Table of contents

Magnification lateral/heigth/size $y = z$, longitudinal/distance $x \perp y$

$g \equiv$ distance from object, sender source (from Objectiv)

$b \equiv$ distance from observer, receiver detector (from Okular)

$l \equiv$ distance observer to next lense

$r \equiv$ radius of curvature (bended reflective surface, lense koncav vs. konvex)

$d \equiv$ max. thickness of curved lense enclosed between one konvex side from g and one konkav side from b with radi r_g and r_b

$s_0 \equiv$ sight/tubus length

$\varepsilon \equiv$ "visual angle" from observer, $ _0 $ smallest visual angle

$f \equiv$ focal length

$$g \parallel x \parallel b \parallel f \qquad y_b \perp b \qquad y_g \perp g \tag{1}$$

$$\tan(\varepsilon) = \frac{y_b}{b} \qquad \tan(\varepsilon_0) = \frac{y_b}{g} \tag{2}$$

$(\Delta\varphi)_{min} = \Delta\theta = 2\varepsilon_0 = 1.22\frac{\lambda}{d_y}$

"psychological visual angle": $2\varepsilon_0^{min} = 1' = 60'' = \frac{1^\circ}{60} = \frac{2\pi}{360}\frac{1}{60} = \frac{\pi}{10800}$

konkav: $ f>0, r<0 $ konvex: $ f<0, r>0 $, virtual $ b<0 $

$$\frac{\eta_g}{g} + \frac{\eta_b}{b} = \frac{\eta - \eta_g}{r_g} - \frac{\eta - \eta_b}{r_b} \tag{3}$$

$\frac{1}{f_b} = \frac{1}{\eta_b}\left(\frac{\eta-\eta_g}{r_g} - \frac{\eta-\eta_b}{r_b}\right)$

$\frac{1}{f_g} = \frac{1}{\eta_g}\left(\frac{\eta-\eta_g}{r_g} - \frac{\eta-\eta_b}{r_b}\right)$

thin lense: $f = f_g = f_b \iff d \to 0$

lense: $f = f_g = f_b \iff \eta_g = \eta_b$

spherical surface (panel), paraxial rays (linear approx., Gauss):

$$\frac{\eta_g}{g} + \frac{\eta_b}{b} = \frac{\eta_b - \eta_g}{r} \tag{4}$$

$$b = f_b = \frac{\eta_b}{\eta_b - \eta_g} \cdot r \qquad g = f_g = \frac{\eta_g}{\eta_b - \eta_g} \cdot r \tag{5}$$

Focal Length:

$$f = \left(\frac{\Delta y}{\Delta \varepsilon}\right)_{min} = \frac{1}{r}\frac{\eta}{\Delta \eta} = \frac{r}{2}\frac{1}{\eta - 1} = -\frac{r}{2} = f_b = f_g \overset{conjungtion}{=} \frac{g \cdot b}{g + b} \tag{6}$$

where: $f^2 = x_g x_b$ and $x_g = x_g(0) = g - f = -f\frac{y_g}{y_b} = +f \cdot \mathcal{G}_y$ and $x_b = x_b(0) = b - f = -f\frac{y_b}{y_g} = -f \cdot \mathcal{G}_y$

lense proportions:

$$x_g(r_b) = -f \cdot \frac{\eta - 1}{\eta} \cdot \frac{d}{r_b} \qquad x_b(r_g) = -f \cdot \frac{\eta - 1}{\eta} \cdot \frac{d}{r_g} \tag{7}$$

$d = x_g(r_b) + x_b(r_g) + \Delta x$ where rays parallel within Δx inside lense

Dioptri (Refractive Power)[1]:

$$D = \frac{\eta_g}{f_g} = \frac{\eta_b}{f_b} \overset{vacuum}{=} \frac{1}{f} = \frac{1}{g} + \frac{1}{b} \overset{paraxial}{=} \frac{\Delta \eta}{f} = \frac{2}{r} \overset{concave}{=} -\frac{2}{r} \overset{r_b=-r_g}{=} \frac{2}{r}(\eta - 1) = (\eta - 1)\left(\frac{1}{r_g} - \frac{1}{r_b} + \frac{(\eta-1)\cdot d}{\eta}\frac{}{r_g} \right. \tag{8}$$

where: $r < 0$

longitudinal magnification:

$\mathcal{G}_x = \frac{g}{b}$

lateral magnification:

$$\mathcal{G}_y \overset{konkav}{=} \frac{-y_b}{y_g} = -\frac{b}{g} \overset{konkvex}{=} \frac{y_b}{y_g} = -\frac{b - r}{g + r} = -\frac{f}{x_g} = -\frac{x_b}{f} = \frac{f}{f - g} \overset{aplanar}{=} \frac{\eta_g}{\eta_b} \cdot \frac{sin(u_g)}{sin(u_b)} \overset{kollinear}{=} \frac{\eta_g}{\eta_b} \cdot \frac{tan(u_g)}{tan(u_b)} \overset{para}{=} \tag{9}$$

viewangle magnification:

$$\mathcal{G}_\varepsilon = \frac{\varepsilon}{\varepsilon_0} = \frac{\frac{y_b}{b+l}}{\frac{y_g}{s_0}} = \frac{s_0}{g}\frac{1}{1 + \frac{l}{b}} \cong \frac{tan(\varepsilon)}{tan(\varepsilon_0)} = \frac{y_b}{y_g} \cdot \frac{g}{b} = \mathcal{G}_y \cdot \mathcal{G}_x \overset{astronom.}{=} -\frac{f^{Obj}}{f^{Oku}} \overset{terrestr.}{=} +\frac{f^{Obj}}{f^{Oku}} \qquad \in \left[\frac{s_0}{f}, \frac{s_0}{f} + 1\right] \tag{10}$$

[1] Brechkraft

total magnification:

$$\mathcal{G} = \mathcal{G}_y^2 \cdot \mathcal{G}_x = \mathcal{G}_y \cdot \frac{\varepsilon}{\varepsilon_0} = \mathcal{G}_y \cdot \mathcal{G}_\varepsilon = -\frac{x_b^{Obj}}{f^{Obj}} \cdot \frac{s_0}{f^{Oku}} \tag{11}$$