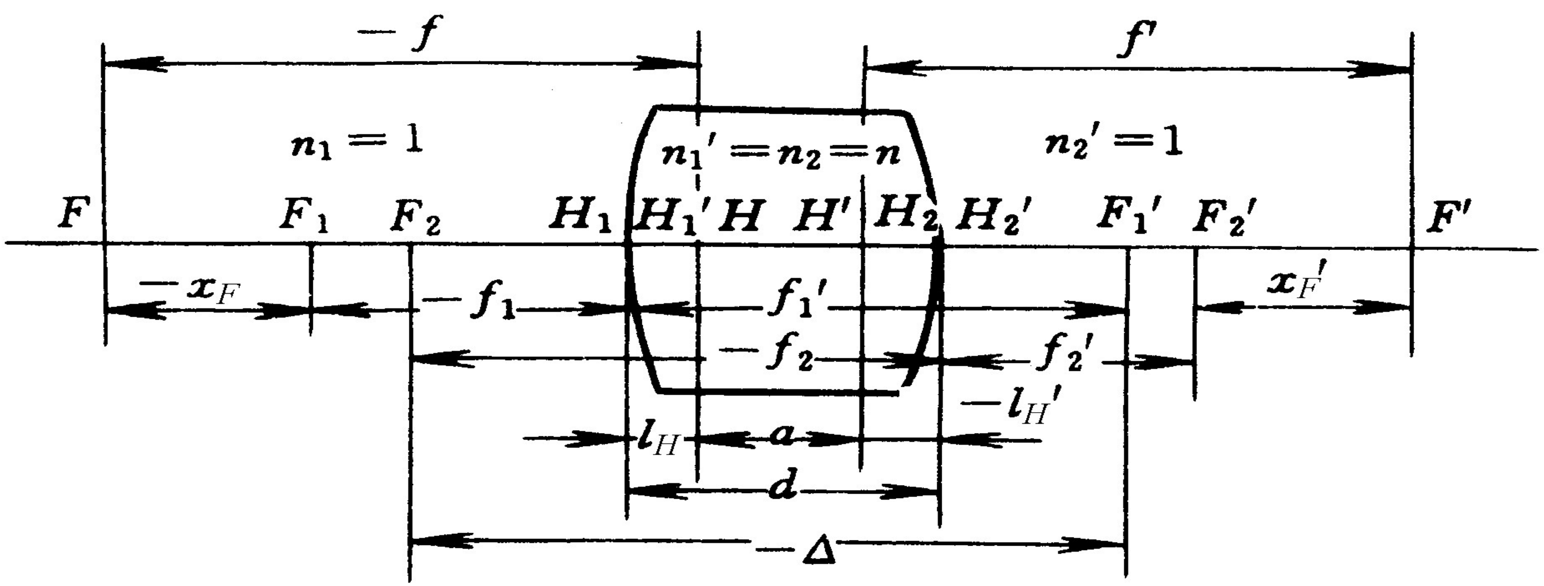
第16讲　单透镜的主平面和焦点位置计算公式

已知：　r_1, r_2, d, n

求：主平面位置，焦点位置

物方主平面：　l_H 以0_1为起点到H

像方主平面：　$l_H{}'$ 以0_2为起点到H’

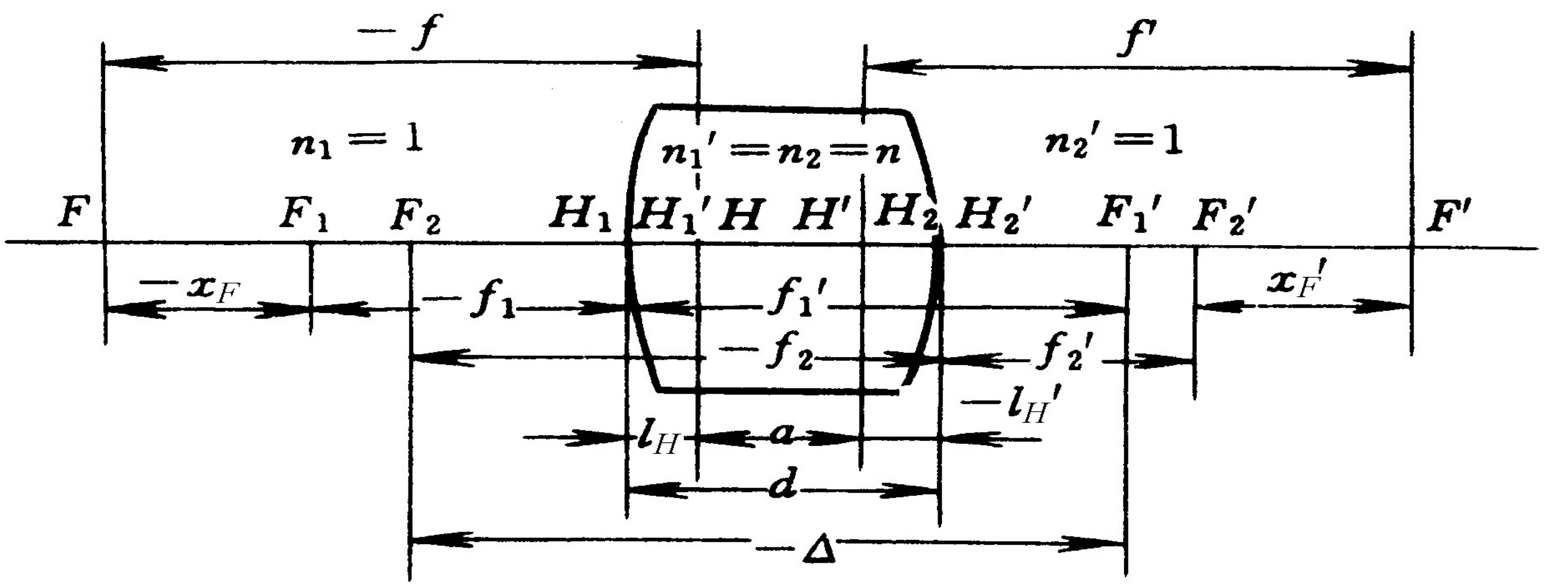


由图有 $$(-x_F)+(-f_1)+l_H=-f$$

$$x_F'+f_2'+(-l_H')=f'$$

即

$$l_H=x_F+f_1-f \qquad l_H'=x_F'+f_2'-f'$$

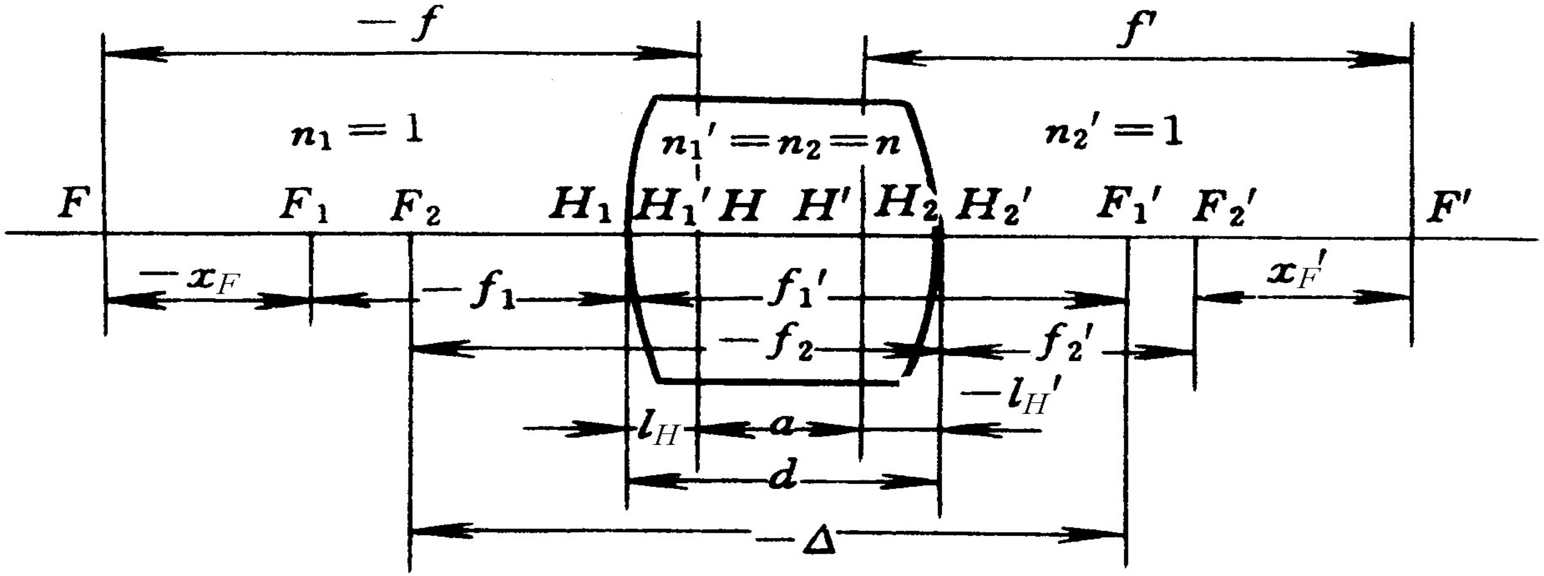


对于单透镜每个面，有

$$f_1' = \frac{nr_1}{n-1} \qquad f_1 = \frac{-r_1}{n-1} \qquad f_2' = \frac{r_2}{1-n} \qquad f_2 = \frac{-nr_2}{1-n} \qquad x_F = \frac{f_1 f_1'}{\Delta}$$

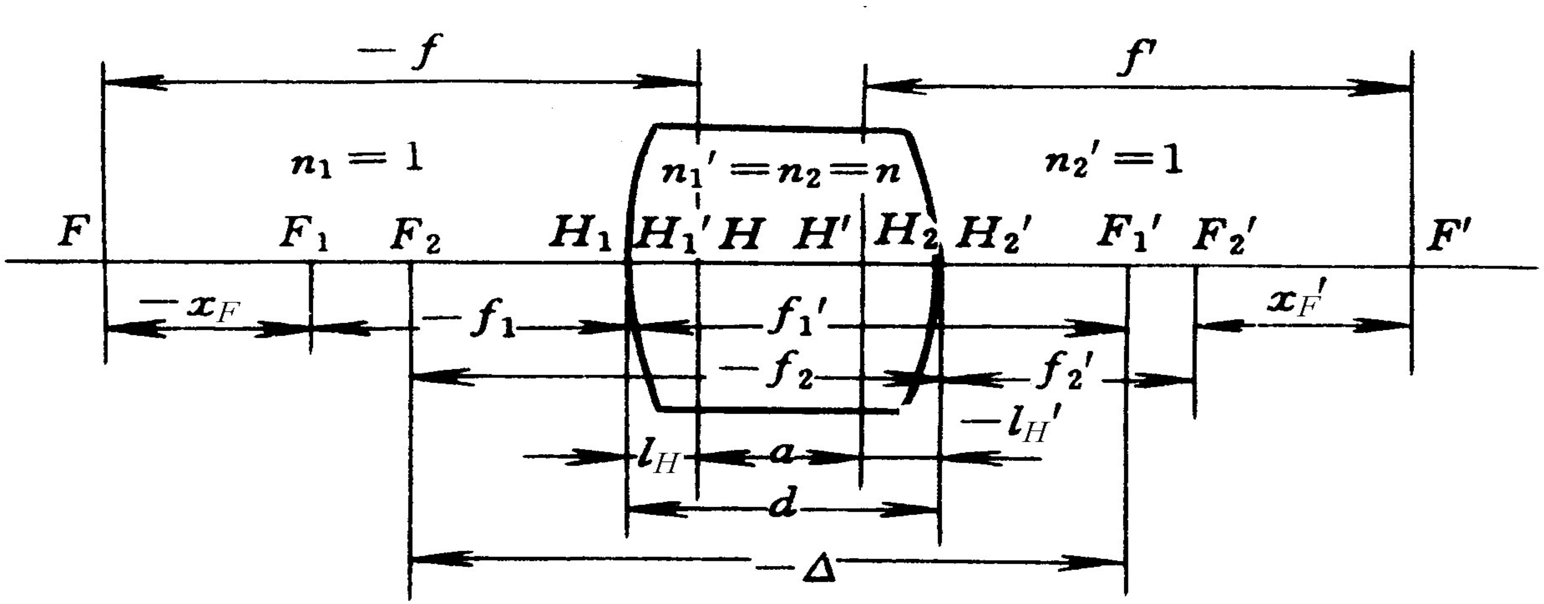
代入组合系统的焦距公式

$$\frac{n_3}{f'} = \frac{n_2}{f_1'} + \frac{n_3}{f_2'} - \frac{n_3 d}{f_1' f_2'} = -\frac{n_1}{f}$$



有

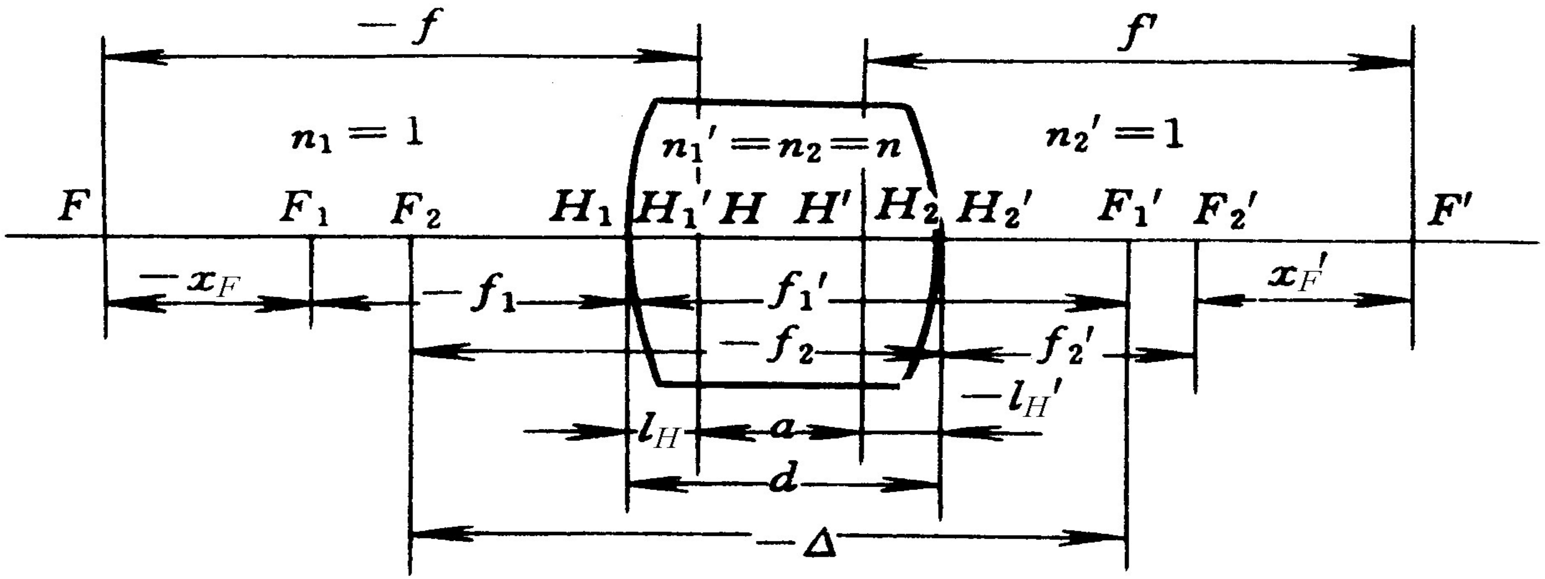
$$\frac{1}{f'}=(n-1)\left(\frac{1}{r_1}-\frac{1}{r_2}\right)-\frac{(n-1)d}{nr_1r_2}=-\frac{1}{f}$$



对于 $l_H = x_F + f_1 - f$ $\quad l_H' = x_F' + f_2' - f'$

由于单透镜每个面，有

$$f_1' = \frac{nr_1}{n-1} \qquad f_1 = \frac{-r_1}{n-1} \qquad f_2' = \frac{r_2}{1-n} \qquad f_2 = \frac{-nr_2}{1-n} \qquad x_F = \frac{f_1 f_1'}{\Delta}$$



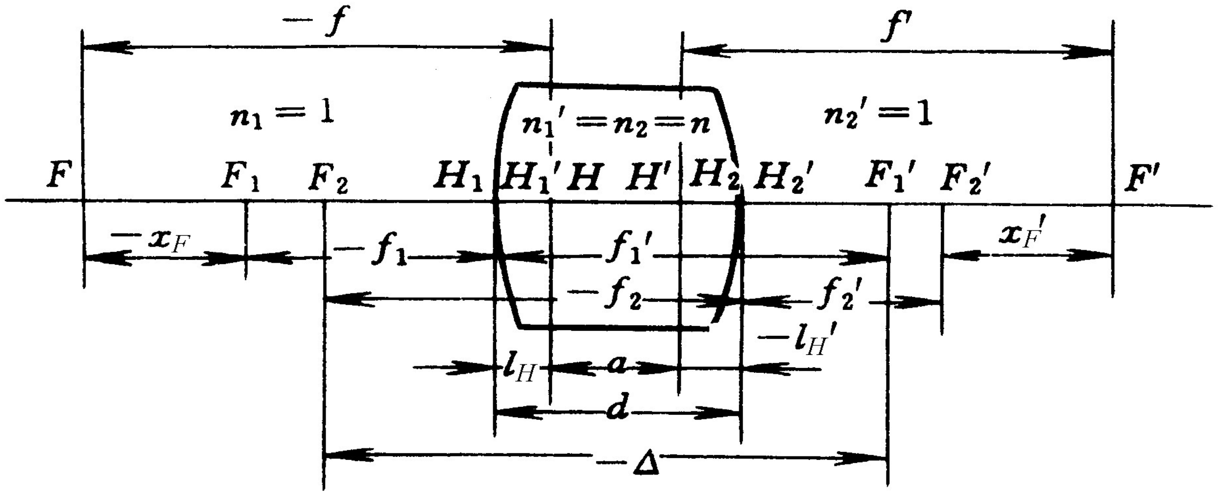
$$l_H = \frac{-r_1 d}{n(r_2 - r_1) + (n-1)d} \qquad l_H' = \frac{-r_2 d}{n(r_2 - r_1) + (n-1)d}$$

用a表示两个主平面之间的距离，a从H到H’，有

$$l_H + a + (-l_H') = d \qquad a = d - l_H + l_H'$$

代入并简化，有

$$a = \frac{d(n-1)(r_2 - r_1 + d)}{n(r_2 - r_1) + (n-1)d}$$



单透镜焦距、主平面位置：

$$\frac{1}{f'} = (n-1)\left(\frac{1}{r_1} - \frac{1}{r_2}\right) - \frac{(n-1)d}{n r_1 r_2} = -\frac{1}{f}$$

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

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

$$a = \frac{d(n-1)(r_2 - r_1 + d)}{n(r_2 - r_1) + (n-1)d}$$

绝大多数实际应用的透镜的厚度和两半径之差相比要小的多，可以将公式简化为

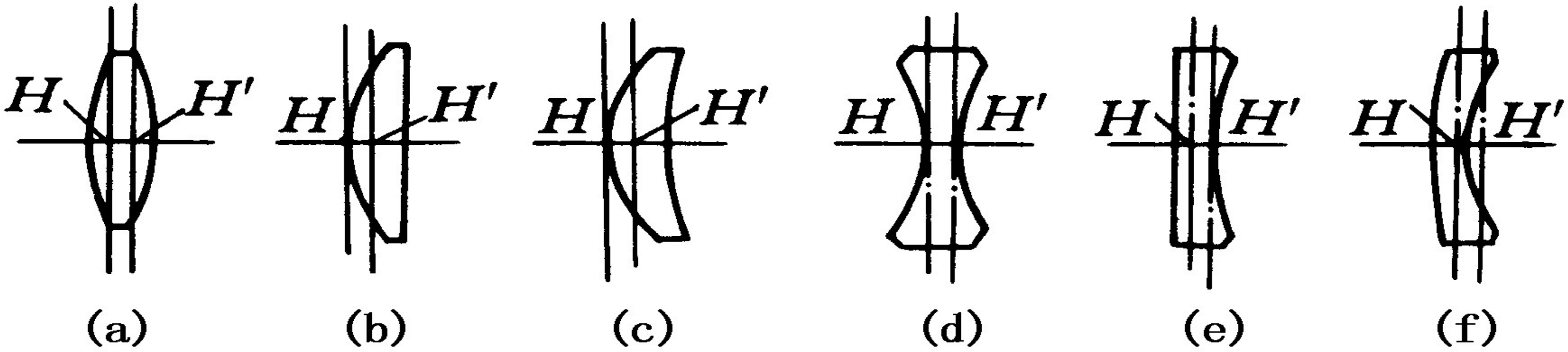
$$\frac{1}{f'} = (n-1)\left(\frac{1}{r_1} - \frac{1}{r_2}\right) = -\frac{1}{f}$$

$$l_H = \frac{-r_1 d}{n(r_2 - r_1)}$$

$$l_H' = \frac{-r_2 d}{n(r_2 - r_1)}$$

$$a = \frac{(n-1)d}{n}$$

各种透镜的形状及主平面位置



$$l_H = \frac{-r_1 d}{n(r_2 - r_1)}$$

$$l_H' = \frac{-r_2 d}{n(r_2 - r_1)}$$

$$\frac{1}{f'} = (n-1)\left(\frac{1}{r_1} - \frac{1}{r_2}\right) = -\frac{1}{f}$$