad \lambda=\frac{2n_1d}{4-1/2}=315.4\text{nm}$$

增透膜和增反膜

利用薄膜干涉可以提高光学器件的透光率 .

例　为了增加透射率， 求 氟化镁膜的最小厚度.

已知 空气 $n_1=1.00$,氟化镁 $n_2=1.38$, $\lambda=550\text{nm}$



氟化镁为增透膜

解 $\Delta_r=2dn_2=(2k+1)\dfrac{\lambda}{2}$

减弱

取　　$k=0$

$$d=d_{\min}=\frac{\lambda}{4n_2}=99.6\text{nm}$$

则 $\Delta_t=2n_2d+\dfrac{\lambda}{2}=\lambda$（增强）