

一 几何光学基本定律

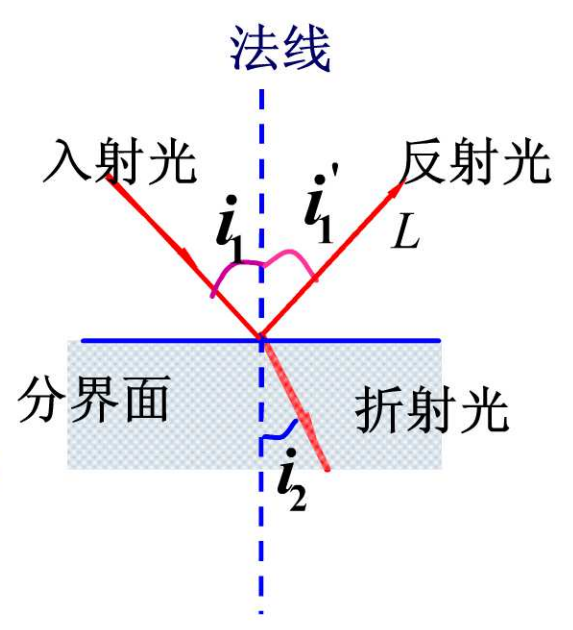
1 反射和折射定律

反射定律 $i_1 = i_1'$

折射定律 $\frac{\sin i_1}{\sin i_2} = \frac{n_2}{n_1} = n_{12}$

n_{12} 相对折射率

n_1 (n_2) 绝对折射率 (相对于真空)



折射定律 $n_1 \sin i_1 = n_2 \sin i_2$

几种常用介质的折射率

介质	折射率
空气	1.000 29
水	1.333
普通玻璃	1.468
冕牌玻璃	1.516
火石玻璃	1.603
重火石玻璃	1.755



2 全反射

全反射条件

光密介质 (n_1) \longrightarrow 光疏介质 (n_2)

入射角 $i_1 \geq i_c$

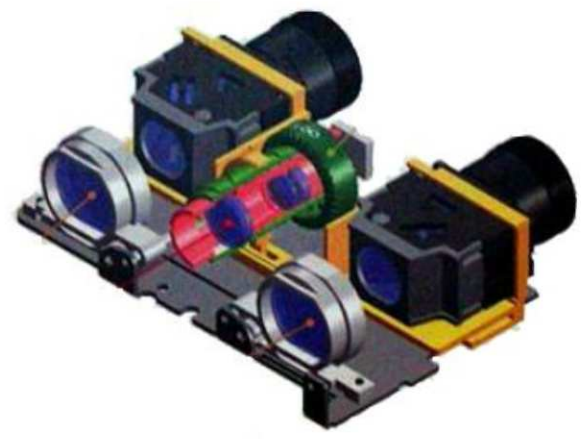
临界角 $i_c = \arcsin(n_2 / n_1)$



全反射的应用：



内窥镜

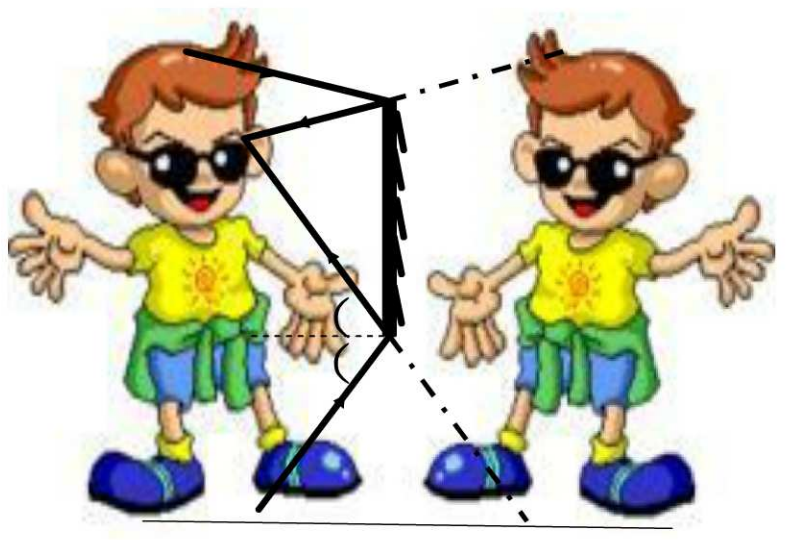
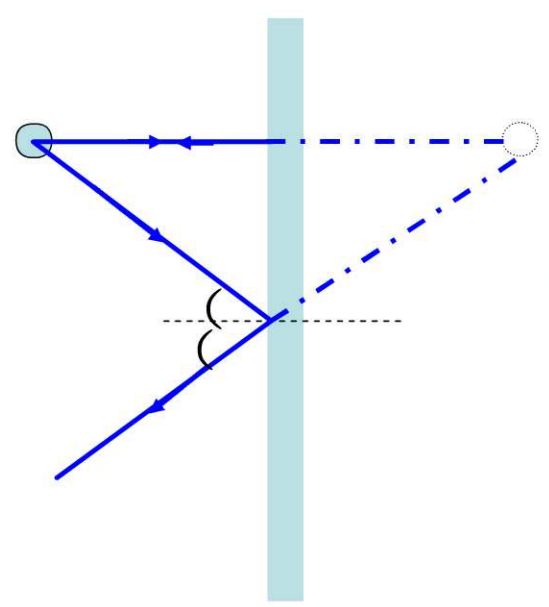


双筒望远镜



二 光在平面上的反射、折射成像

1 平面的反射成像



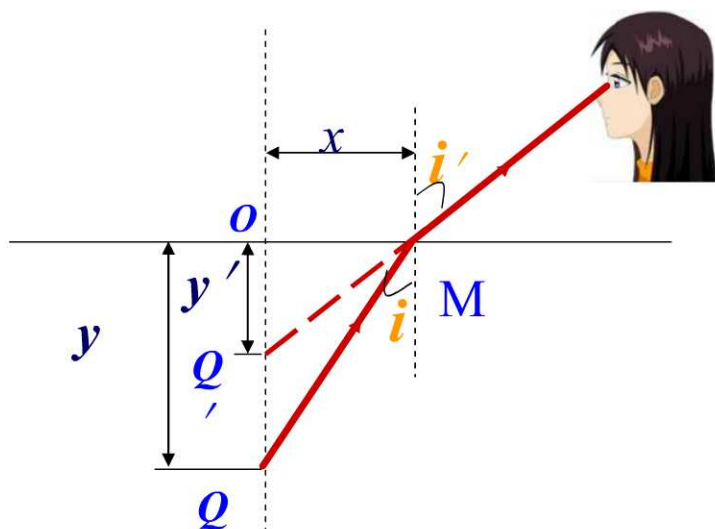
2 平面的折射成像

$$n \sin i = \sin i'$$

$$y = x \cot i$$

$$y' = x \cot i'$$

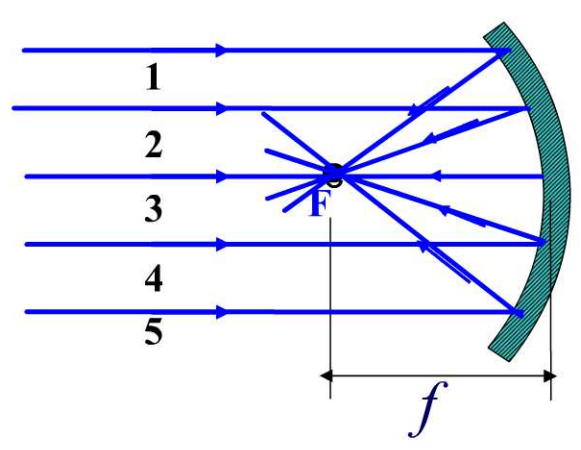
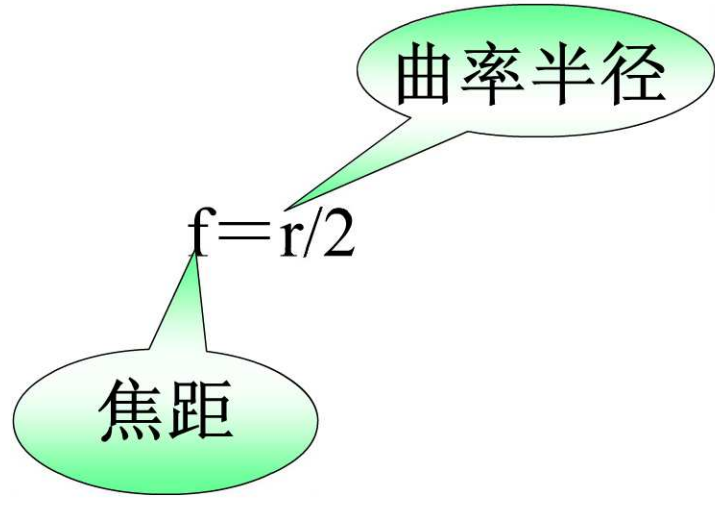
$$y' = y \frac{\sin i \cos i'}{\sin i' \cos i} = \frac{\gamma \sqrt{1 - n^2 \sin^2 i}}{n \cos i}$$



三 光在球面上的反射、折射成像

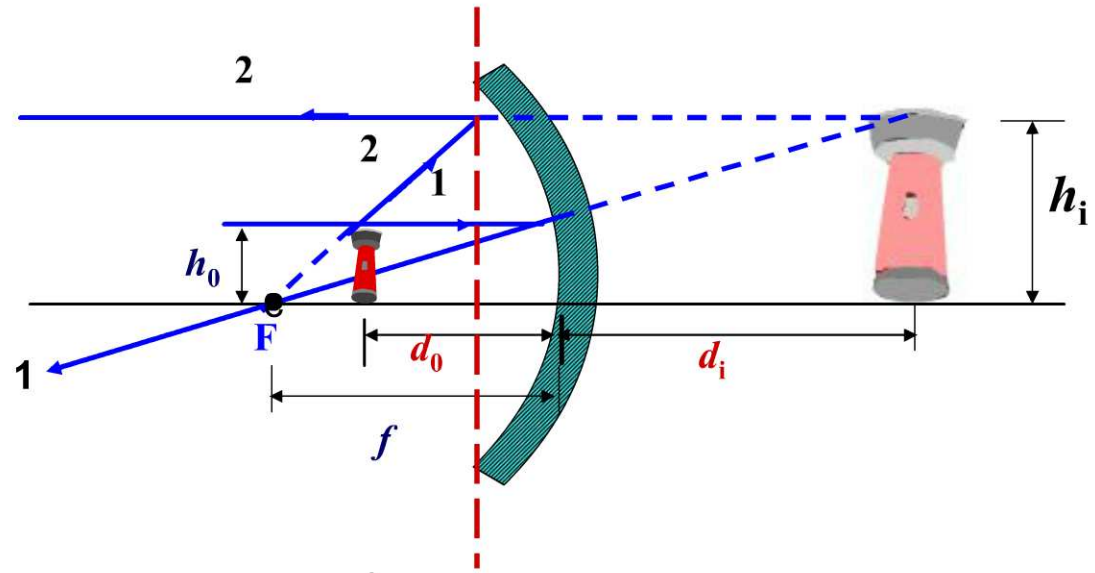
1 球面镜的反射成像

(1) 凹面镜的反射成像



成像公式
$$\frac{1}{p} + \frac{1}{p'} = \frac{1}{f}$$

p 为物距， p' 为相距

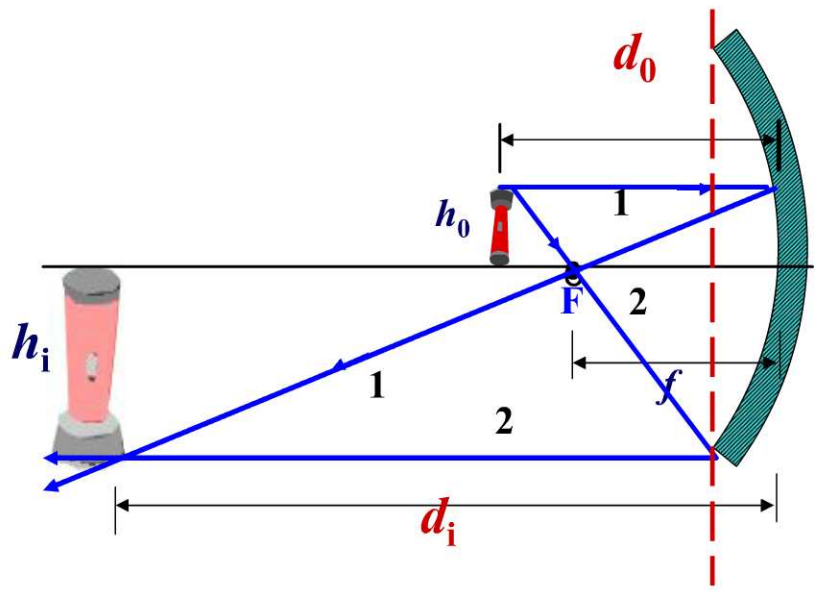


$p < 0, f < 0, p' > 0$



注意

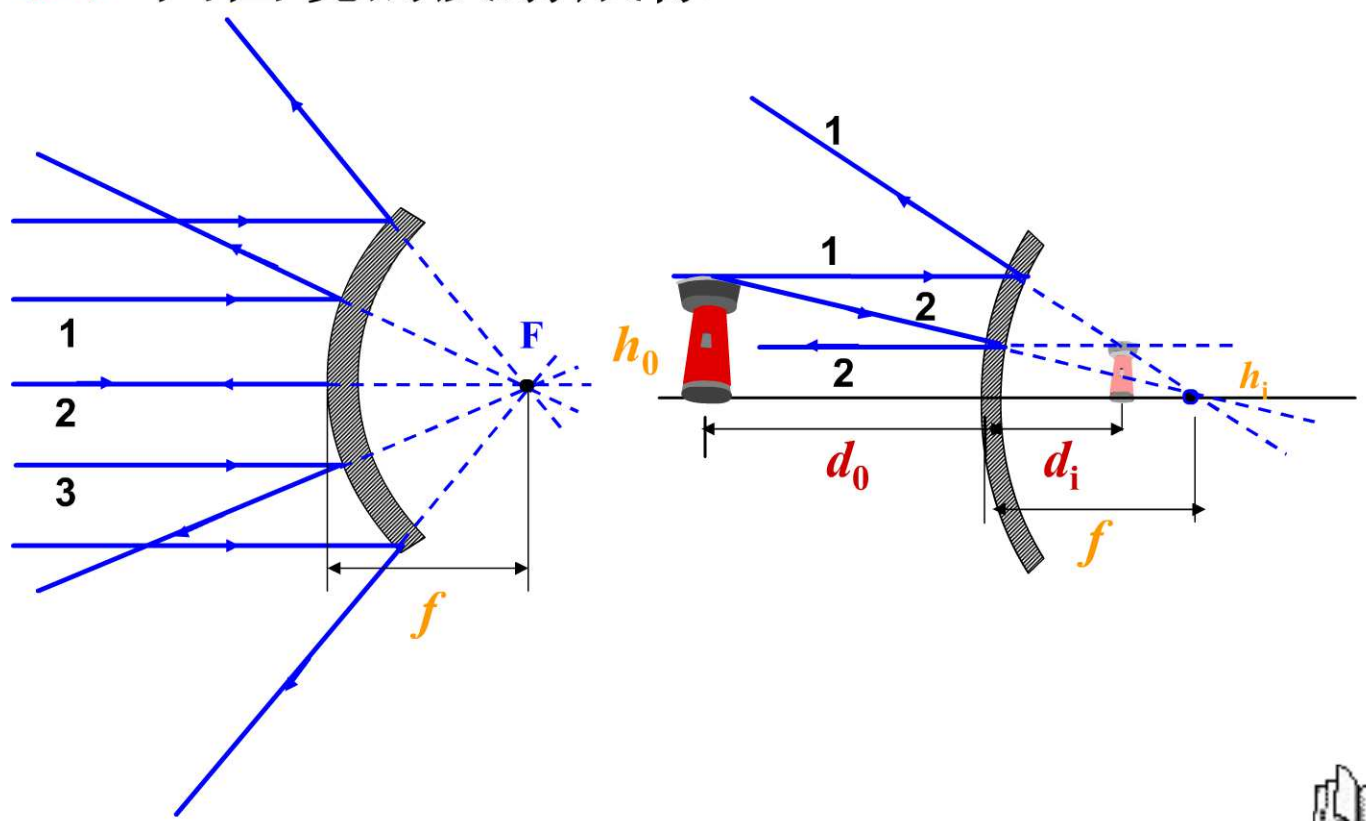
p, p', f 的正负



$$p < 0, f < 0, p' < 0$$



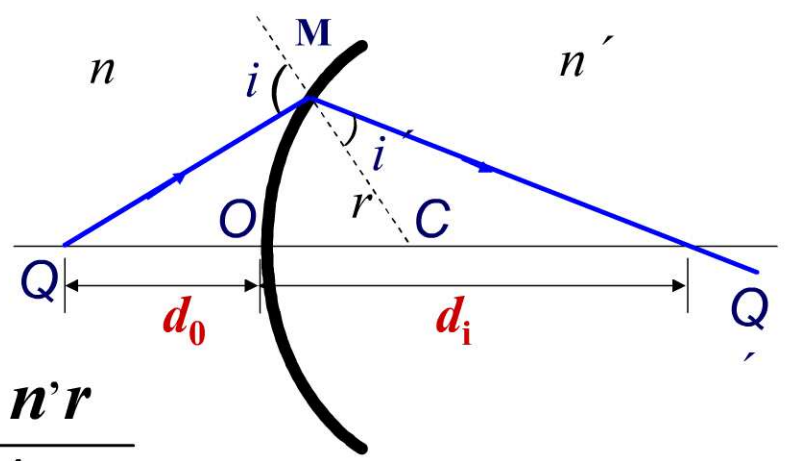
(2) 凸面镜的反射成像



2 球面上的折射成像

(1) 成像公式

$$\frac{n'}{p'} - \frac{n}{p} = \frac{n' - n}{r}$$



像方焦距 $f' = \frac{n'r}{n' - n}$

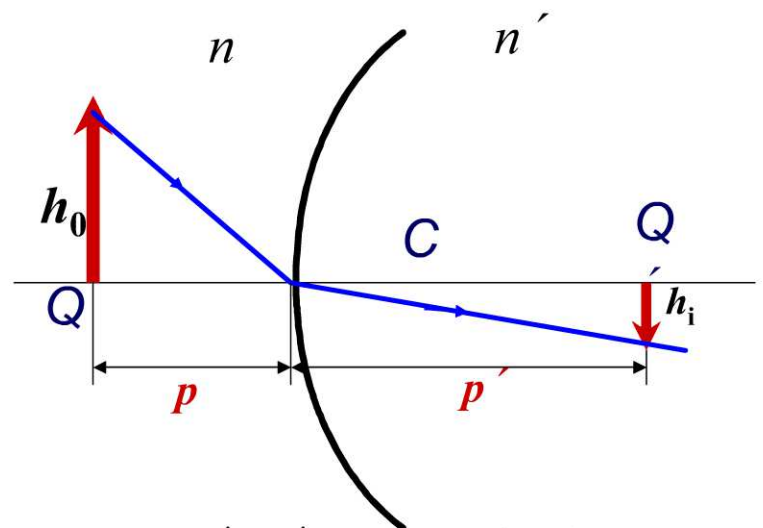
物方焦距 $f = \frac{-nr}{n' - n}$ $\frac{f'}{p'} + \frac{f}{p} = 1$



(2) 横向放大率

定义 $V = \frac{h_i}{h_o}$

$$V = \frac{np'}{n'p}$$

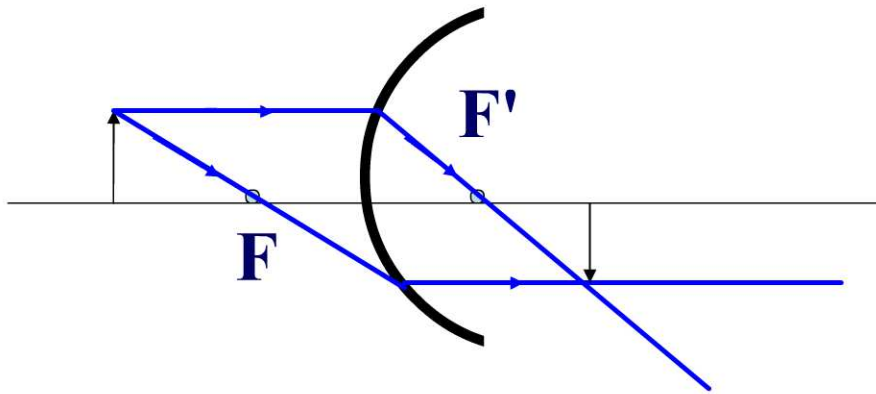


$V > 0$, 像正立 $|V| > 1$, 放大

$V < 0$, 像倒立 $|V| < 1$, 缩小



(3) 近轴光线的作图法



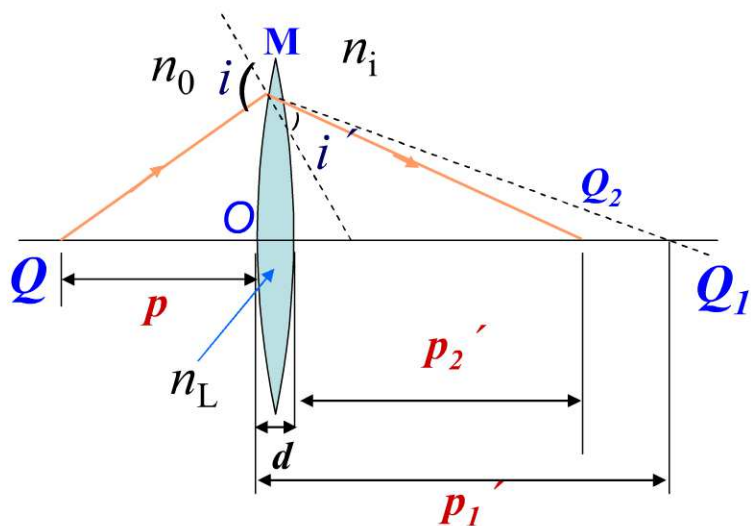
四 薄透镜

1 薄透镜成像公式

$$\frac{f'}{p'} + \frac{f}{p} = 1$$

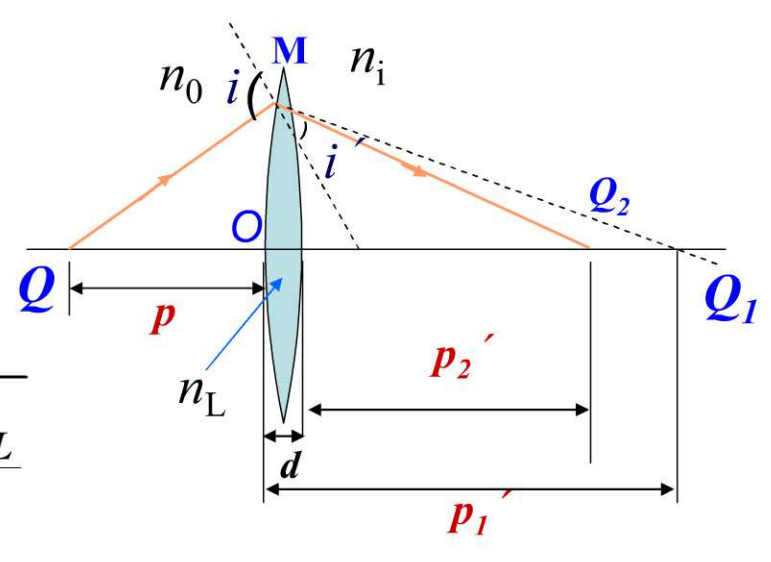
其中

像方焦距 $f' = \frac{n_i}{\frac{n_L - n_0}{r_1} + \frac{n_i - n_L}{r_2}}$



物方焦距

$$f = \frac{n_o}{\frac{n_L - n_o}{r_1} + \frac{n_i - n_L}{r_2}}$$








当 $n_i = n_o \approx 1$

$$f' = -f = \frac{1}{(n_L - 1) \left(\frac{1}{r_1} - \frac{1}{r_2} \right)} \quad \text{磨镜者公式}$$

$$\frac{f'}{p'} + \frac{f}{p} = 1 \quad \longrightarrow \quad \frac{1}{p'} - \frac{1}{p} = \frac{1}{f'}$$



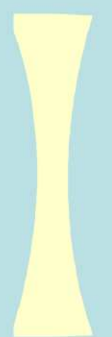




各种形状的透镜 凸透镜 (会聚)

凹凸透镜	平凸透镜	双凸透镜	平凸透镜	凹凸透镜
				
$r_1 < 0, r_2 < 0$ $ r_1 > r_2 $	$r_1 = \infty$ $r_2 < 0$	$r_1 > 0, r_2 < 0$	$r_1 > 0$ $r_2 = \infty$	$r_1 > 0, r_2 > 0$ $r_1 < r_2$

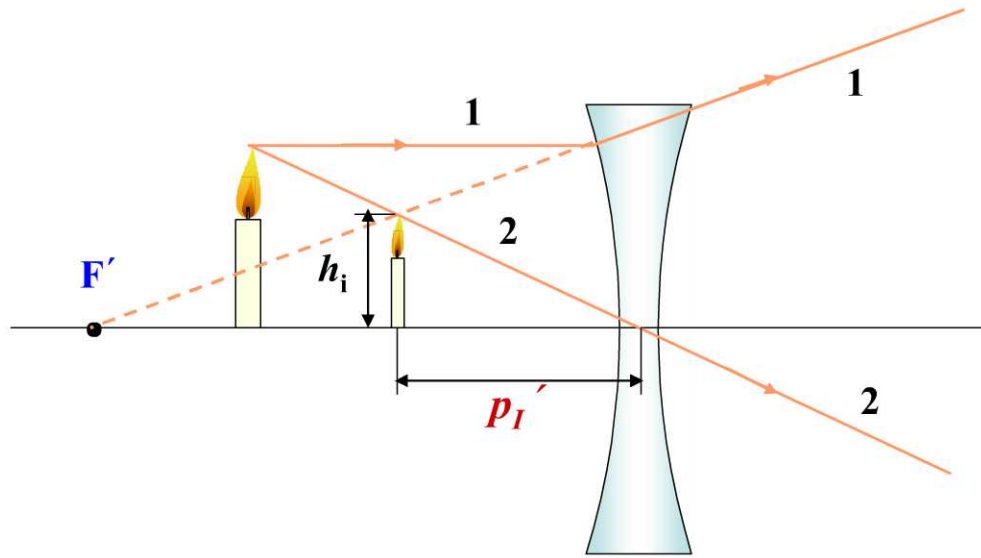


凹透镜 (发散)

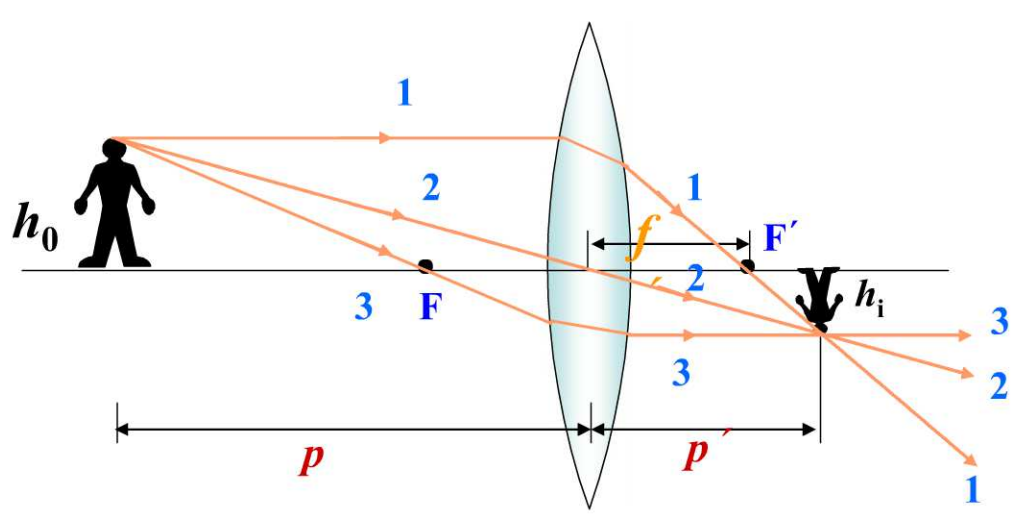
凹凸透镜	平凹透镜	双凹透镜	平凹透镜	凹凸透镜
				
$r_1 < 0, r_2 < 0$ $ r_1 < r_2 $	$r_2 = \infty$ $r_1 < 0$	$r_1 < 0, r_2 > 0$	$r_2 > 0$ $r_1 = \infty$	$r_1 > 0, r_2 > 0$ $ r_1 > r_2 $



凹透镜成像图



凸透镜成像图

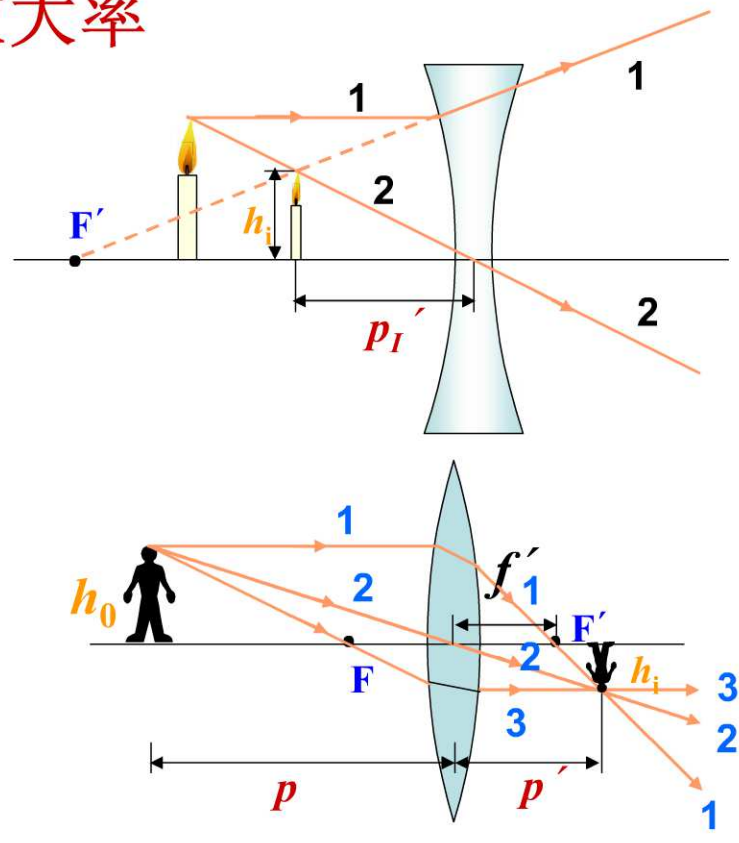


2 薄透镜的横向放大率

$$V = \frac{n_o p'}{n_i p}$$

当 $n_i = n_o \approx 1$

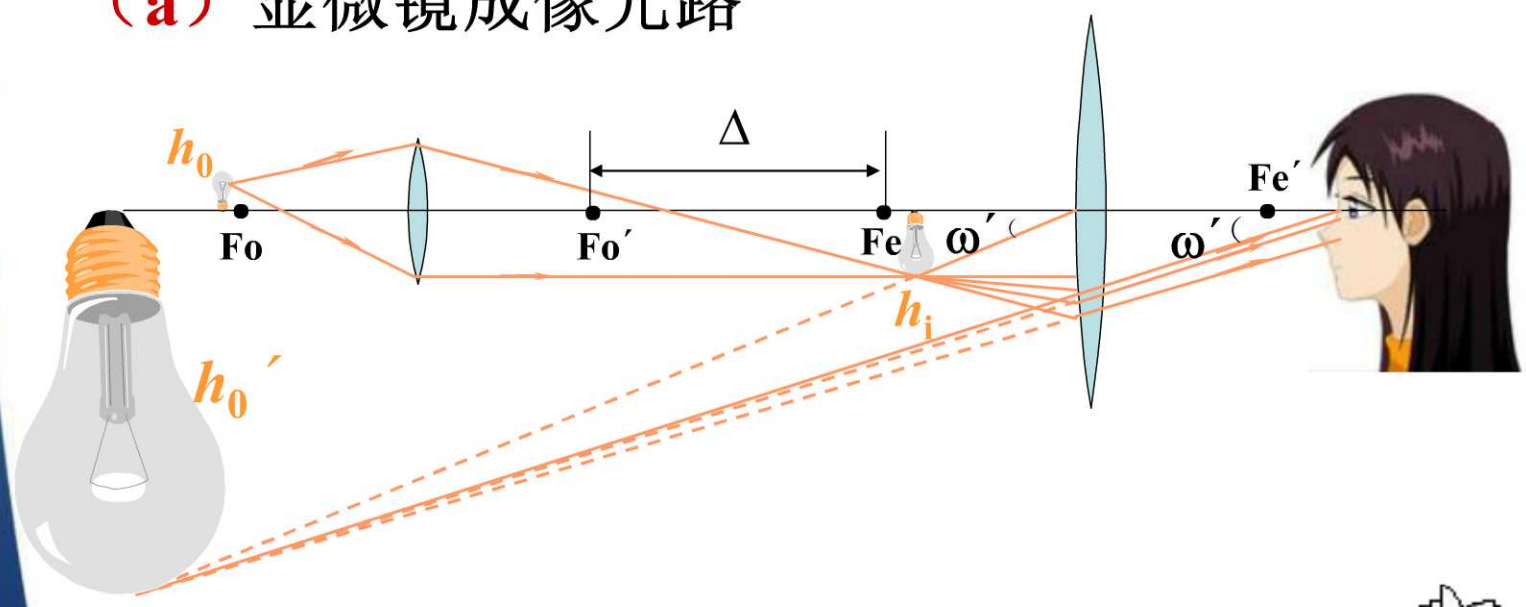
$$V = \frac{p'}{p}$$



五 显微镜、望远镜和照相机

1 显微镜

(a) 显微镜成像光路



(b) 显微镜的放大率

定义

$$M = \frac{\omega'}{\omega}$$

其中

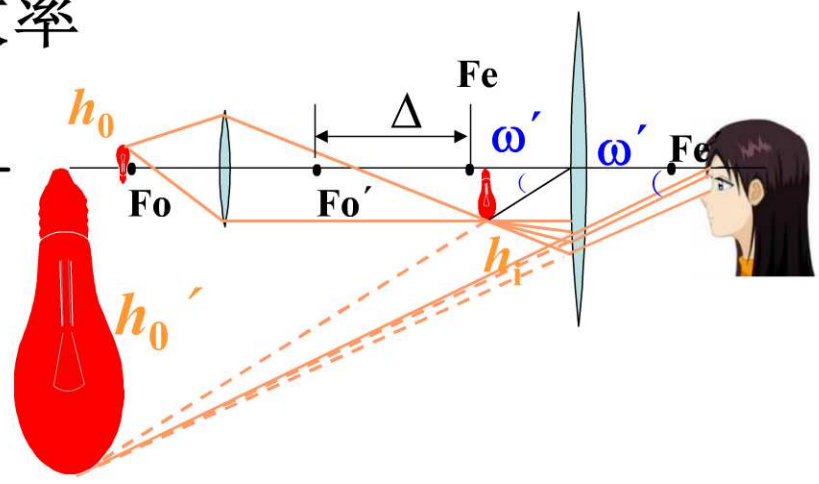
$$\omega = \frac{h_o}{S_o}$$

$$\omega' = \frac{h_i}{f_e'}$$

物镜的横向放大率

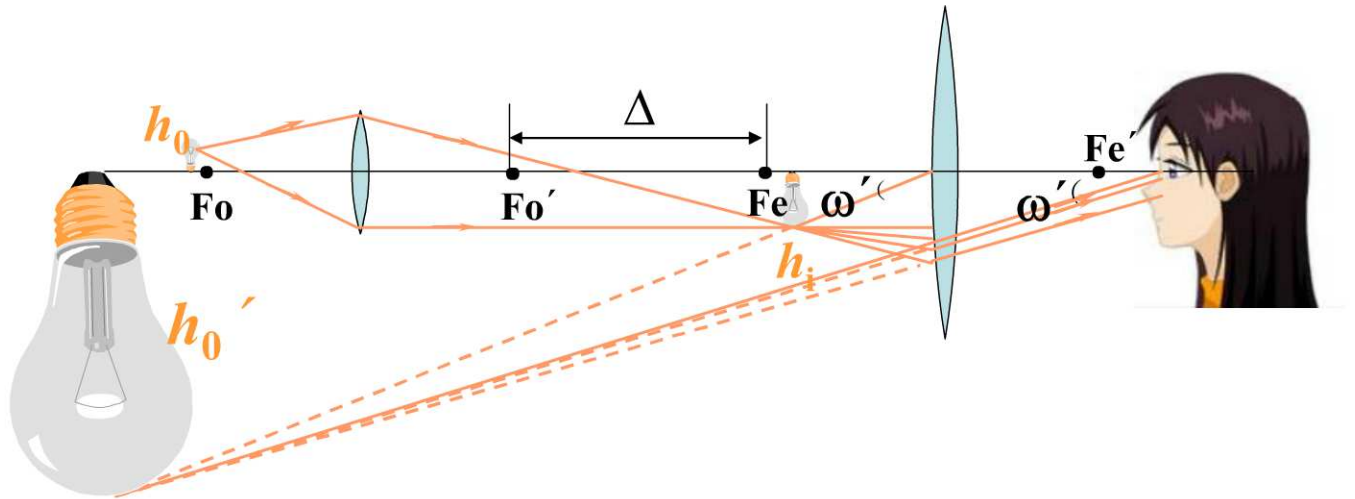
$$\frac{h_i}{h_o} \approx -\frac{\Delta}{f_o'}$$

Δ 为光学筒长，即物镜与目镜的间距



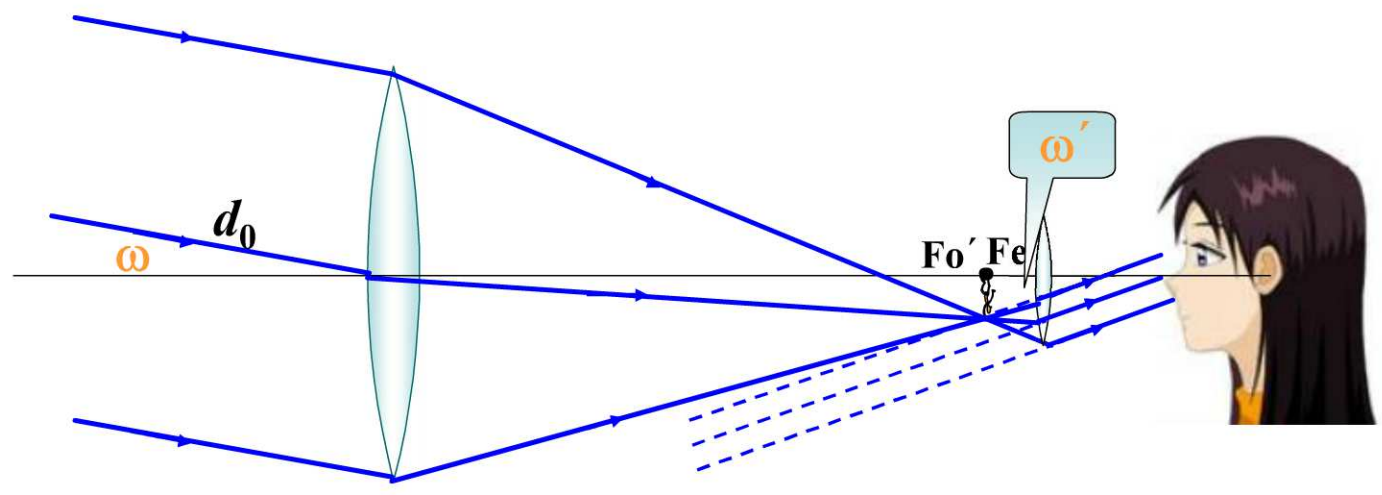
显微镜的视角放大率

$$M = \frac{\omega'}{\omega} = \frac{h_i / f_e'}{h_o / S_o} = -\frac{S_o \Delta}{f_o' f_e'} = -\frac{S_o \Delta}{f_o f_e}$$



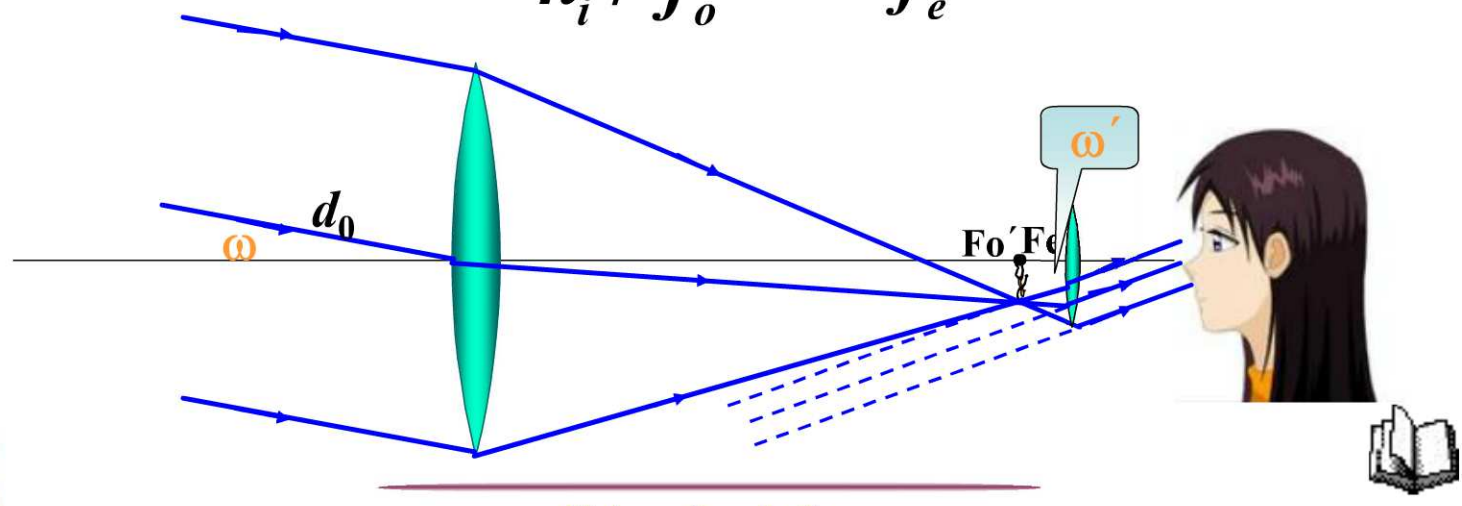
2 望远镜

(a) 望远镜的成像光路



(b) 望远镜的放大率

$$\omega = -\frac{h_i}{f_o'} \quad \because h_i < 0, f_o' > 0 \quad \omega' = \frac{h_i}{f_e'}$$
$$M = \frac{\omega'}{\omega} = \frac{h_i / f_e'}{-h_i / f_o'} = -\frac{f_o'}{f_e'}$$



3 照相机

