光学 hw

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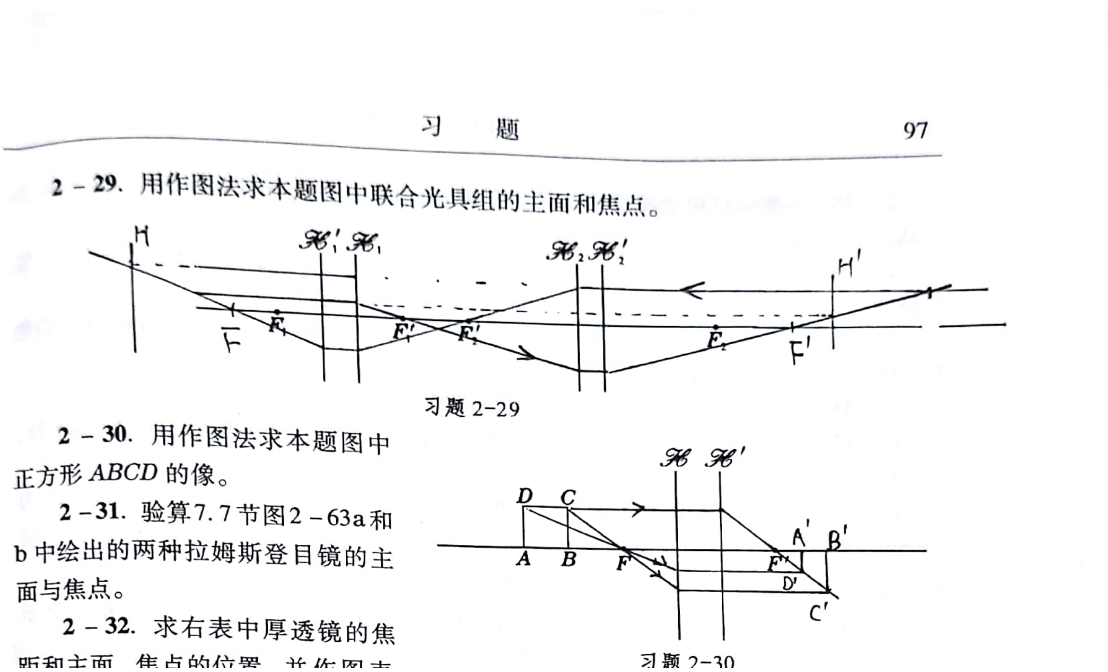
2-29，2-30



2 - 29. 用作图法求本题图中联合光具组的主面和焦点。

习题 2-29

2 - 30. 用作图法求本题图中正方形 *ABCD* 的像。

2 - 31. 验算7.7节图2-63a和b中绘出的两种拉姆斯登目镜的主面与焦点。

2 - 32. 求右表中厚透镜的焦距和主面、焦点的位置，并作图表

习题 2-30

2-32

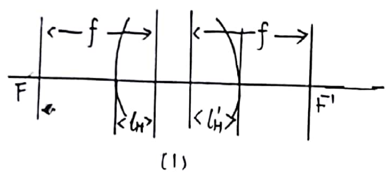
2-32

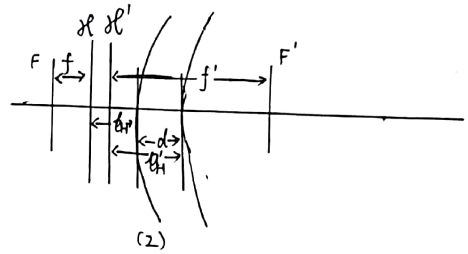
(1) $\phi = (n-1)\left(\frac{1}{r_1} - \frac{1}{r_2}\right) + \frac{(n-1)^2}{n r_1 r_2} d$

$= 10 - \frac{1}{6} \Rightarrow$

$f = \frac{1}{\phi} = 10.17\,cm$

两主面距界面顶点距离 $l_H = \frac{-r_1 d}{n(r_2-r_1)+(n-1)d} = -0.339\,cm. = l_H'$





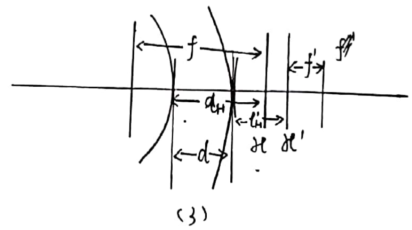
(2) $\phi = \frac{1}{2} \cdot 5 + \frac{\frac{1}{4}}{\frac{3}{2} \cdot 0.02} \cdot 0.01$

$= \frac{5}{2} + \frac{1}{4 \times 3}$

$\Rightarrow f = \frac{1}{\phi} = 38.71\,cm$

$l_H = \frac{-r_1 d}{n(r_2-r_1)+(n-1)d} = 0.645\,cm$

$l_H' = \frac{-r_2 d}{n(r_2-r_1)+(n-1)d} = -1.290\,cm$



(3) $\phi = \frac{1}{2}(-\frac{5}{3}) + \frac{1/4}{\frac{3}{2} \cdot 0.03} 0.01$

$= -0.778$

$f = \frac{1}{\phi} = 128.57\,cm$

$l_H = \frac{-0.15 \times 0.01}{\frac{3}{2}(-5) \times 0.01 + \frac{1}{2} \times 0.01} = 2.143\,cm$

$l_H' = \frac{-0.2 \times 0.01}{\frac{3}{2}(-0.05) + \frac{0.01}{2}} = 2.857\,cm$

2-37

2-37.

$$\begin{cases} \dfrac{f}{s} + \dfrac{f'}{s'} = 1 \\ \dfrac{f}{s+\Delta x} + \dfrac{f'}{s'+\Delta x'} = 1 \end{cases} \Rightarrow \begin{cases} fs' + f's = ss' & ① \\ fs' + f\Delta x' + f's + f'\Delta x = ss' + s'\Delta x + s\Delta x' + \Delta x\Delta x' & ② \end{cases}$$

$$②-①: \begin{cases} f\Delta x' + f'\Delta x = s'\Delta x + s\Delta x' + \Delta x\Delta x' \\ fs' + f's = ss' \end{cases}$$

$$\Rightarrow \begin{cases} f\Delta x's + f'\Delta xs = ss'\Delta x + s^2\Delta x' + s\Delta x\Delta x' & ③ \\ f\Delta xs' + f'\Delta xs = ss'\Delta x & ④ \\ f\Delta x's' + f'\Delta x's = \Delta x'ss' & ⑤ \end{cases}$$

$$③-④⑤\quad f'\Delta xs - f'\Delta x's' = ss'\Delta x + s^2\Delta x' + s\Delta x\Delta x' - \Delta x'ss'$$

$$③-④\quad f\Delta x's - f\Delta xs' = s^2\Delta x'$$

$$f = \frac{s^2\Delta x' + \Delta x\Delta x's}{\Delta x's - \Delta xs'}$$

$$\Rightarrow \begin{cases} f\Delta x's' + f'\Delta xs' = s'^2\Delta x + ss'\Delta x' + \Delta x\Delta x's' & ⑥ \\ f\Delta x's' + f'\Delta x's = ss'\Delta x & ⑦ \end{cases}$$

$$⑥-⑦\quad f'(\Delta xs' - \Delta x's) = s'^2\Delta x + \Delta x\Delta x's'$$

$$f' = \frac{s'^2\Delta x + \Delta x\Delta x's'}{\Delta xs' - \Delta x's}$$

$$\frac{\Delta x}{\frac{1}{v_1} - \frac{1}{v_2}} = \frac{f}{f'} \frac{\Delta x}{-\frac{s}{s'} + \frac{s+\Delta x}{s'+\Delta x'}} = \frac{f}{f'} \frac{\Delta xs'(s'+\Delta x')}{-ss' - s\Delta x' + ss' + \Delta xs'}$$

$$= \frac{f}{f'} \frac{\Delta xs'^2 + \Delta x\Delta x's'}{\Delta xs' - s\Delta x'}$$

代入f'

$\Rightarrow$ 原式 $= f$

$$\frac{\Delta x'}{v_1 - v_2} = \frac{f'}{f} \frac{\Delta x'}{-\frac{s'}{s} + \frac{s'+\Delta x'}{s+\Delta x}}$$

$$= \frac{f'}{f} \frac{s^2\Delta x' + \Delta x\Delta x's}{\Delta x's - \Delta xs'}$$

代入f

原式 $= f'$

2-40

1

戴上眼镜后应该能看到无穷远，即：

$$\Phi = (\frac{1}{\infty} - \frac{1}{2.5})D = -0.4D = 40\text{度}$$

2

戴上眼镜后应该能看到明视距离 0.25m，即：

$$\Phi = (\frac{1}{0.25} - \frac{1}{1})D = 3D = 300\text{度}$$

2-42

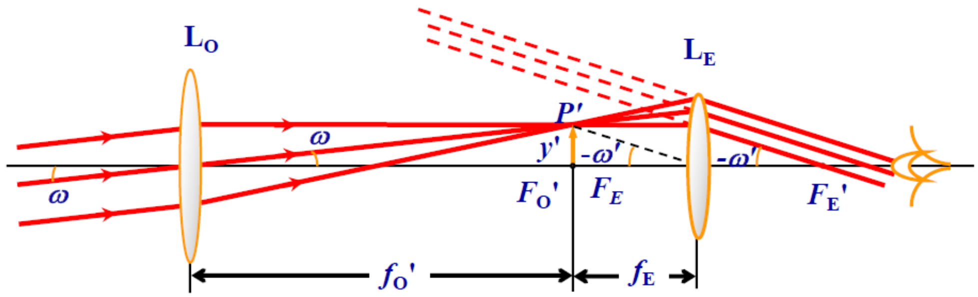
物镜放大率：

$$V_0 = -\frac{x}{f} = -40$$

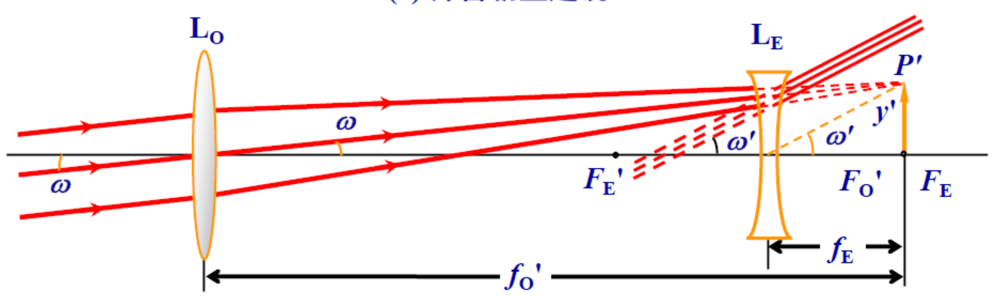
显微镜总放大率为物镜放大率与目镜放大率之积：

$$V_{total} = V_0 \times 20 = -600$$

2-45



(a) 开普勒望远镜



(b) 伽利略望远镜

(a) 开普勒型望远镜

其角放大率

$$W = \frac{\tan(\omega')}{\tan\omega} = -3$$

且

$$\tan(\omega') = \frac{-y'}{f_E} \qquad \tan\omega = \frac{y'}{-f'_O} \qquad f'_O = 50cm$$

即：

$$f_E = f'_O/3 = 50/3cm = 16.7cm$$

$$\Rightarrow \Phi_E = 1/f_E = 6m^{-1}$$

$$d = f'_O + f_E = 66.7cm$$

(b) 伽利略型望远镜

其角放大率

$$W=\frac{\tan(\omega')}{\tan\omega}=-3$$

且

$$\tan(\omega')=\frac{-y'}{f_E}\qquad \tan\omega=\frac{y'}{f'_O}\qquad f'_O=-50cm$$

即：

$$f_E=f'_O/3=-50/3cm=-16.7cm$$

$$\Rightarrow \Phi_E=1/f_E=-6m^{-1}$$

$$d=f'_O+f_E=33.3cm$$

2-47

假设所求望远镜为开普勒型望远镜，则物距 $s=f'_O+f_E$ 为两镜间隔。代入

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

可以得到

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

$$\Rightarrow s'=\frac{f_E}{f'_O}(f_E+f'_O)\simeq f_E$$

设物镜直径 D_0, 出射光瞳直径 D' 放大率

$$\frac{D'}{D_0}=|V|=\left|\frac{-s'}{s}\right|=\left|\frac{-\frac{f_E}{f_O}(f_E+f'_O)}{f'_O+f_E}\right|$$

对于 V 有：

$$V=\frac{-\frac{f_E}{f'_O}(f_E+f_O)}{f'_O+f_E}=-\frac{f_E}{f'_O}$$

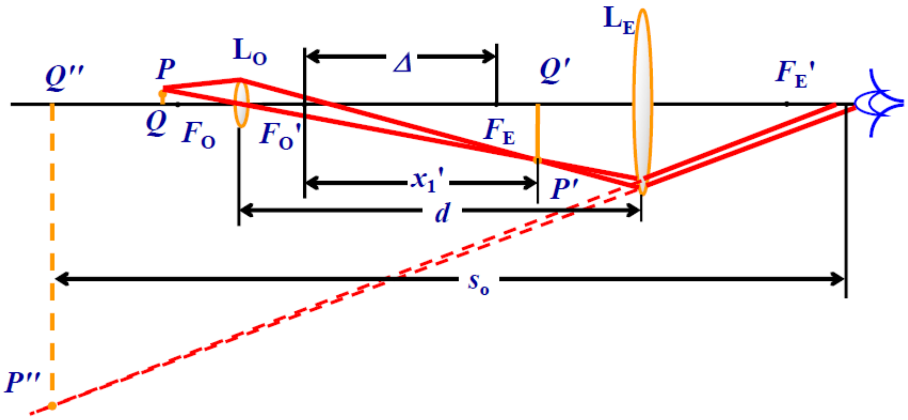
即：

$$\frac{D'}{D_0}=\left|\frac{f_E}{f'_O}\right|=1/|M|$$

$$\Rightarrow D'=\frac{D_0}{|M|}$$

Q.E.D.

2-49



1

物距 $s = f'_O + f_E + \Delta$ 为两镜间隔。代入

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

可以得到

$$\frac{1}{f'_O + f_E + \Delta} + \frac{1}{s'} = \frac{1}{f_E}$$

$$\Rightarrow s' = \frac{f_E(f'_O + f_E + \Delta)}{f'_O + \Delta} = f_E(1 + \frac{f'_O}{f'_O + \Delta}) \simeq f_E$$

2

$$M = \frac{Q'P'/f_e}{QP/s_0} = \frac{Q'P'}{QP}\frac{s_0}{f_e} = \frac{s_0}{f_e}\frac{-\Delta}{f'_O}$$

$$\text{代入} V = \frac{-\Delta}{f'_O},\ f_0 = nf'_0$$

$$|M| = \frac{s_0 n\Delta}{f_O f_E}$$

$$\tan u_0 = \frac{D_0}{2nf_O} \simeq u_0$$

$$\frac{-D'}{D_0} = V = \frac{\Delta}{f_e}$$

$$\Rightarrow \frac{2s_0nu_0}{|M|} = \frac{2s_0nD_0f_ef_O}{2f_Os_o\Delta n} = \frac{D_0f_e}{\Delta} = D'$$

2-50

对于 DD 形成的入瞳 $D'D'$

$$\frac{1}{s_0} + \frac{1}{4a} = \frac{1}{2a}$$

$$\Rightarrow s_0 = 4a = 2f_1$$

则该入瞳半径为 r_3
对于 L_2 形成的入瞳 L_2'

$$\frac{1}{s_0} + \frac{1}{6a} = \frac{1}{2a}$$

$$\Rightarrow s_0 = 3a = \frac{1}{2}s_0'$$

则该入瞳半径为 $r = \frac{3}{2}r_3$.
由几何关系，可知入瞳 $D'D'$ 对光束限制作用最大，是真实的入瞳，该入瞳半径为 r_3，距离 L_1 左侧 $4a$。
因此孔径光阑为 DD。
对于 DD 形成的出瞳 $D''D''$

$$\frac{1}{d-l} + \frac{1}{s_1} = \frac{1}{a}$$

$$\Rightarrow s_0 = 2a = 2f_2$$

则该出瞳距离 L_2 右侧 $2a$，半径为 r_3
在孔径光阑左侧只有 L_1 限制光束，L_1 边缘即为入射窗，视场光阑。

2

令 $K_1 = \frac{1}{r_1} - \frac{1}{r_2}, K_2 = \frac{1}{r_2}$, 则 C 线和 F 线的光焦度分别为：

$$P_F = (n_{F1} - 1)K_1 + (n_{F2} - 1)K_2$$

$$P_C = (n_{C1} - 1)K_1 + (n_{C2} - 1)K_2$$

由于消除相差时成像在同一点，

$$P_F - P_C = (n_{F1} - n_{C1})K_1 + (n_{F2} - n_{C2})K_2 = 0$$

且焦距满足：

$$P_D = (n_{D1} - 1)K_1 + (n_{D2} - 1)K_2 = 1/100mm = 10D$$

求解上述方程，可解得：

$$K_1 = 44.9109, K_2 = -21.2736$$

$$\Rightarrow r_1 = 15.11mm, r_2 = -47.01mm$$