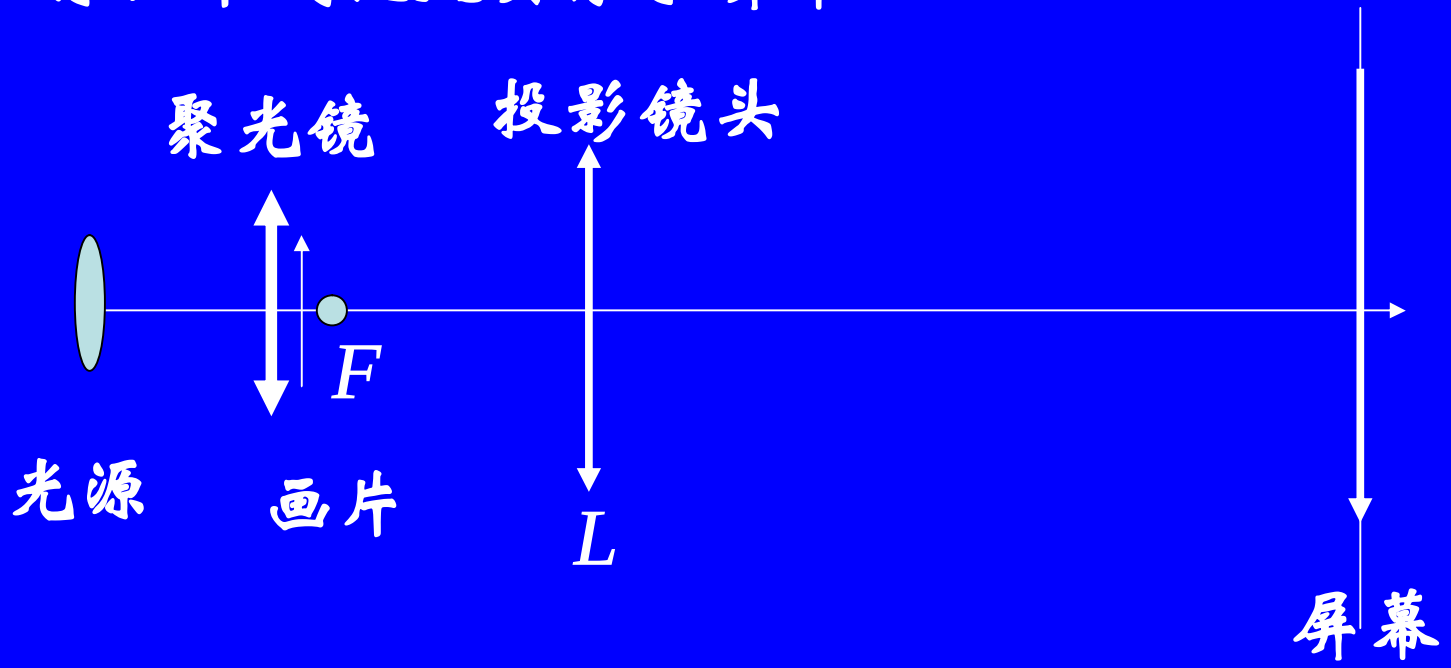
§8 光学仪器

8.1 投影仪器

将画片成放大实像于屏幕。



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

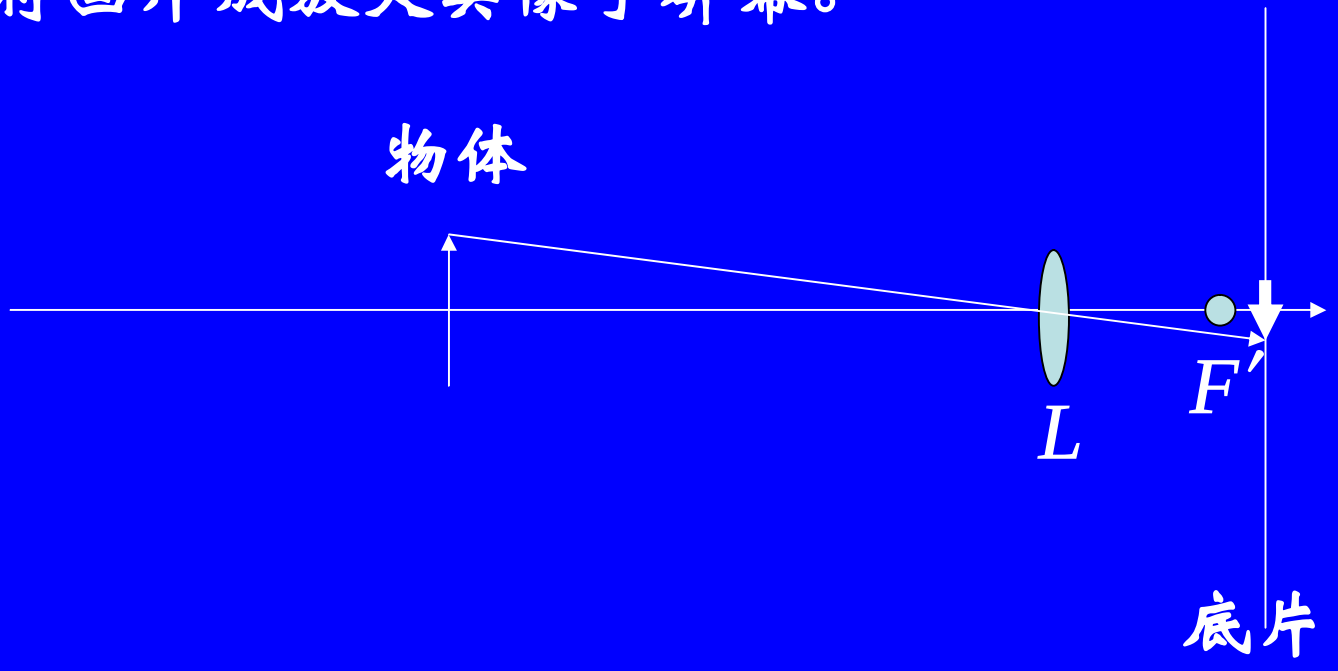
$$s \approx f$$

$$s' >> f$$

$$V=-\frac{s'}{s}\approx-\frac{s'}{f}$$

8.2 照相机

将画片成放大实像于屏幕。



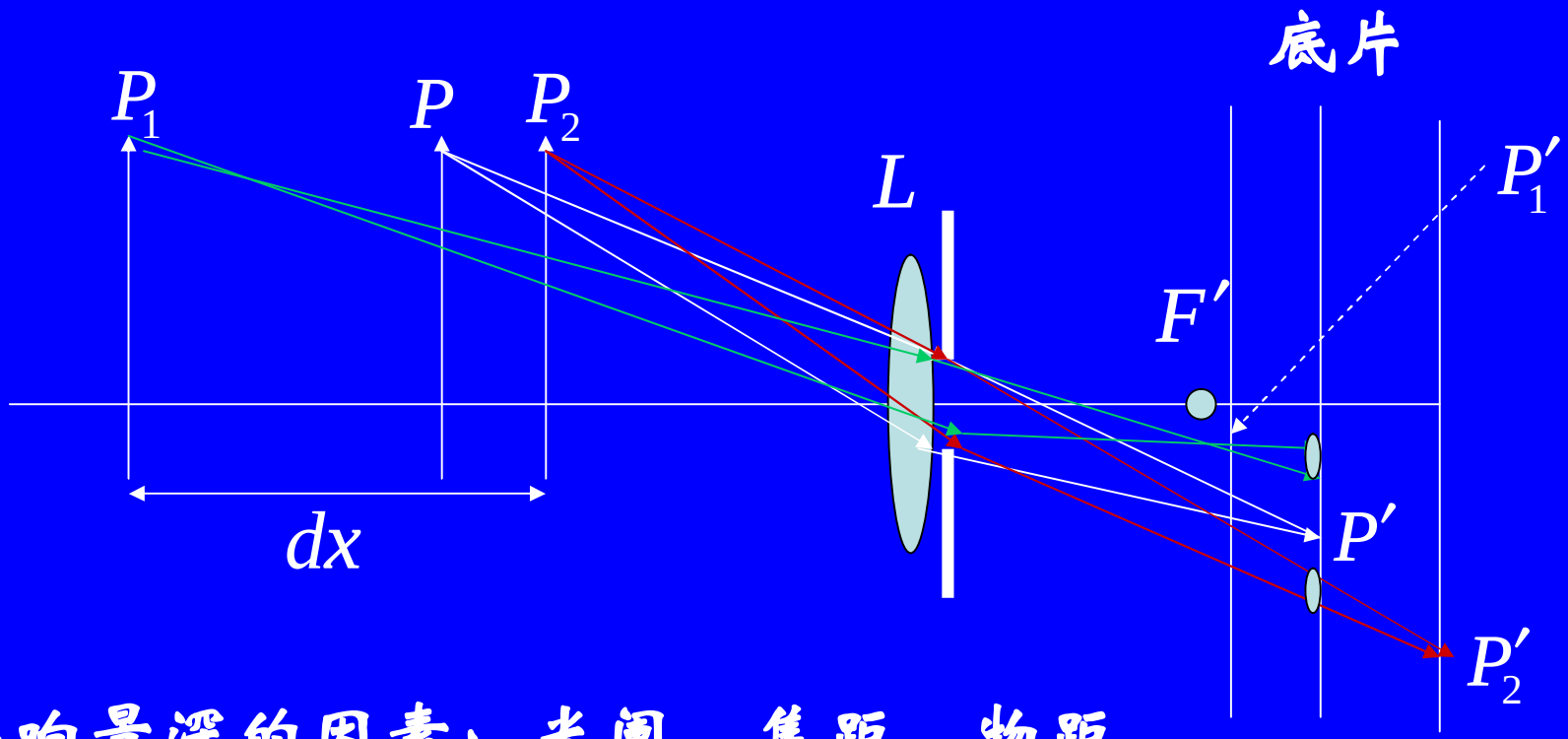
$$\frac{1}{s'}+\frac{1}{s}=\frac{1}{f}$$

$$s' \approx f'$$

$$s >> f$$

$$V=-\frac{s'}{s}\approx-\frac{f}{s}$$

照相中的景深

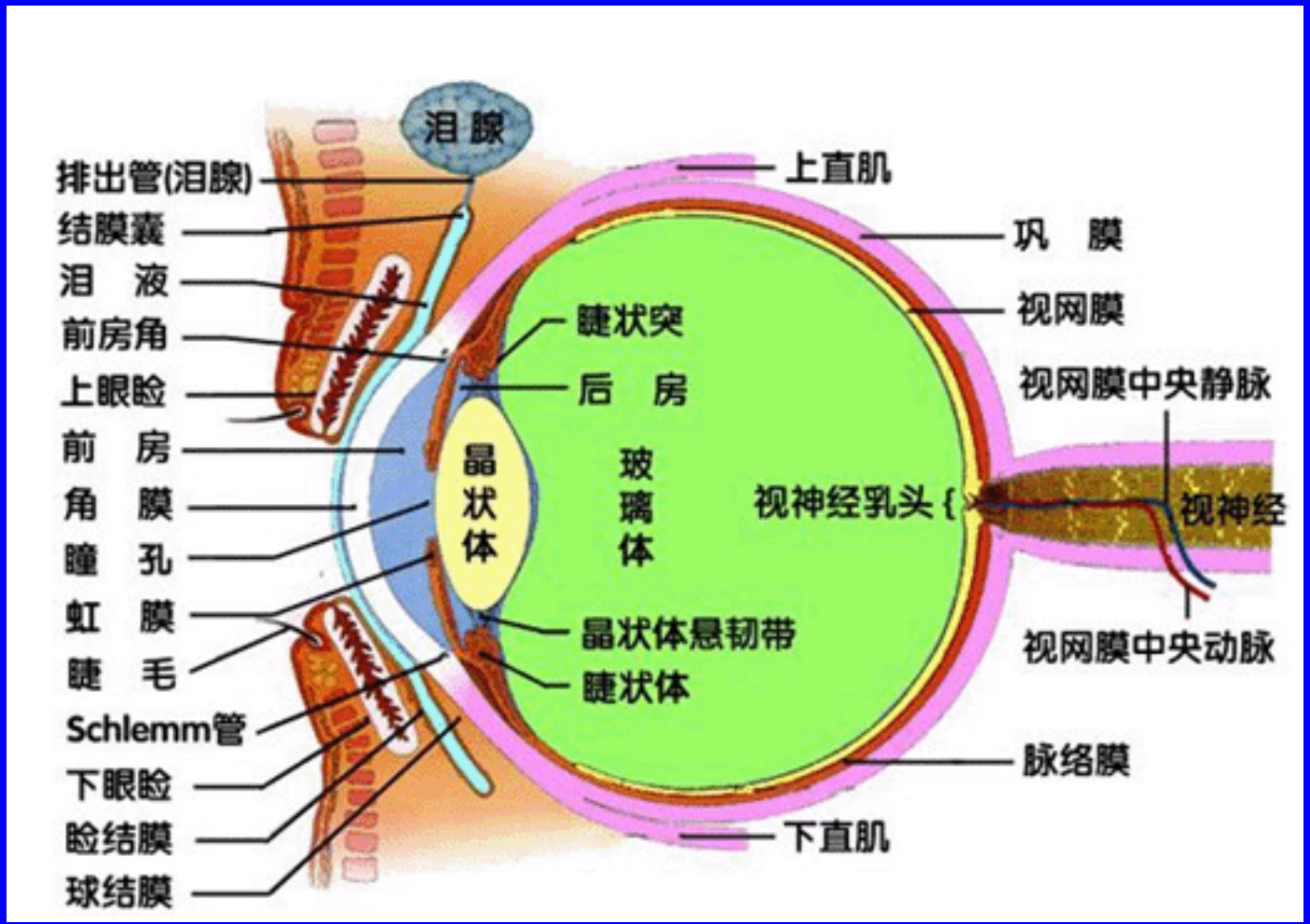


影响景深的因素：光阑，焦距，物距

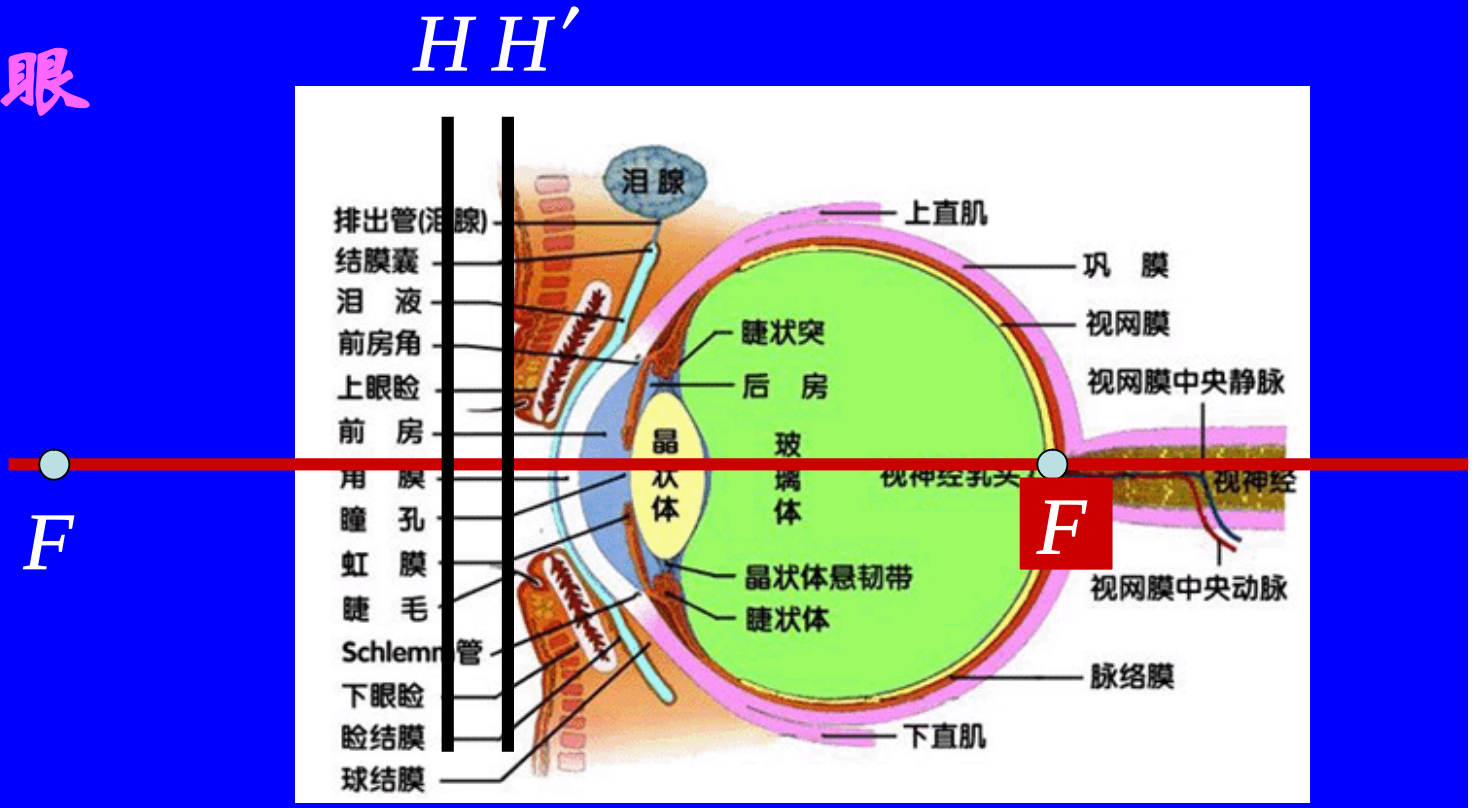
$$xx' = ff' = f^2 \qquad \frac{dx'}{dx} = -\frac{f^2}{x^2}$$

8.3 眼睛

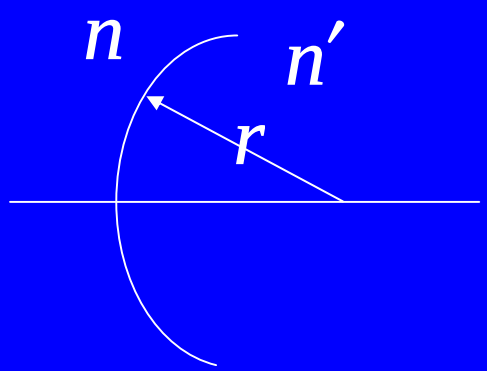
1）结构


泪腺
排出管(泪腺)
结膜囊
泪　液
前房角
上眼睑
前　房
角　膜
瞳　孔
虹　膜
睫　毛
Schlemm管
下眼睑
睑结膜
球结膜
上直肌
巩　膜
视网膜
睫状突
后　房
晶状体
玻璃体
视神经乳头
视网膜中央静脉
视神经
视网膜中央动脉
晶状体悬韧带
睫状体
脉络膜
下直肌

2）简化眼



单个折射球面



$$n=1, n'=4/3, r=5.7mm$$

$$f=17.1cm,\ f'=22.8cm$$

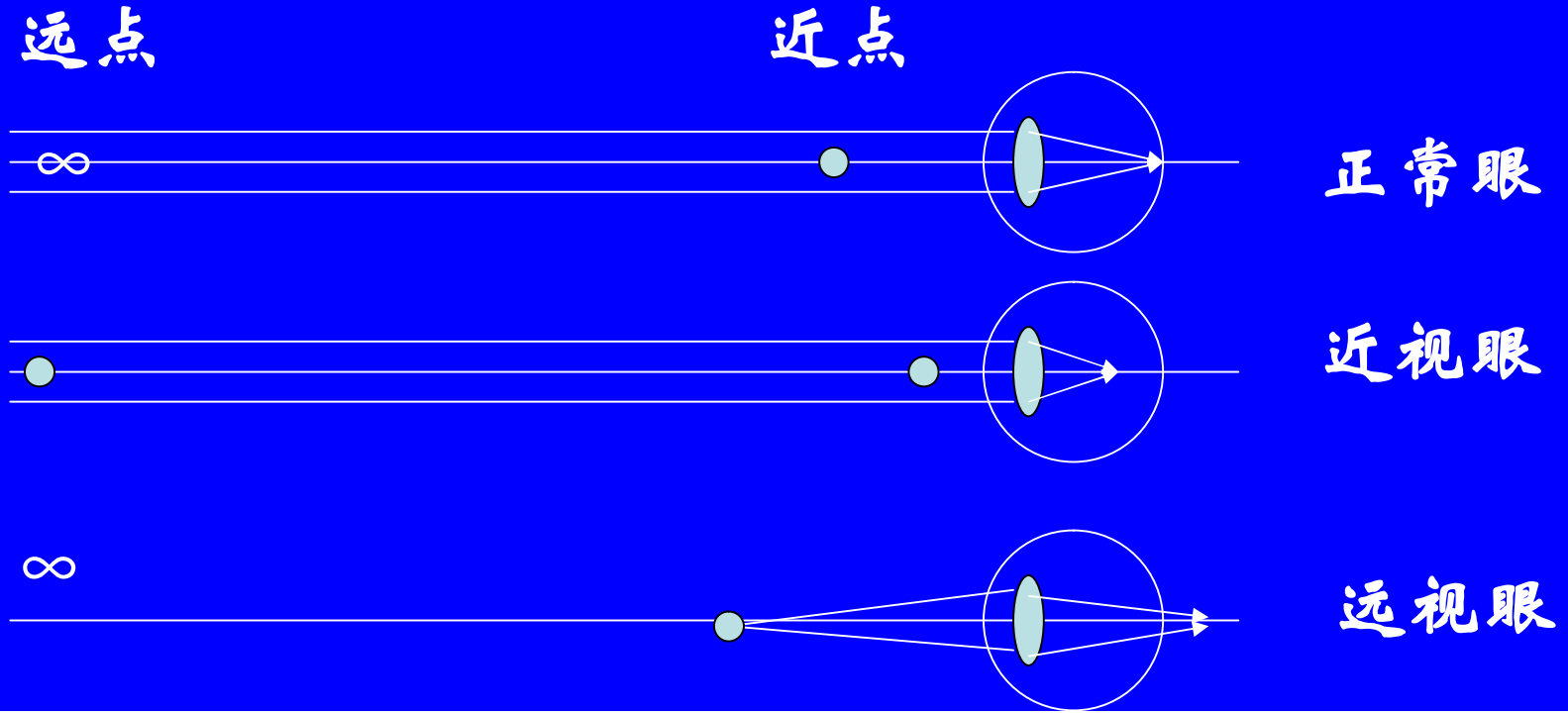
3）近点，远点，明视距离

远点：眼睛肌肉最放松时所看到的最远的点

近点：眼睛肌肉最紧张时所看到的最近的点

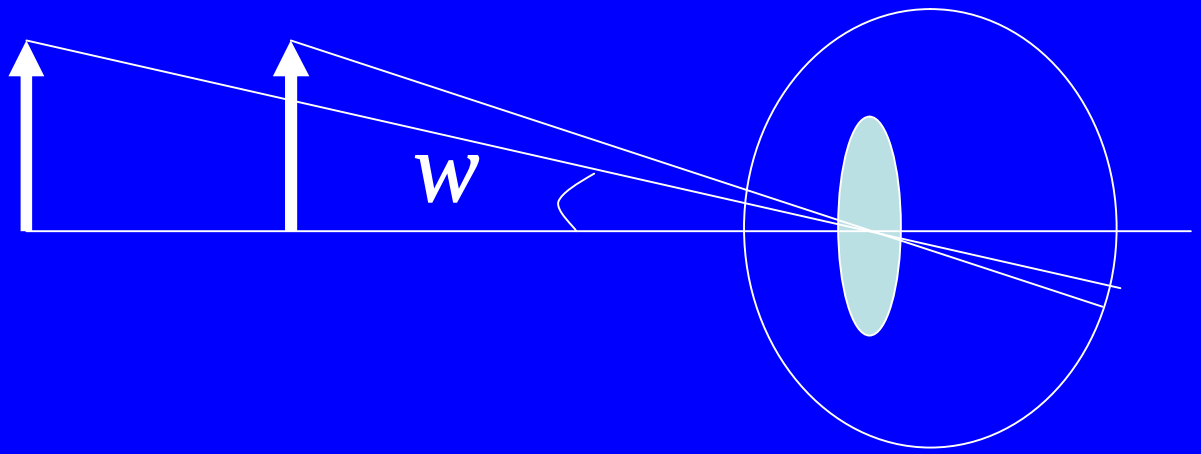
明视距离：正常照明下眼睛最舒适观测物体的距离

$$s_0 = 25cm$$



4）视角

物体或物体经光具组所成的像对人眼所张角度



人眼最小分辨角：

能够分辨的最近两点对眼睛所张视角

大约为 $1' = 2.9\times10^{-4}\,rad$

练习：

正常照明下明视距离处眼睛可分辨物体尺寸

$$w_0 = \frac{y}{s_0}$$

$$1' = 2.9 \times 10^{-4}\, rad$$

8.4 放大镜和目镜

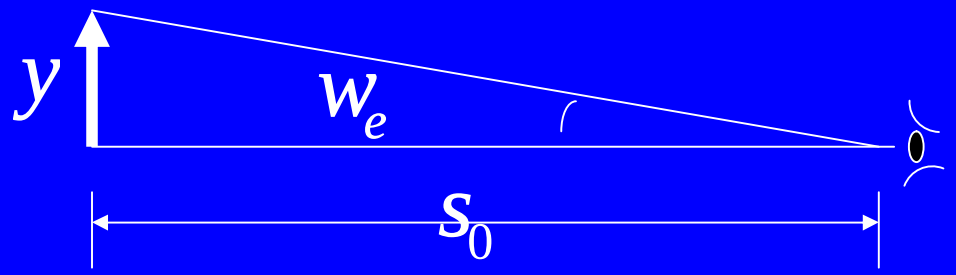
组成：焦距f很短的会聚透镜，$f << s_0$　　$f << s_0$

作用：视角放大

放大镜：直接观测物体

目镜：观测中间像

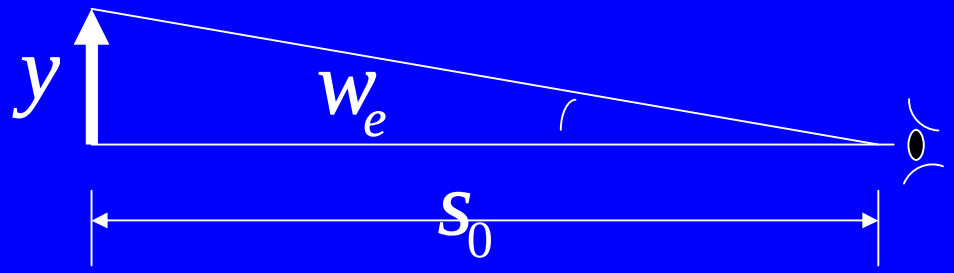
眼睛直接观测物体y的最大视角：



$$\tan w_e = y / s_0$$

$$w_e \approx y / s_0$$

眼睛直接观测物体y的最大视角：

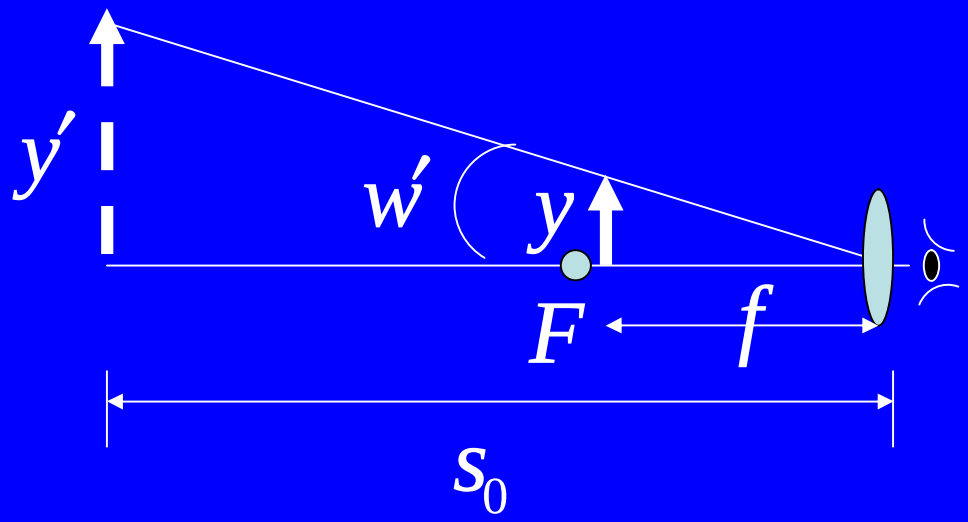


$$\tan w_e = y / s_0$$

$$w_e \approx y / s_0$$

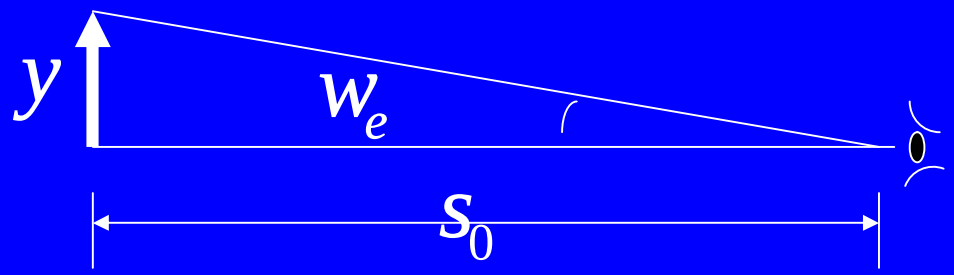
用放大镜：物点在靠近焦点F内

放大成虚像，使像在明视距离处



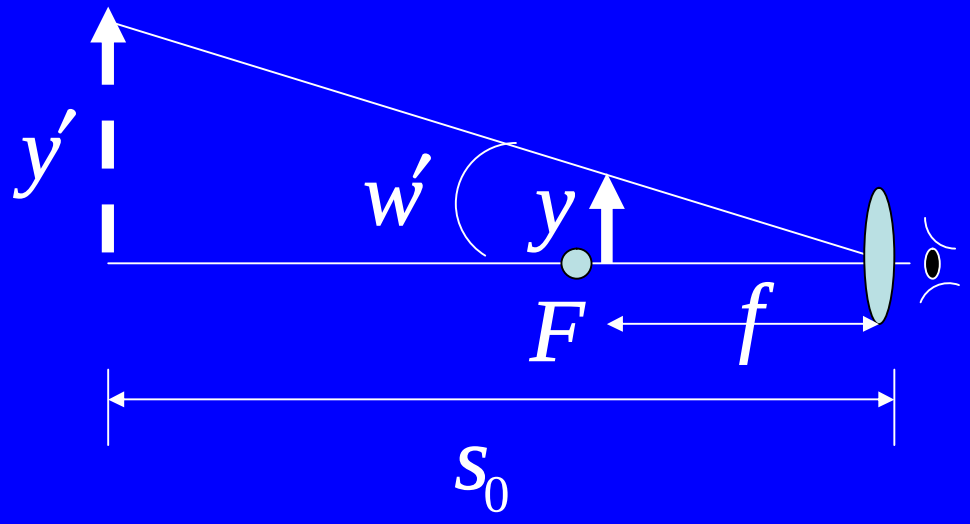
$$\tan w' = y' / s_0$$

$$\approx y / f$$



$$\tan w_e = y/s_0$$

$$w_e \approx y/s_0$$



$$\tan w' = y'/s_0$$

$$\approx y/f$$

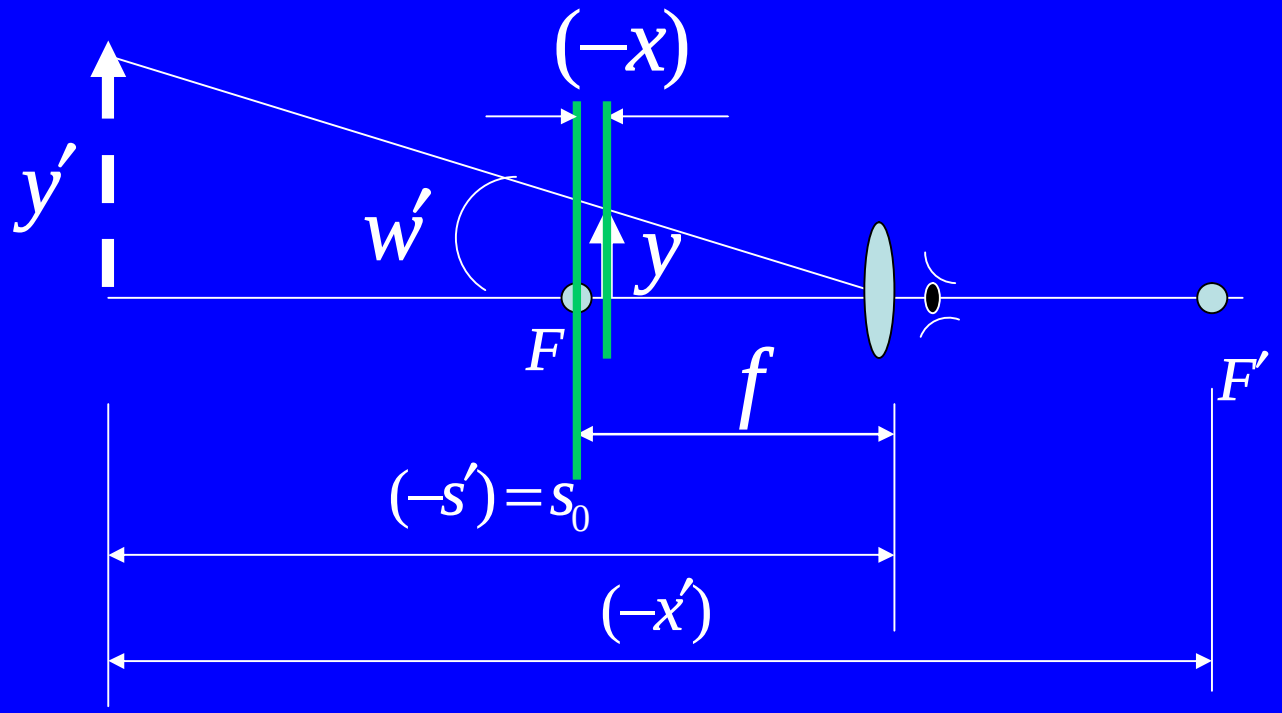
视角放大率：

$$M \equiv \frac{w'}{w} = \frac{s_0}{f}$$

一般放大镜：

M=3~5

焦深：

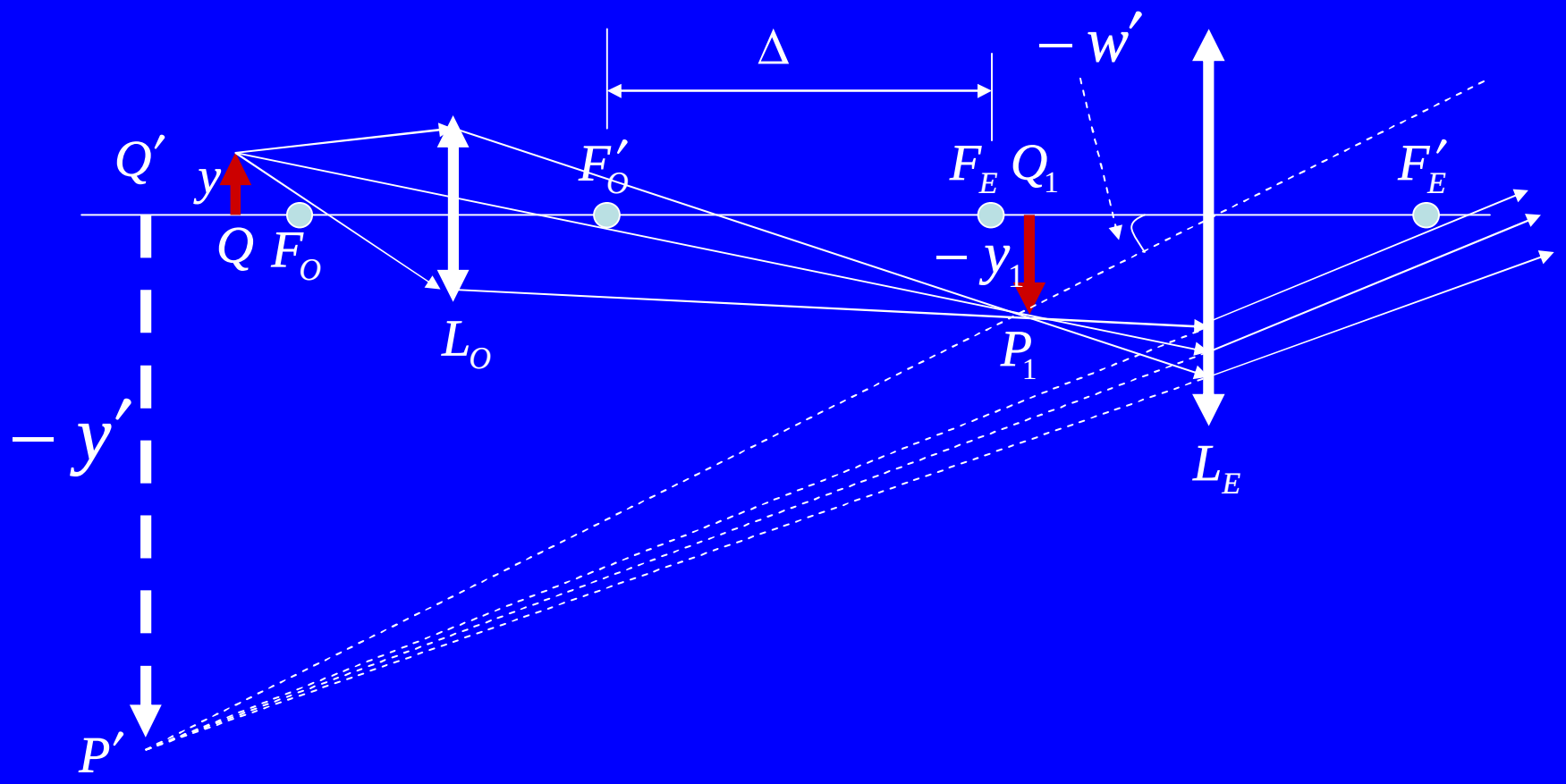


$$xx' = f^2$$

$$x = \frac{f^2}{x'} = \frac{f^2}{-(s_0 + f)} \approx -\frac{f^2}{s_0} \qquad |x|_{\max} = \frac{f^2}{s_0}$$

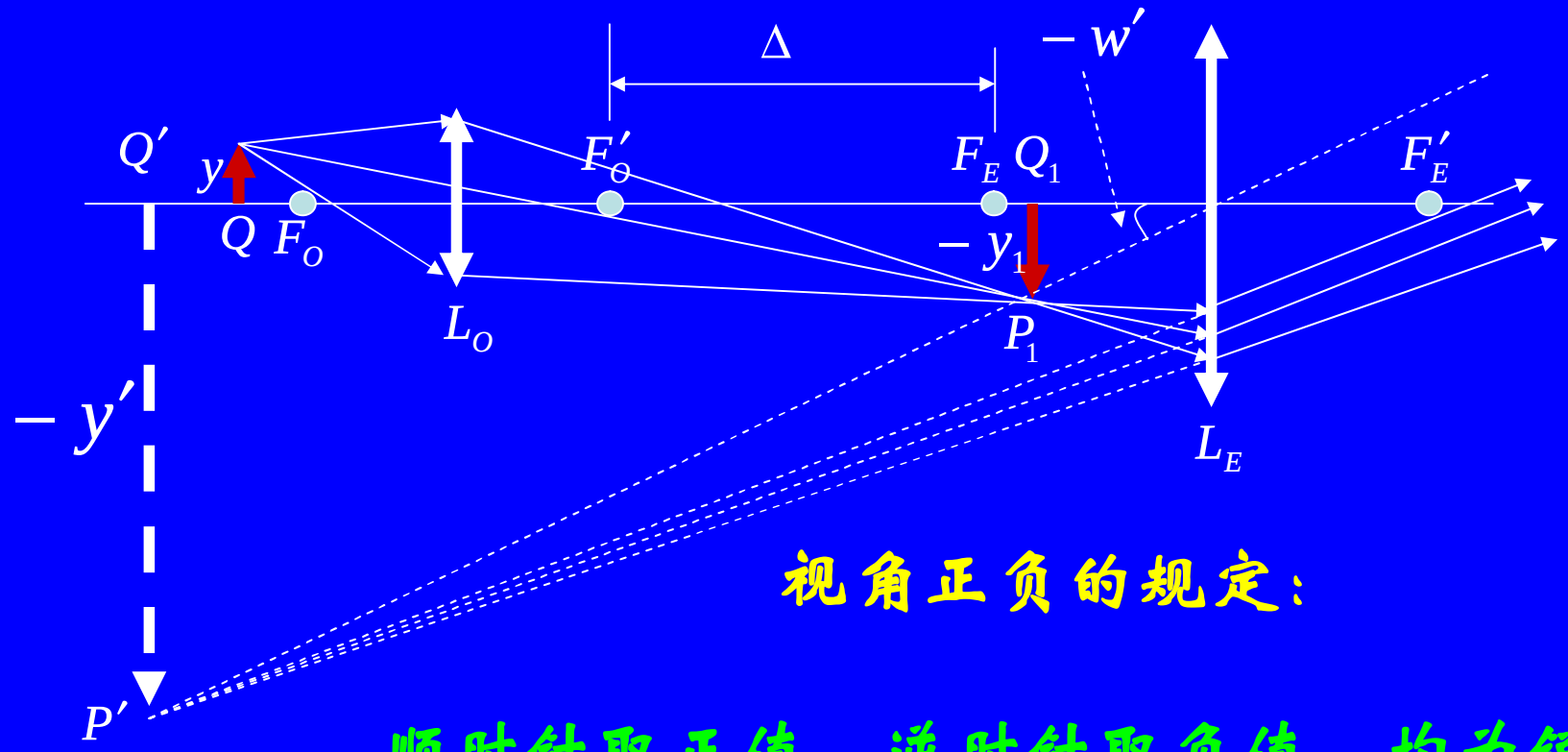
8.5 显微镜

1) 结构和光路：



特点：$f_O < f_E << s_0$，　$f_O, f_E << \Delta$，　Δ 为光学筒长

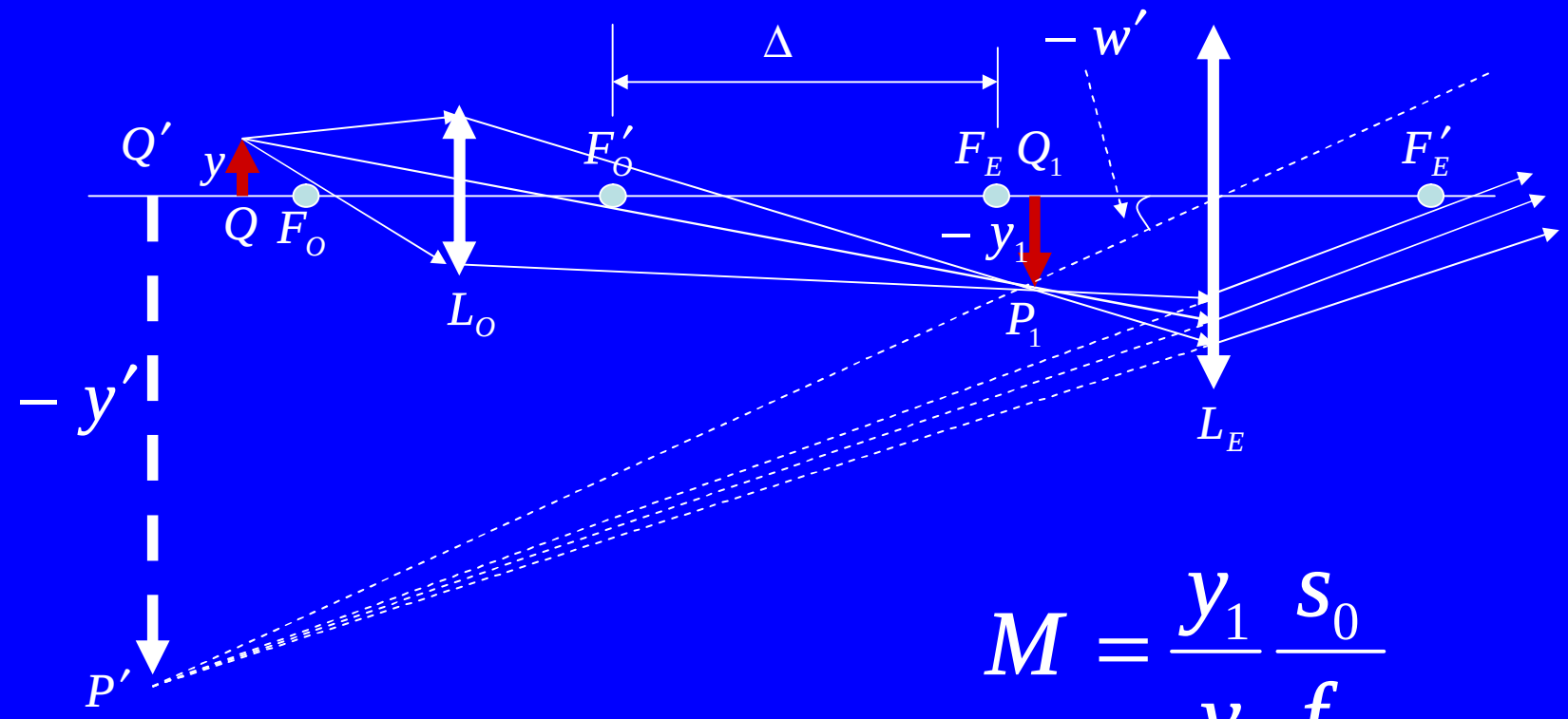
2) 视角放大率：



视角正负的规定：

顺时针取正值，逆时针取负值，均为锐角

$$M \equiv \frac{w'}{w} \qquad w = \frac{y}{s_0} \qquad -w' \approx \frac{-y_1}{f_E} \qquad M = \frac{y_1}{y}\frac{s_0}{f_E}$$



$$M = \frac{y_1}{y}\frac{s_0}{f_E}$$

$$V_O = \frac{y_1}{y} = -\frac{x_1'}{f_O'} \approx -\frac{\Delta}{f_O}$$

$$M_E = \frac{s_0}{f_E}$$

$$M = -\frac{\Delta}{f_O}\frac{s_0}{f_E} = V_O M_E$$

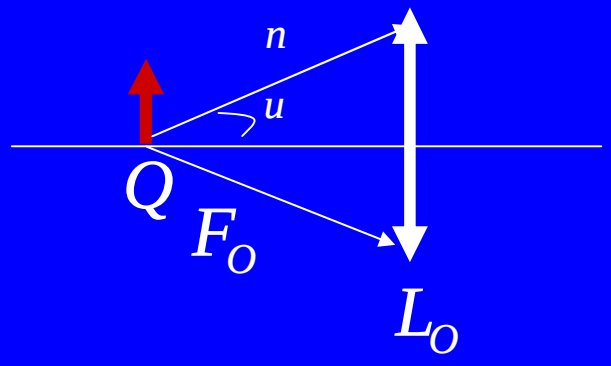
$$M = -\frac{\Delta}{f_O}\frac{s_0}{f_E} = V_O M_E$$

部分显微镜的基本数据

物镜			光学筒长	目镜	
倍率V_O	焦距 f_O	N.A.	计算值	倍率M_E	焦距 f_E
3×	39.50mm	0.10	118.50mm	5×	50mm
8×	19.96mm	0.25	159.68mm		
45×	4.12mm	0.63	185.40mm	10×	25mm
100×	1.91mm	1.32	191.00mm		

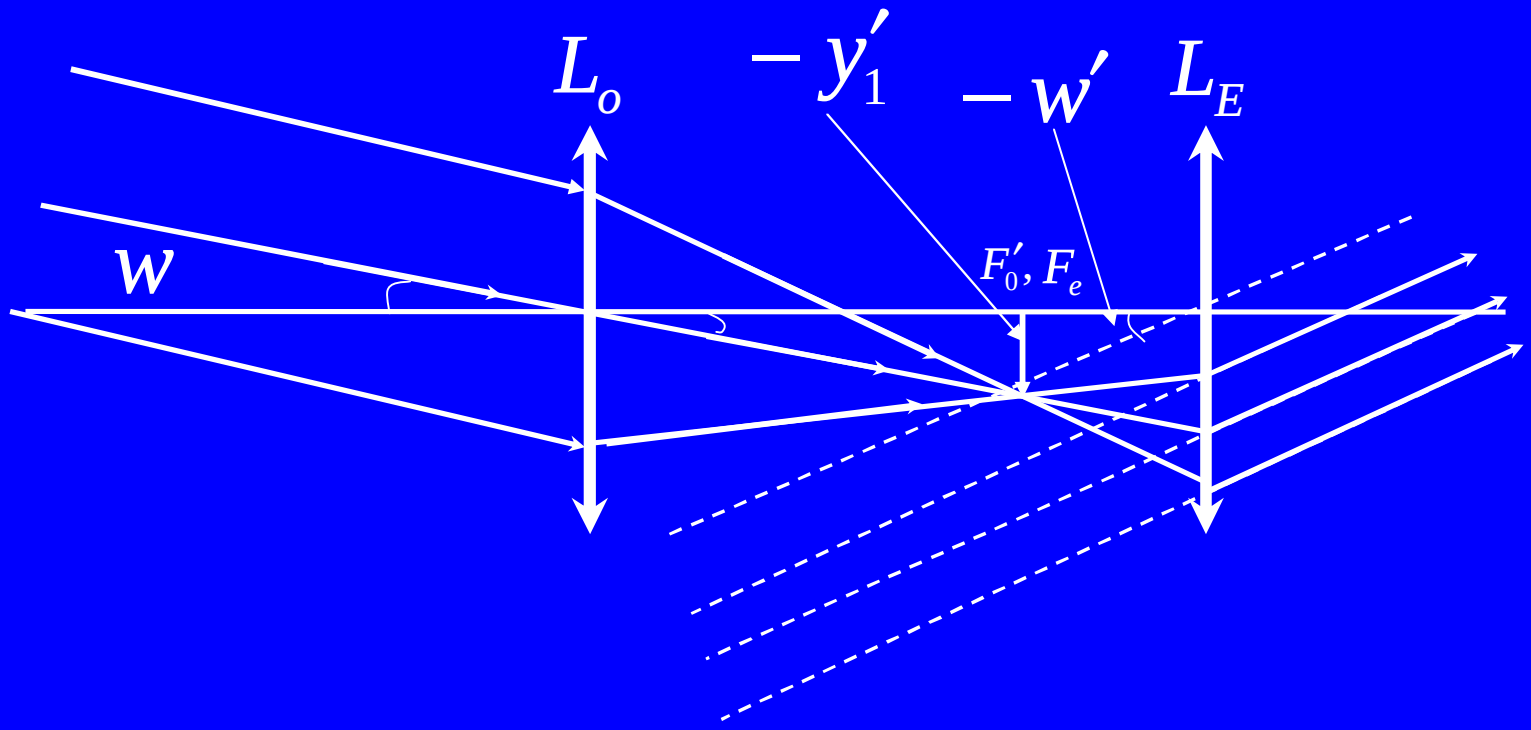
物镜的数值孔径

$$n\sin u = N.A.$$

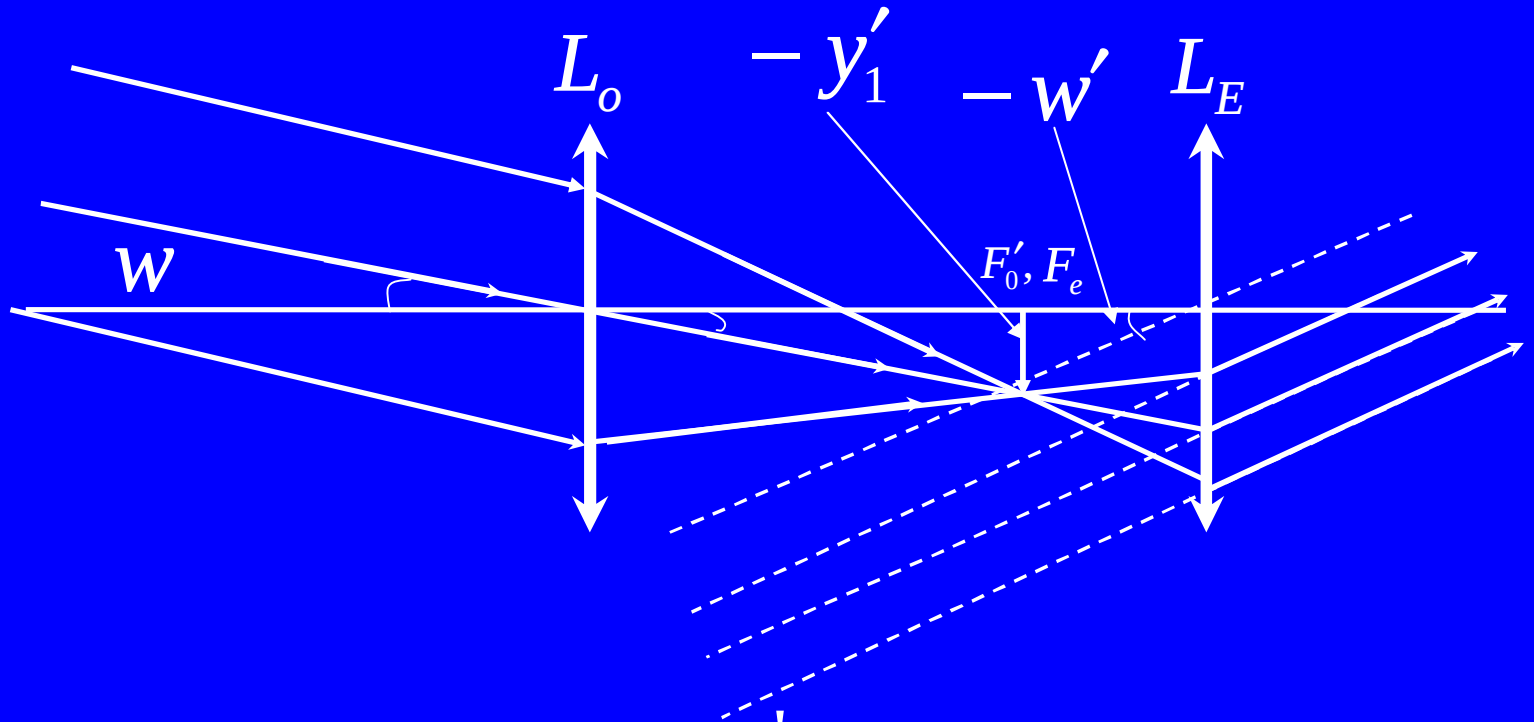


8.6 望远镜

1）结构和光路：



特点：　$f_E < f_O$　，$\Delta = 0$



2)视角放大率： $M = \dfrac{w'}{w}$

$$w = \frac{-y_1}{f_O} \qquad -w' = \frac{-y_1}{f_E}$$

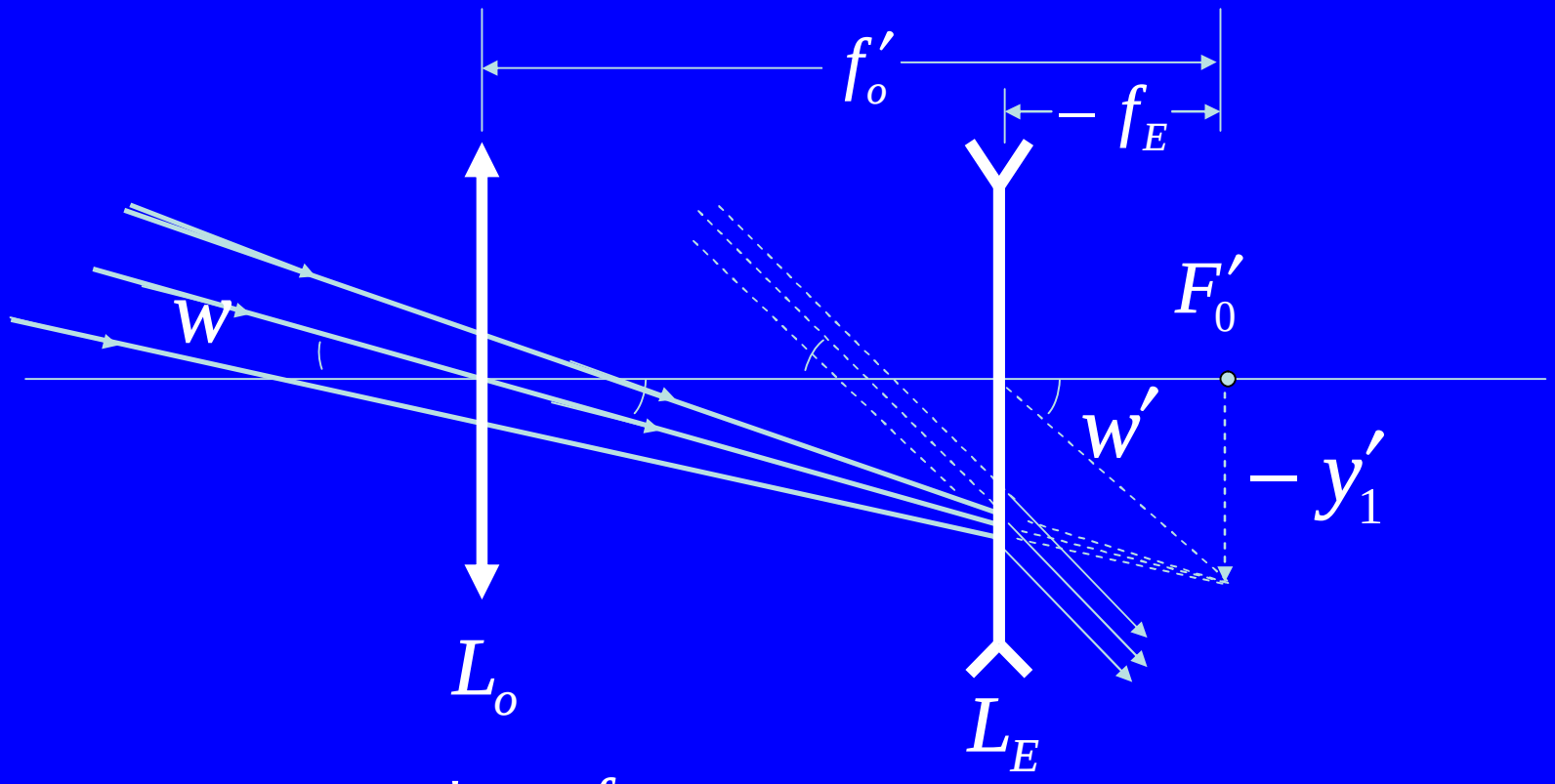
$$M = \frac{w'}{w} = -\frac{f_O}{f_E}$$

负号表示像是倒立的 $M<0$

3)开普勒和伽利略望远镜：

若 $f_E > 0, f_O > 0$ ，称为开普勒望远镜；

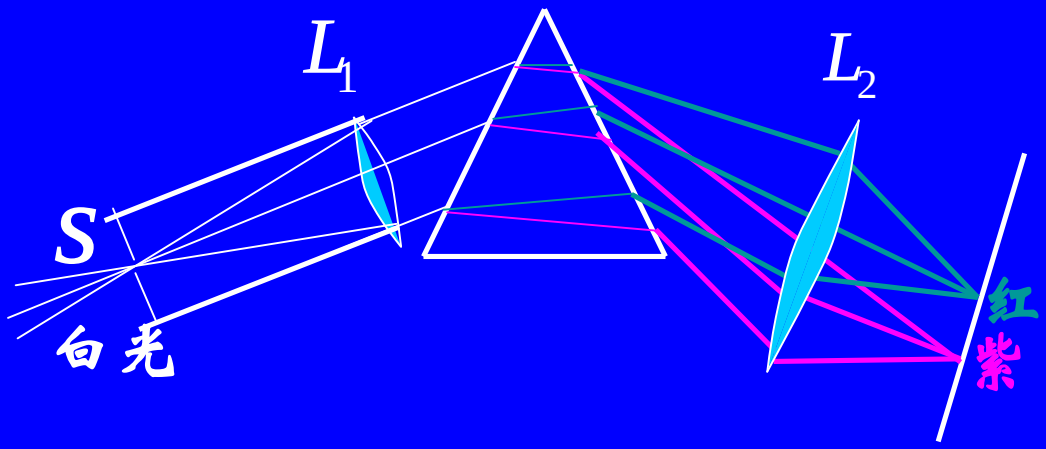
若 $f_E < 0, f_O > 0$ ，称为伽利略望远镜。



$$M = \frac{w'}{w} = -\frac{f_O}{f_E} \qquad M > 0$$

8.7 棱镜光谱仪

1）结构与光路：



2）角色散本领：

$$D=\frac{dd}{dl},\qquad D=\frac{dd_m}{dl}=\frac{dd_m}{dn}\frac{dn}{dl}=\left(\frac{dn}{dd_m}\right)^{-1}\frac{dn}{dl}$$

$$D = \frac{dd_m}{dl} = \frac{dd_m}{dn}\frac{dn}{dl} = \left(\frac{dn}{dd_m}\right)^{-1}\frac{dn}{dl}$$

$$n = \frac{\sin\frac{a + d_m}{2}}{\sin\frac{a}{2}} \qquad \frac{dn}{dd_m} = \frac{\frac{1}{2}\cos\frac{a + d_m}{2}}{\sin\frac{a}{2}}$$

$$D = \frac{2\sin\frac{a}{2}}{\cos\frac{a + d_m}{2}} \cdot \frac{dn}{dl}$$

$$D = \frac{2\sin\frac{a}{2}}{\cos\frac{a + d_m}{2}} \cdot \frac{dn}{dl}$$

$$\cos\frac{a + d_m}{2} = \cos i_1 = \sqrt{1 - \sin^2 i_1}$$

$$= \sqrt{1 - n^2 \sin^2 i_2} = \sqrt{1 - n^2 \sin^2 \frac{a}{2}}$$

$$\rightarrow D = \frac{2\sin\frac{a}{2}}{\sqrt{1 - n^2 \sin^2 \frac{a}{2}}} \cdot \frac{dn}{dl}$$

dn/dl

称为色散率，它由棱镜材料的性质确定。

作业：

习题：2，3，6