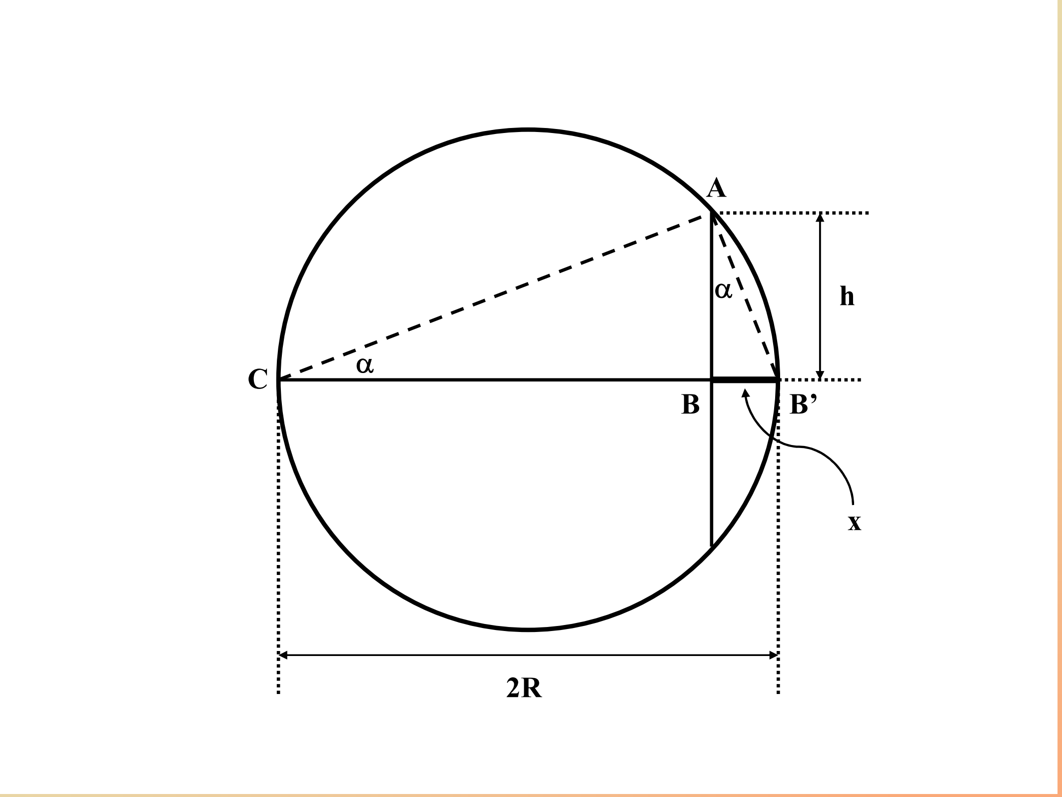
Optika

Paraxiális közelítés

$1° = 0{,}01745329$ rad $\sin(1°) = 0{,}017452406$ $$\frac{\varphi - \sin(\varphi)}{\varphi} = 0{,}0051\%$$

$5° = 0{,}087266$ rad $\sin(5°) = 0{,}087155$ $$\frac{\varphi - \sin(\varphi)}{\varphi} = 0{,}12\%$$

Paraxiális közelítés

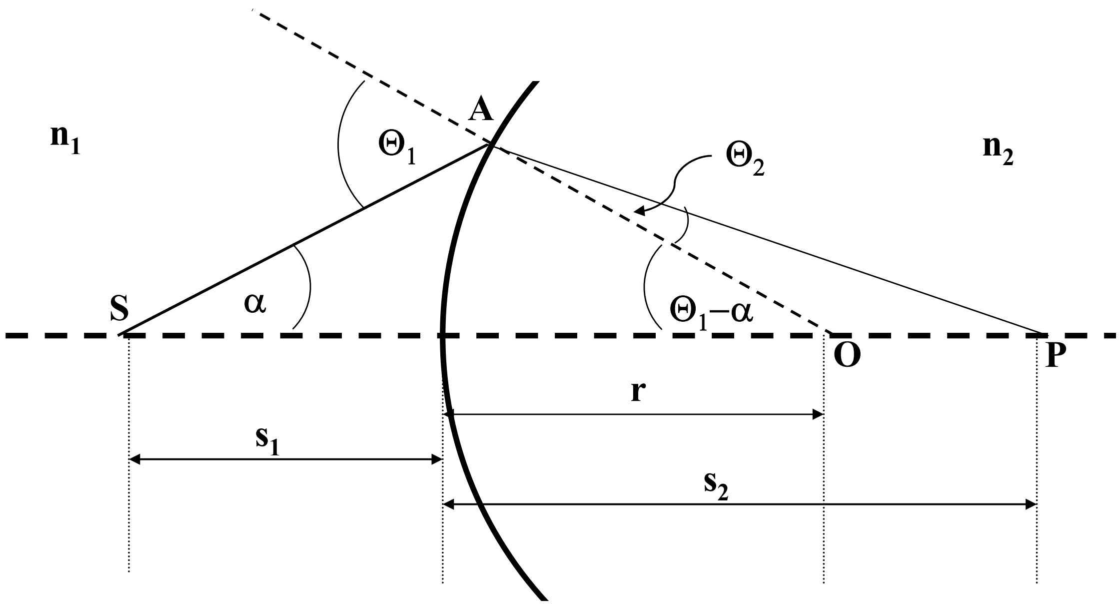


$$\frac{h}{2R - x} = \frac{x}{h}$$

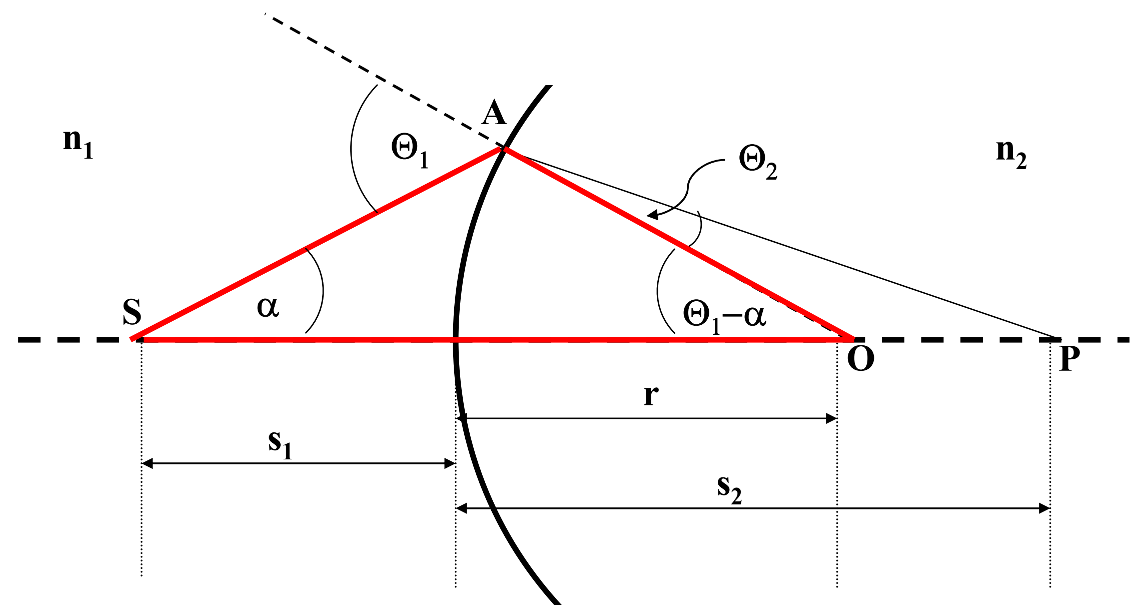
$$h^2 = (2R - x)x$$

2R>>h>>x

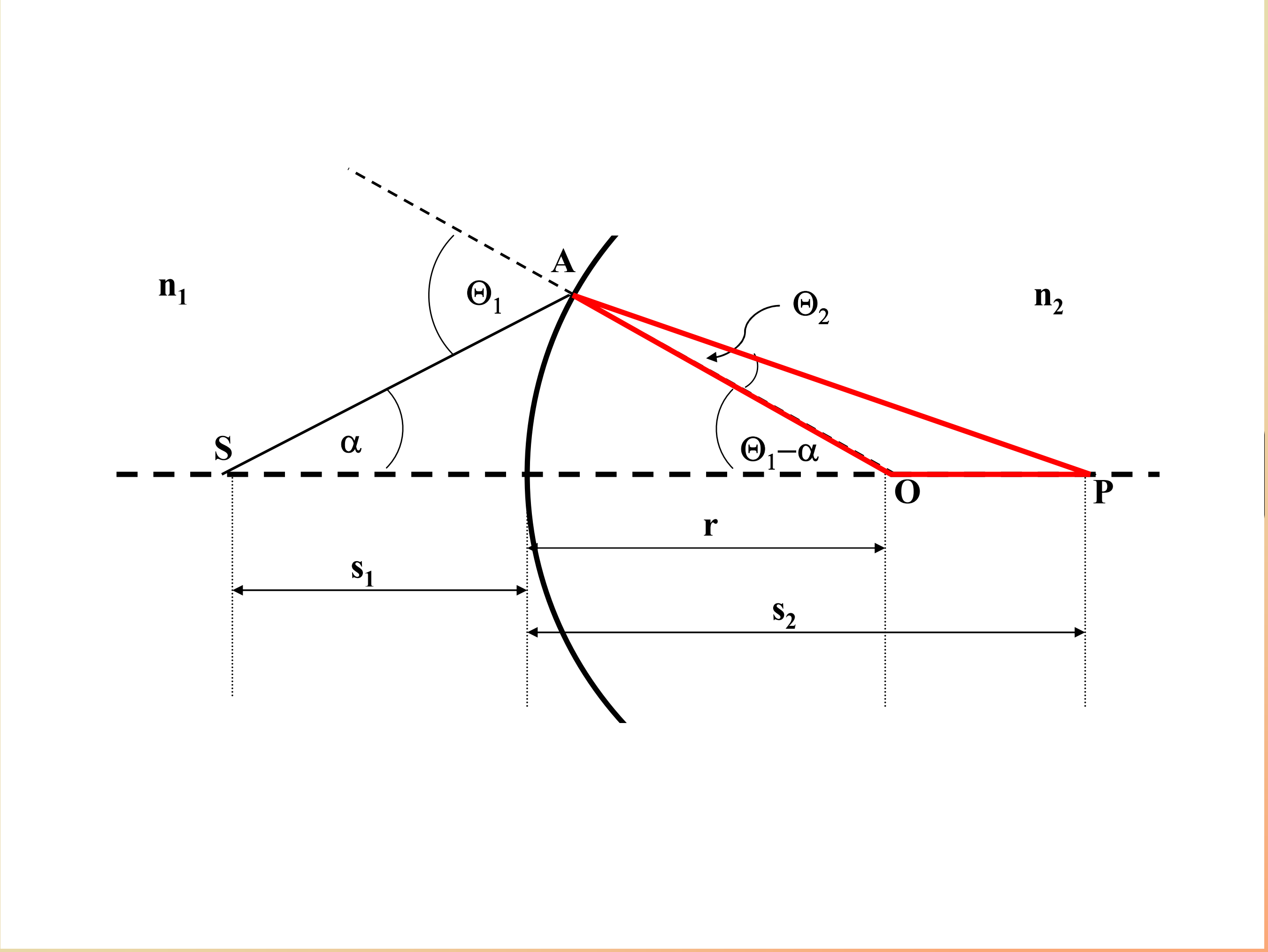
$$\mathbf{x = \frac{h^2}{2R}}$$



A
n1
n2
Θ1
Θ2
α
S
Θ1−α
O
P
r
s1
s2



$$\frac{s_1 + r}{\sin(180 - \theta_1)} = \frac{r}{\sin\alpha}$$



$$\frac{s_2 - r}{\sin\theta_2} = \frac{r}{\sin(\theta_1 - \theta_2 - \alpha)}$$

$$\frac{s_1 + r}{\theta_1} = \frac{r}{\alpha}$$

$$\frac{s_2 - r}{\theta_2} = \frac{r}{\theta_1 - \theta_2 - \alpha}$$

$$\frac{\theta_1}{\theta_2} = n$$

Paraxiális közelítés

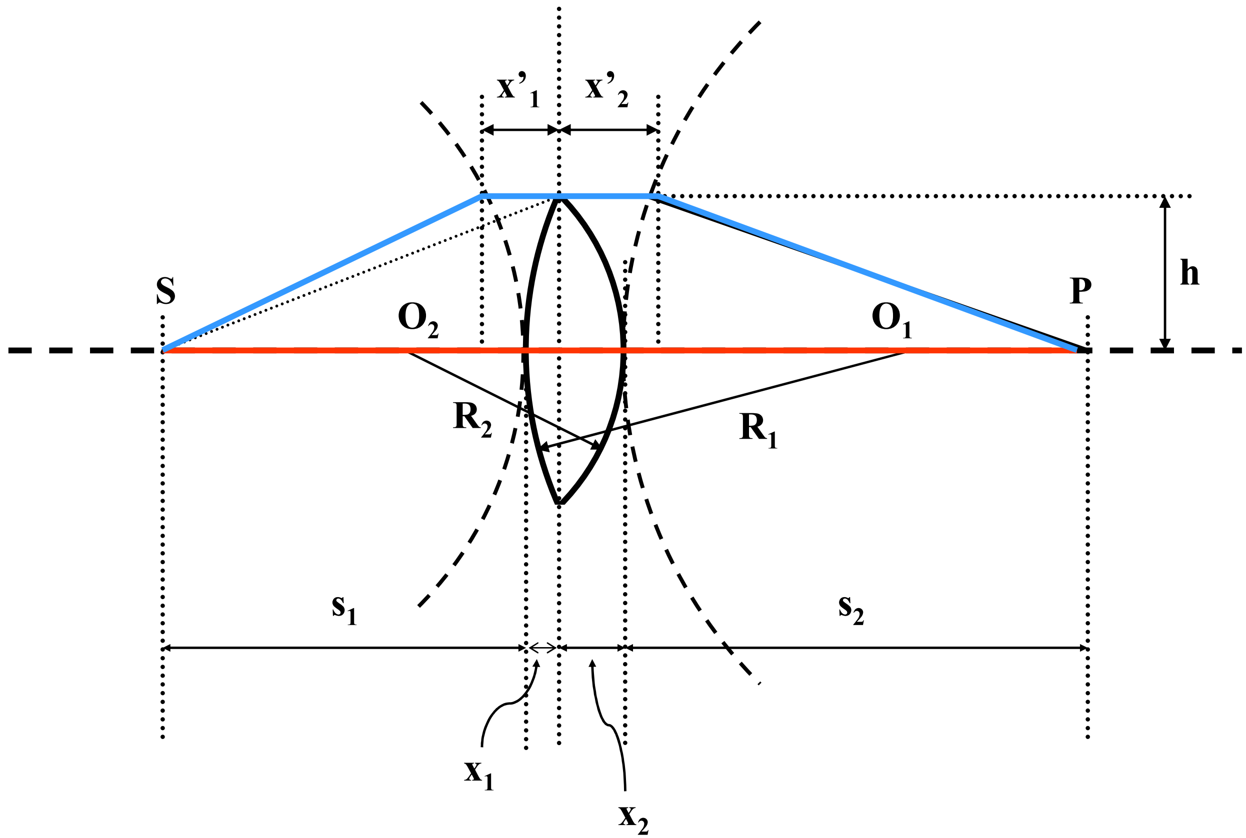
A megoldás:

$$\frac{s_2 - r}{\frac{\cancel{\alpha}}{n\,r}(s_1 + r)} = \frac{r}{\left(\frac{\cancel{\alpha}}{r} - \frac{\cancel{\alpha}}{r\,n}\right)(s_1 + r) - \cancel{\alpha}}$$

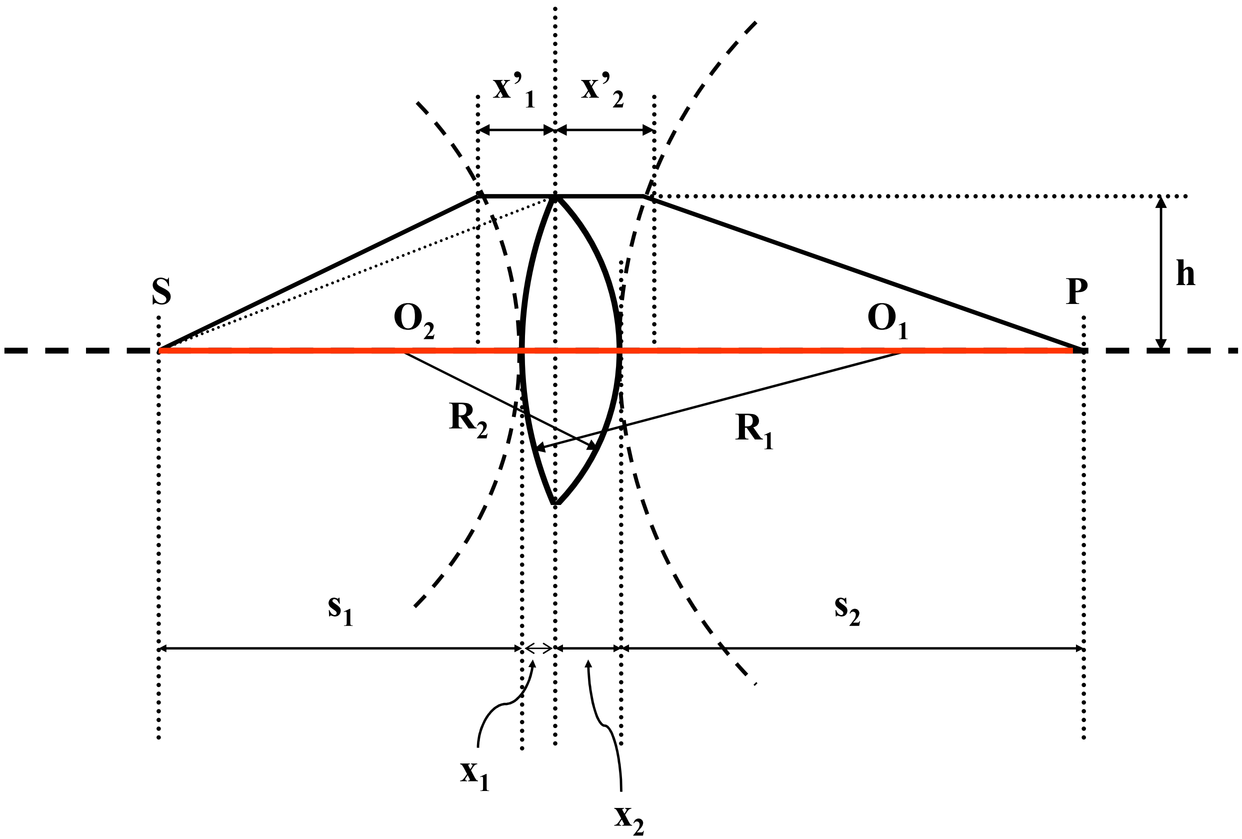
Nem függ α-tól!

Optikai kép!

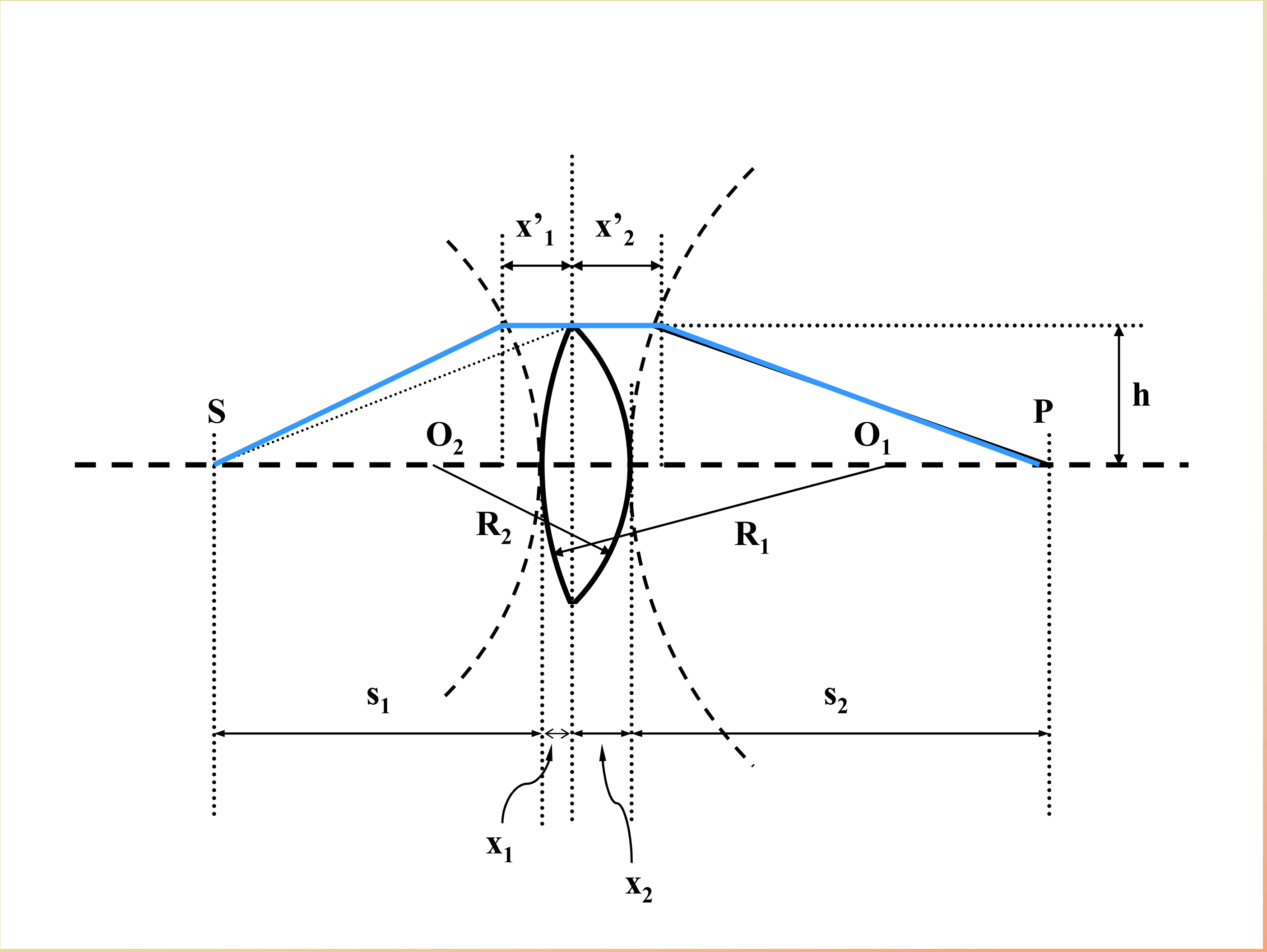
$$s_2 = r + \frac{(s_1 + r)r}{(n-1)(s_1 + r) - r\,n}$$



x'1
x'2
h
S
P
O2
O1
R2
R1
s1
s2
x1
x2



$$T_1 = \frac{s_1}{c} + \frac{x_1 + x_2}{\frac{c}{n}} + \frac{s_2}{c}$$



$$T_2 = \frac{s_1 + x'_1 + x'_2 + s_2}{c}$$

$$T_1 = T_2$$

$$\frac{s_1}{c} + \frac{x_1 + x_2}{\frac{c}{n}} + \frac{s_2}{c} = \frac{s_1 + x_1^{'} + x_2^{'} + s_2}{c}$$

$$x'_1 + x'_2 = n\ x_1 + n\ x_2$$

$$x_1 = \frac{h^2}{2R_1} \qquad x_2 = \frac{h^2}{2R_2} \qquad x'_1 = \frac{h^2}{2s_1} + \frac{h^2}{2R_1} \qquad x'_2 = \frac{h^2}{2s_2} + \frac{h^2}{2R_2}$$

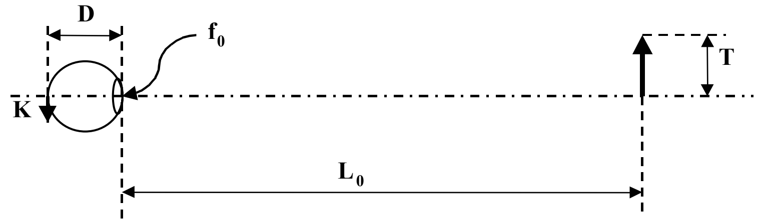
$$\frac{1}{s_1} + \frac{1}{s_2} = (n-1)\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$$

$$s_1 \to \infty \quad \Rightarrow \quad s_2 \to f$$

$$\frac{1}{f} = (n-1)\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$$

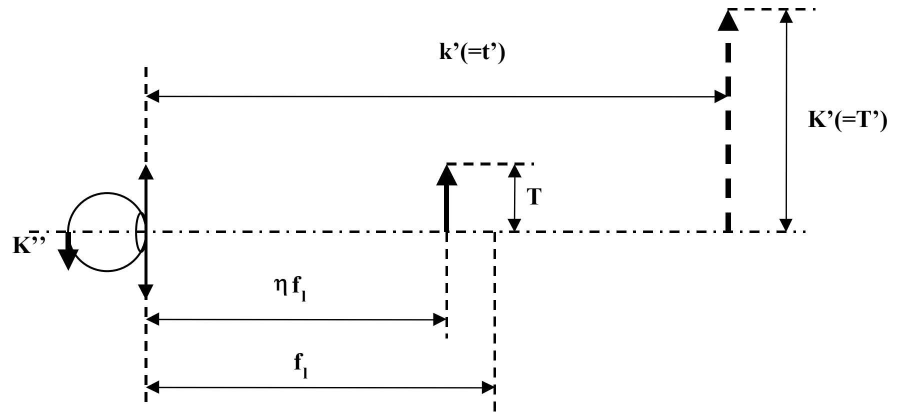
$$\frac{1}{s_1} + \frac{1}{s_2} = \frac{1}{f} \qquad \Rightarrow \qquad \frac{1}{t} + \frac{1}{k} = \frac{1}{f}$$

A nagyító (lupe) működése



Mivel $t \approx L_0, t >> f_0 \Rightarrow k \approx f_0$ $\Longrightarrow$ $K = T\dfrac{f_0}{L_0}$

A nagyító (lupe) működése



Legyen $t = \eta f$, ahol $\eta < 1$ de ≈ 1

A nagyító (lupe) működése

$$\frac{1}{\eta f_l} + \frac{1}{k'} = \frac{1}{f_l} \Rightarrow k' = \frac{\eta f_l}{\eta - 1} (= t')$$

$$K' = \frac{k'}{\eta f_l} T \qquad \Rightarrow \qquad K' = \frac{1}{1-\eta} T$$

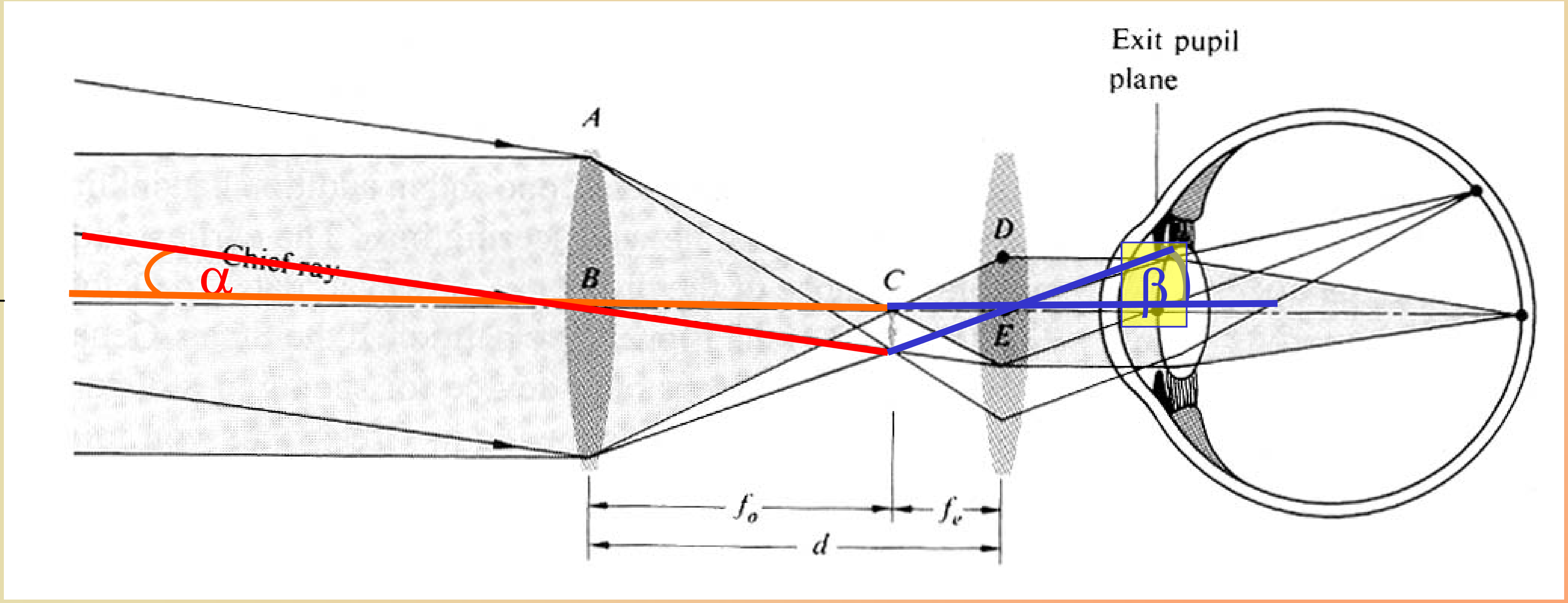
$$K'' = \frac{k''}{t'} K' = \frac{f_0(\eta - 1)}{\eta f_l} \frac{T}{\eta - 1} = \frac{f_0 T}{\eta f_l}$$

$$N = \frac{K''}{K} = \frac{f_0 T}{\eta f_l} \frac{L_0}{f_0 T}$$

mivel $\eta \approx 1$

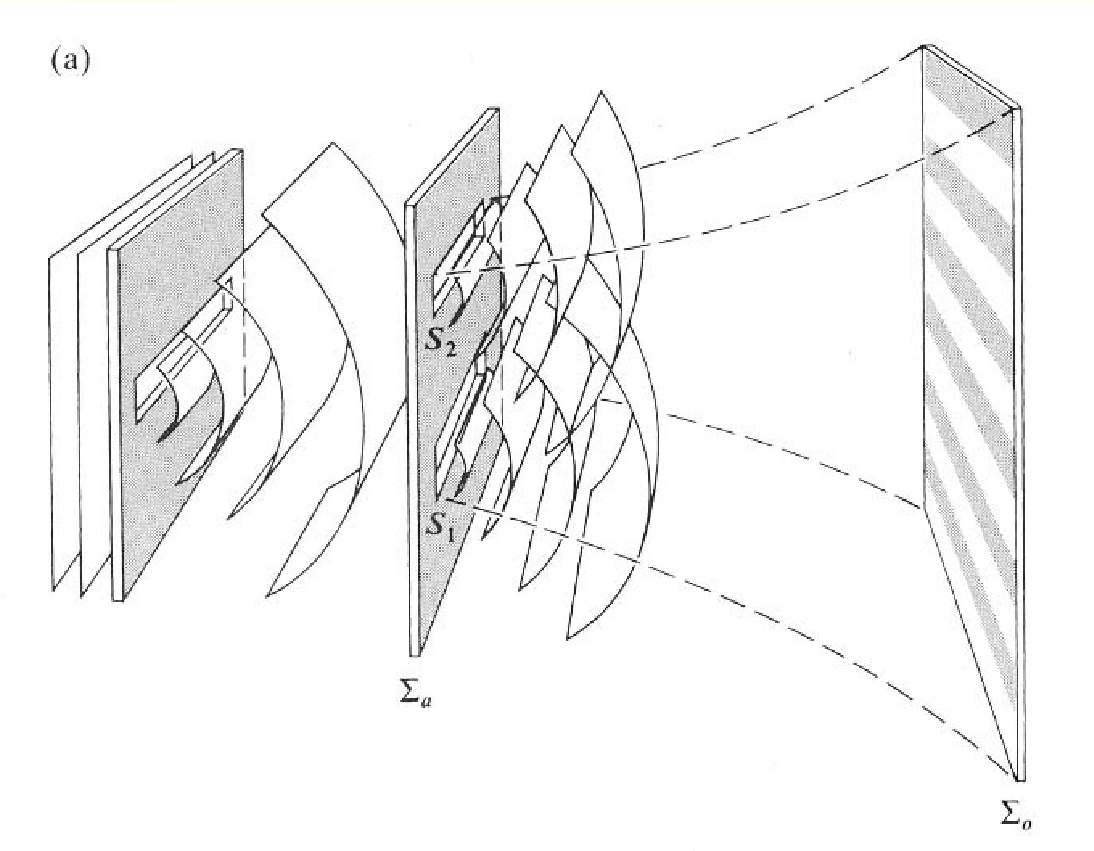
$$N = \frac{L_0}{f_l}$$

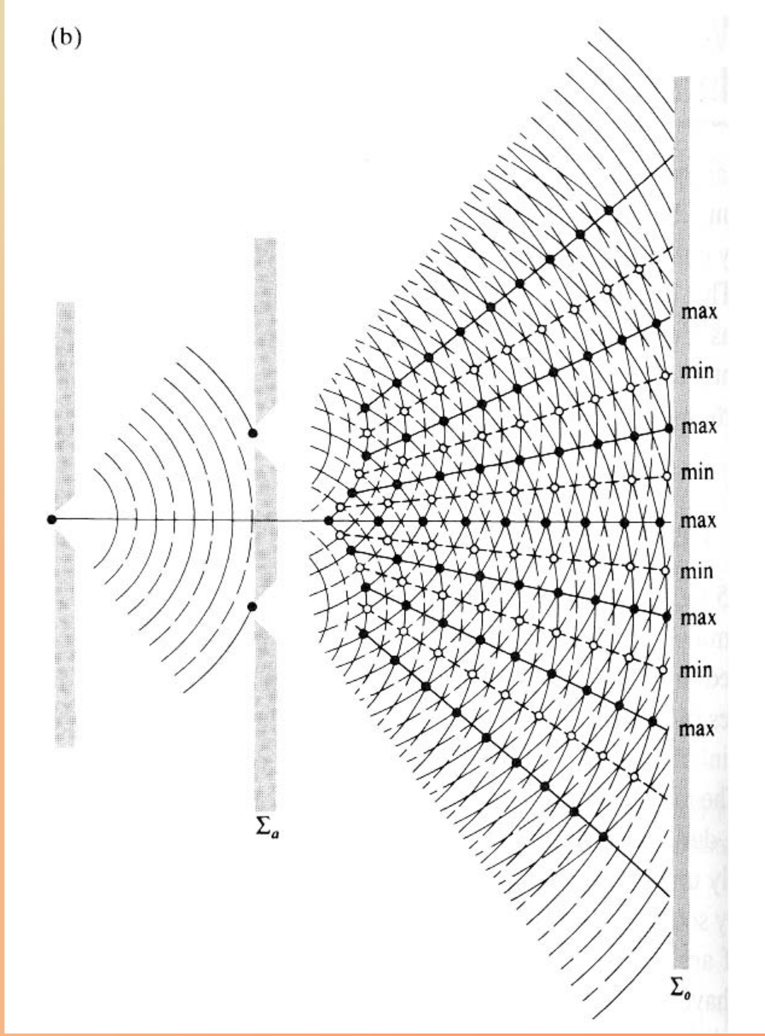
A távcső működése



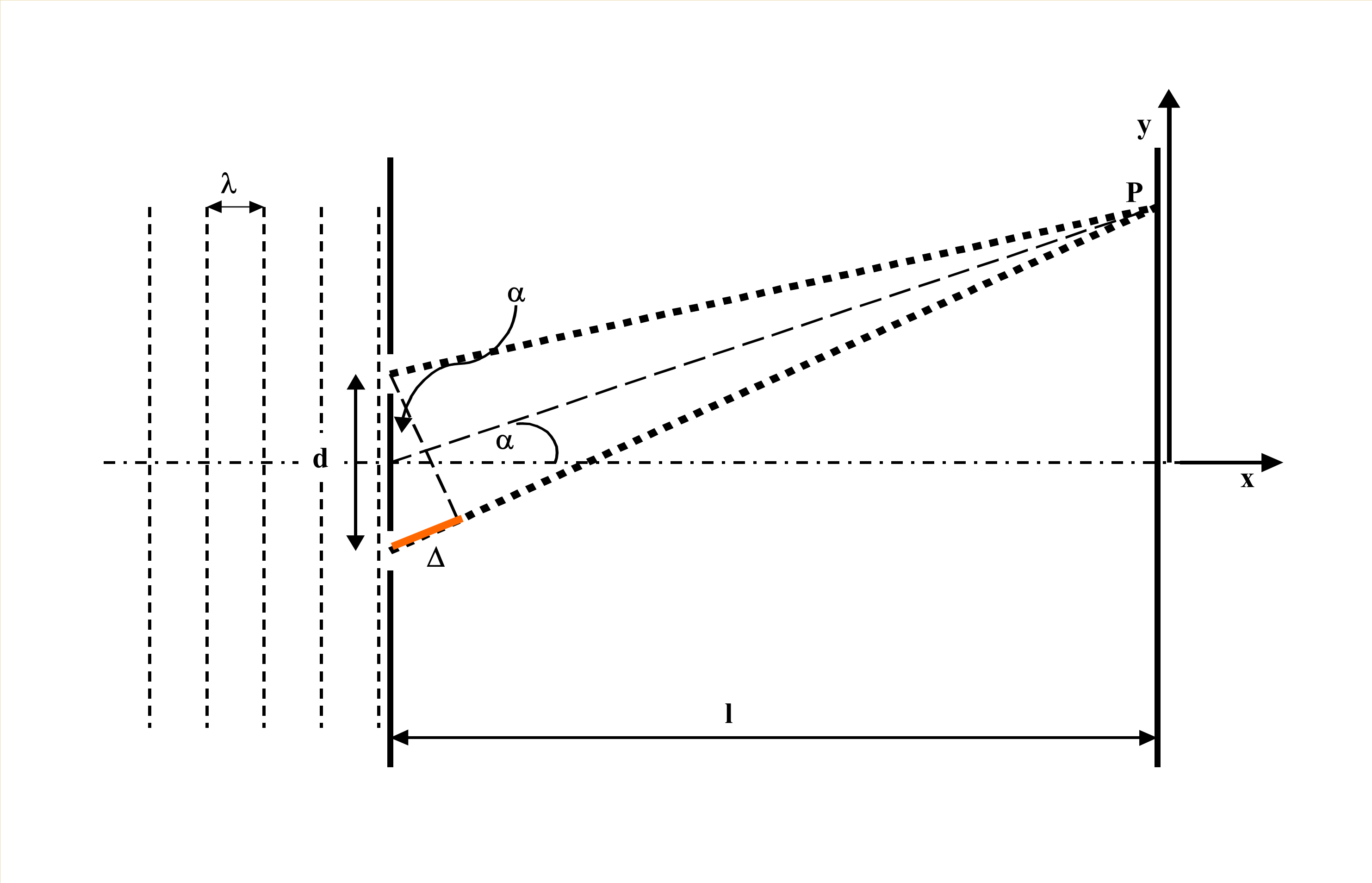
Szögnagyítás: $N_{sz} = \beta/\alpha \Rightarrow N_{sz} = f_1/f_2$

Young interferencia





Young interferencia



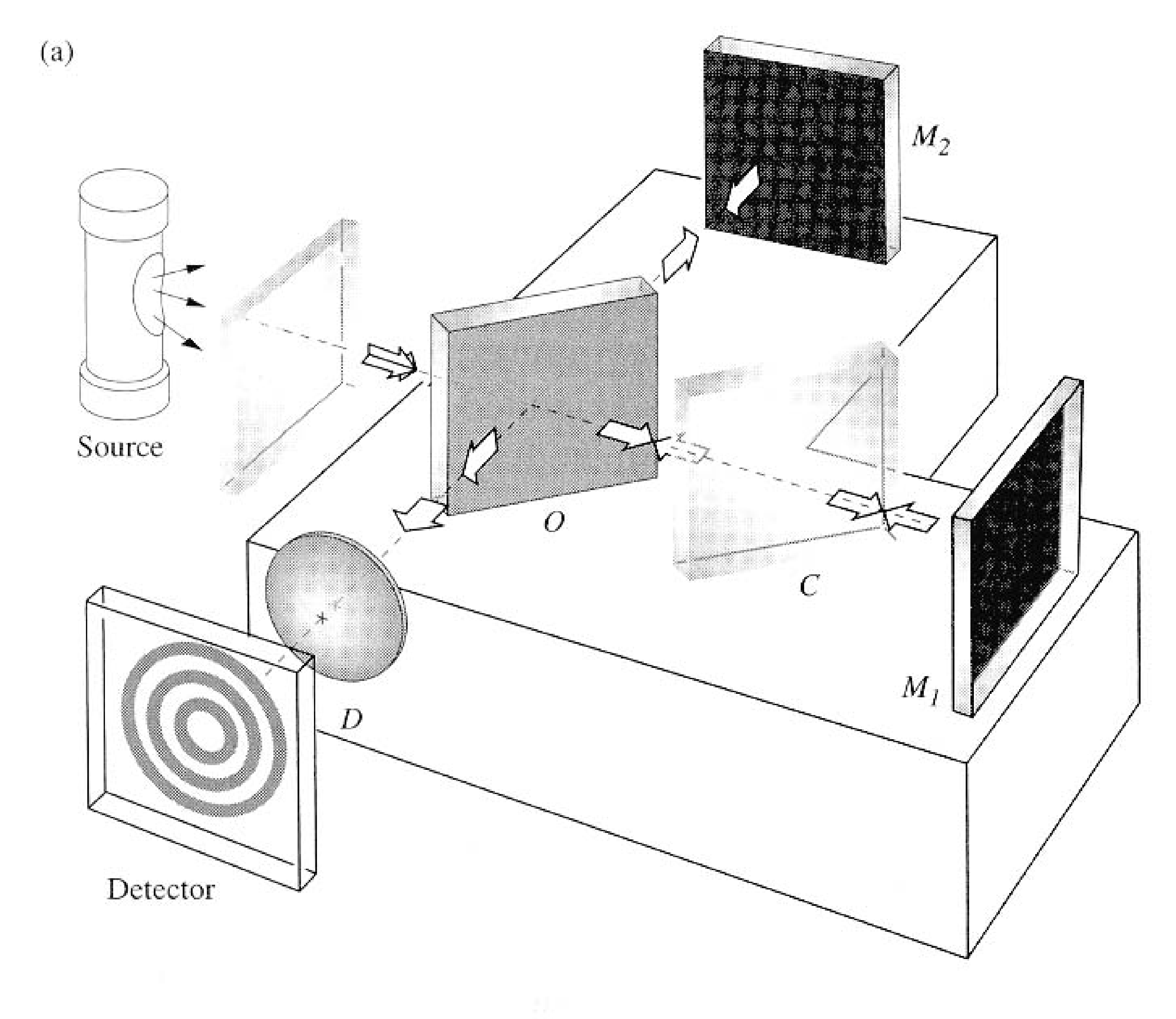
$$l >> y,d \Rightarrow \sin\alpha,\ tg\alpha \approx \alpha \qquad \Delta = \alpha d \qquad \alpha = \frac{y}{l} \qquad \Delta = \frac{yd}{l}$$

Young interferencia

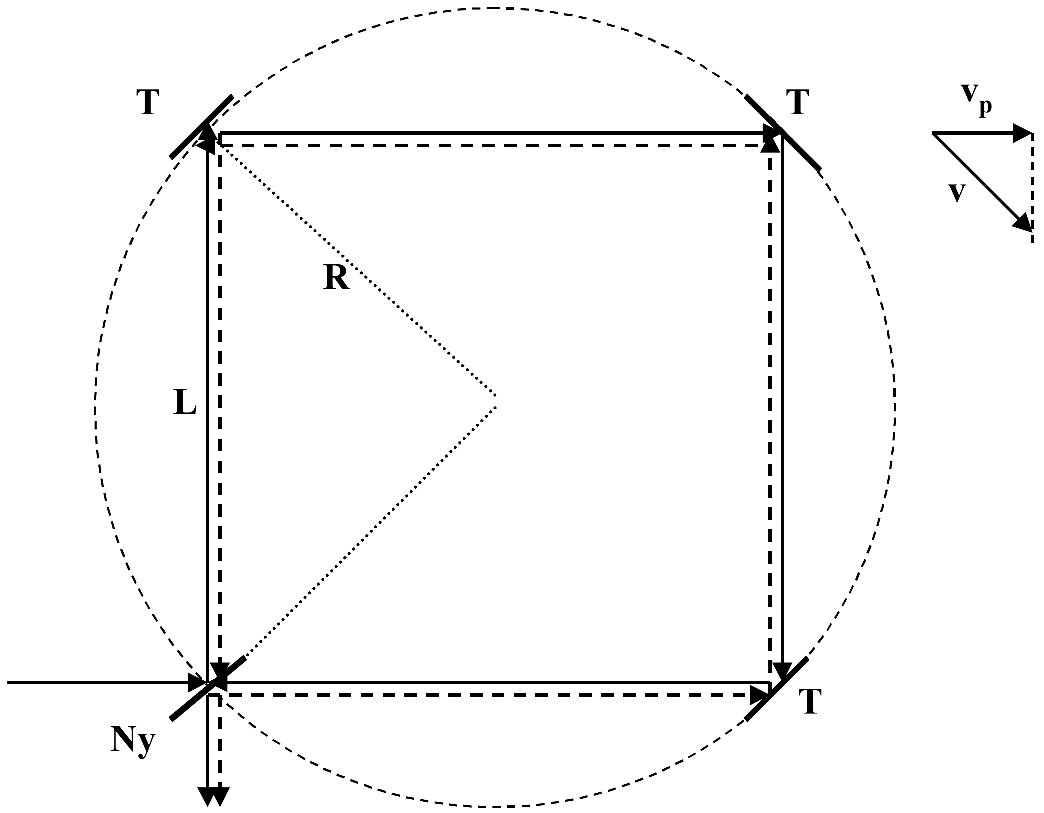
legyen δy **az első maximum helye**

$$\frac{d\,\delta y}{l} = \lambda \qquad \Rightarrow \qquad \delta y = \frac{l}{d}\lambda$$

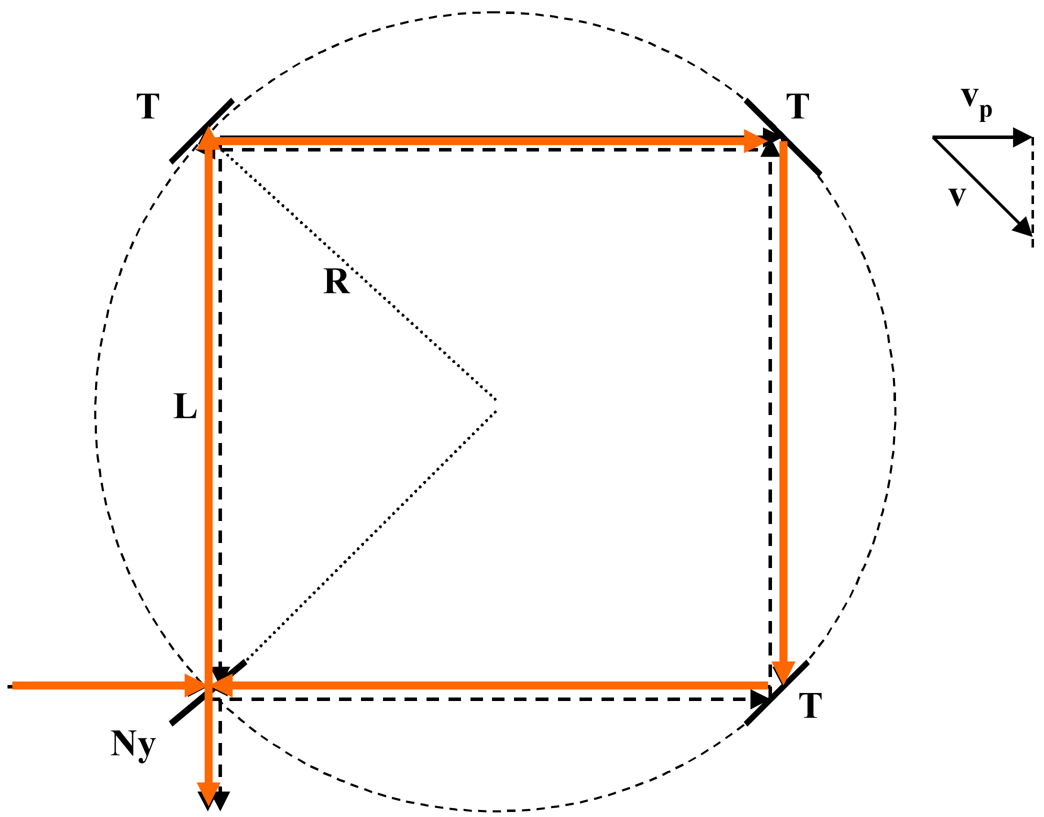
Michelson interferométer



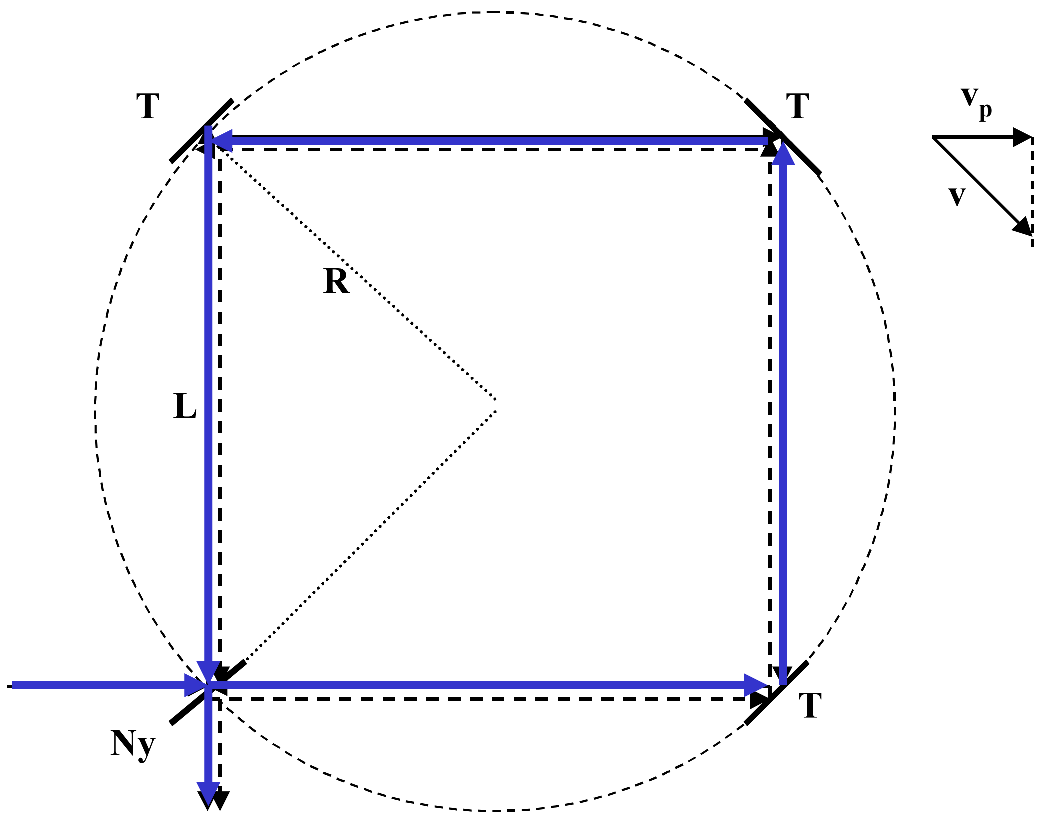
Sagnac interferométer



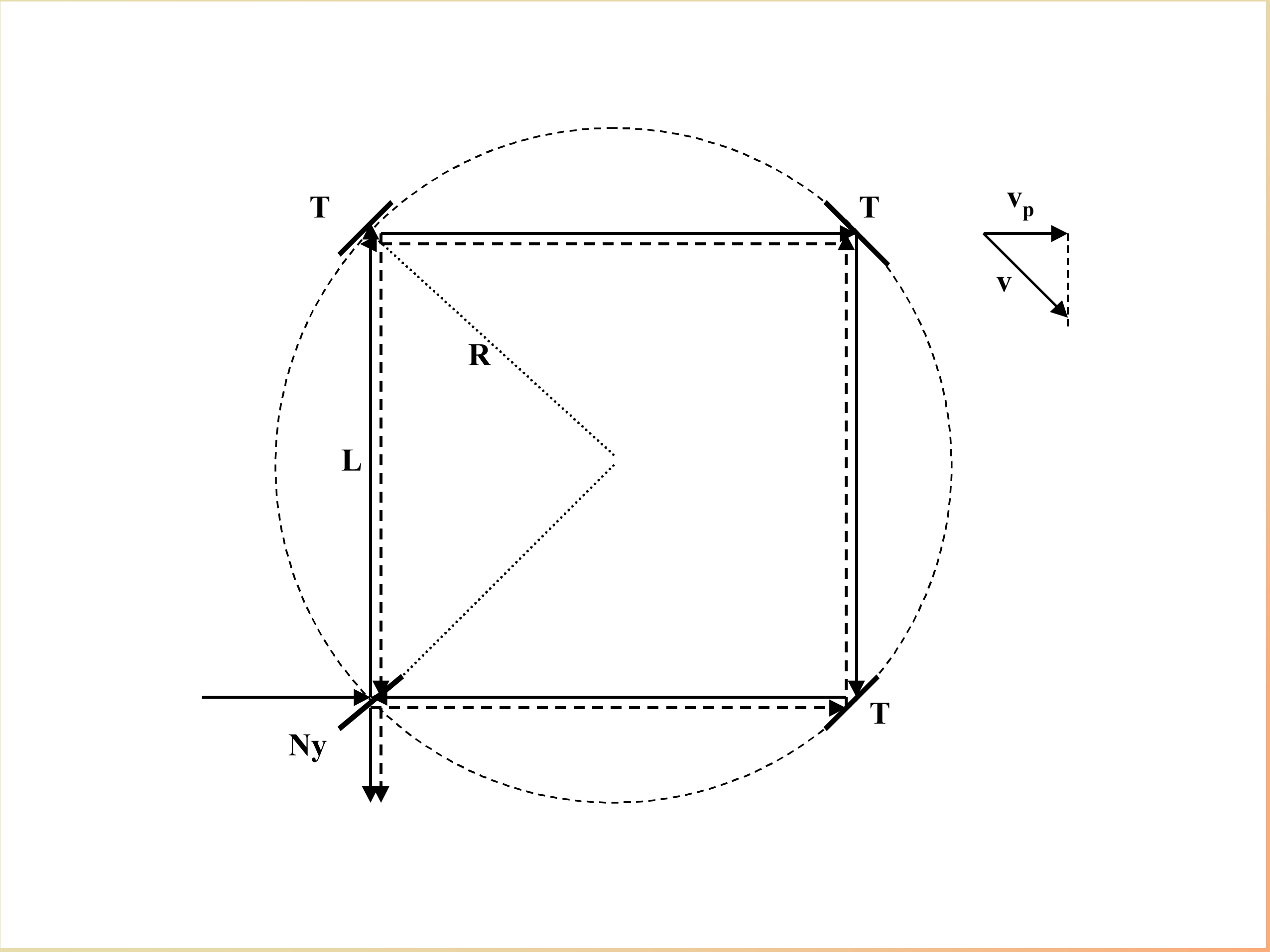
Sagnac interferométer



Sagnac interferométer



Sagnac interferométer

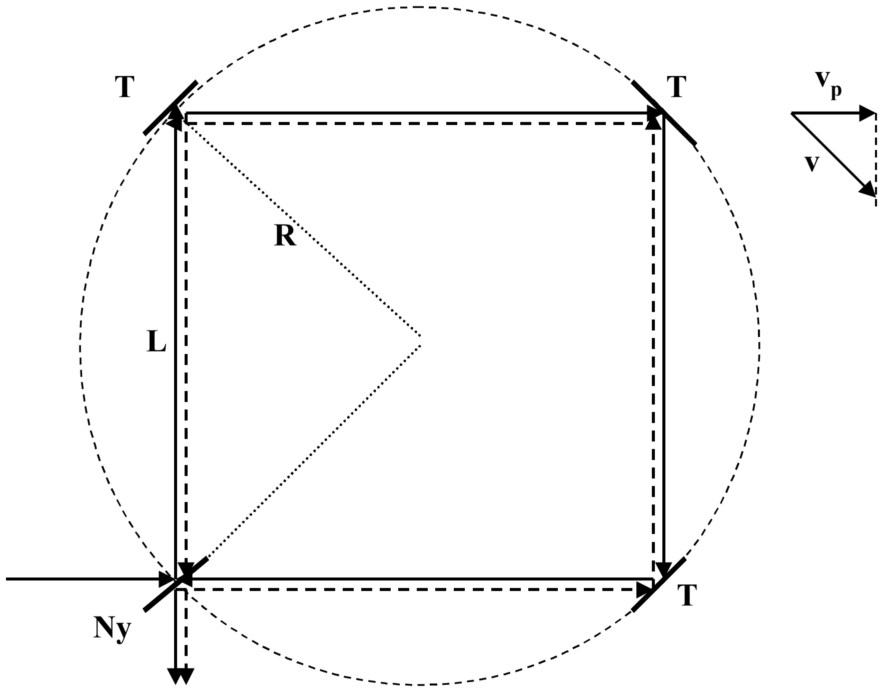


$$\Delta t_e = \frac{L + v_p \Delta t_e}{c}$$

$$v_p = \frac{v}{\sqrt{2}} = \frac{\sqrt{2} R\omega}{2}$$

$$T_e = \frac{8R}{\sqrt{2}c - R\omega}$$

Sagnac interferométer



$$\Delta t_f = \frac{L - v_p \Delta t_f}{c}$$

$$v_p = \frac{v}{\sqrt{2}} = \frac{\sqrt{2} R\omega}{2}$$

$$T_f = \frac{8R}{\sqrt{2}c + R\omega}$$

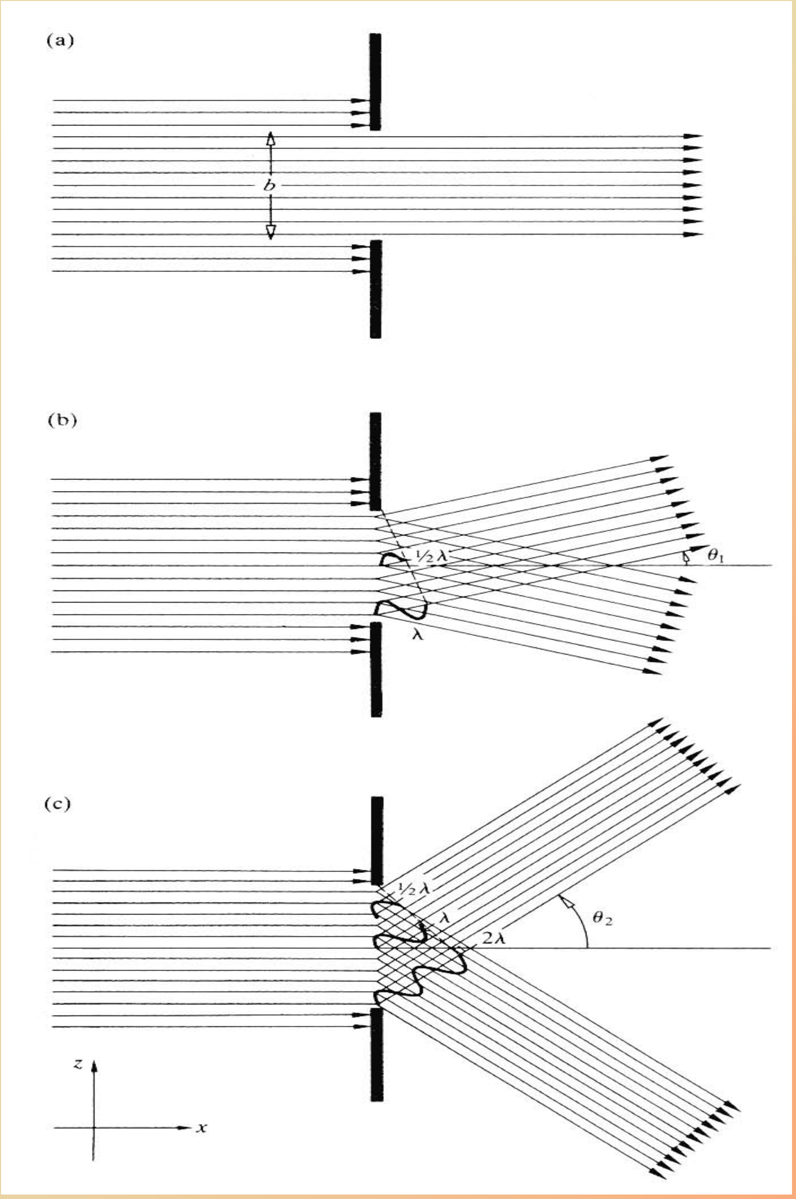
Sagnac interferométer

$$\Delta T = T_e - T_f = 8R\left(\frac{1}{\sqrt{2}c - R\omega} - \frac{1}{\sqrt{2}c + R\omega}\right) = \frac{8R^2\omega}{c^2 - R^2\omega^2}$$

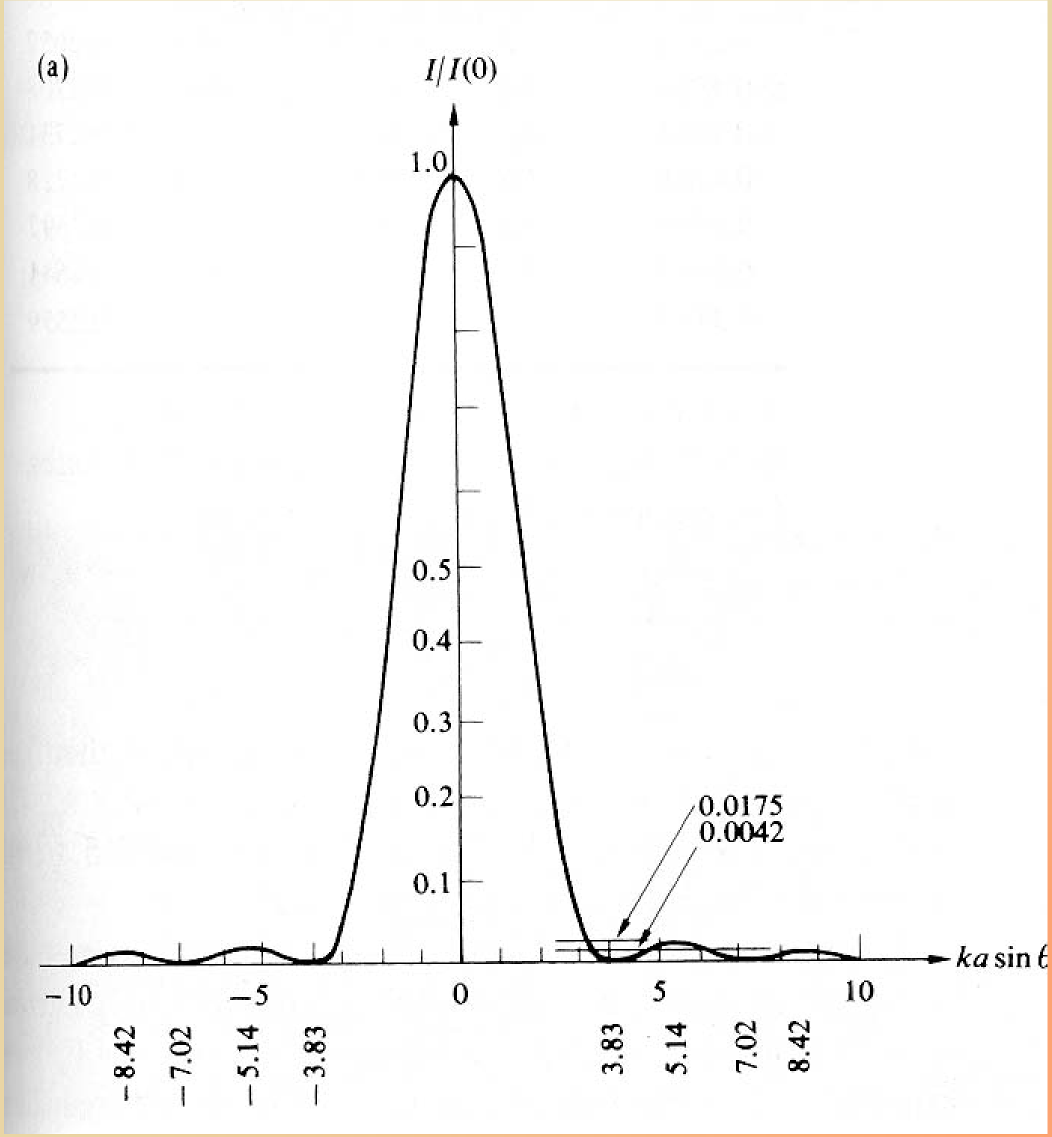
Mivel $c^2 \gg (R\omega)^2$ **, valamint** $R^2 = A$

$$\Delta T = \frac{8R^2\omega}{c^2} = \frac{4A\omega}{c^2}$$

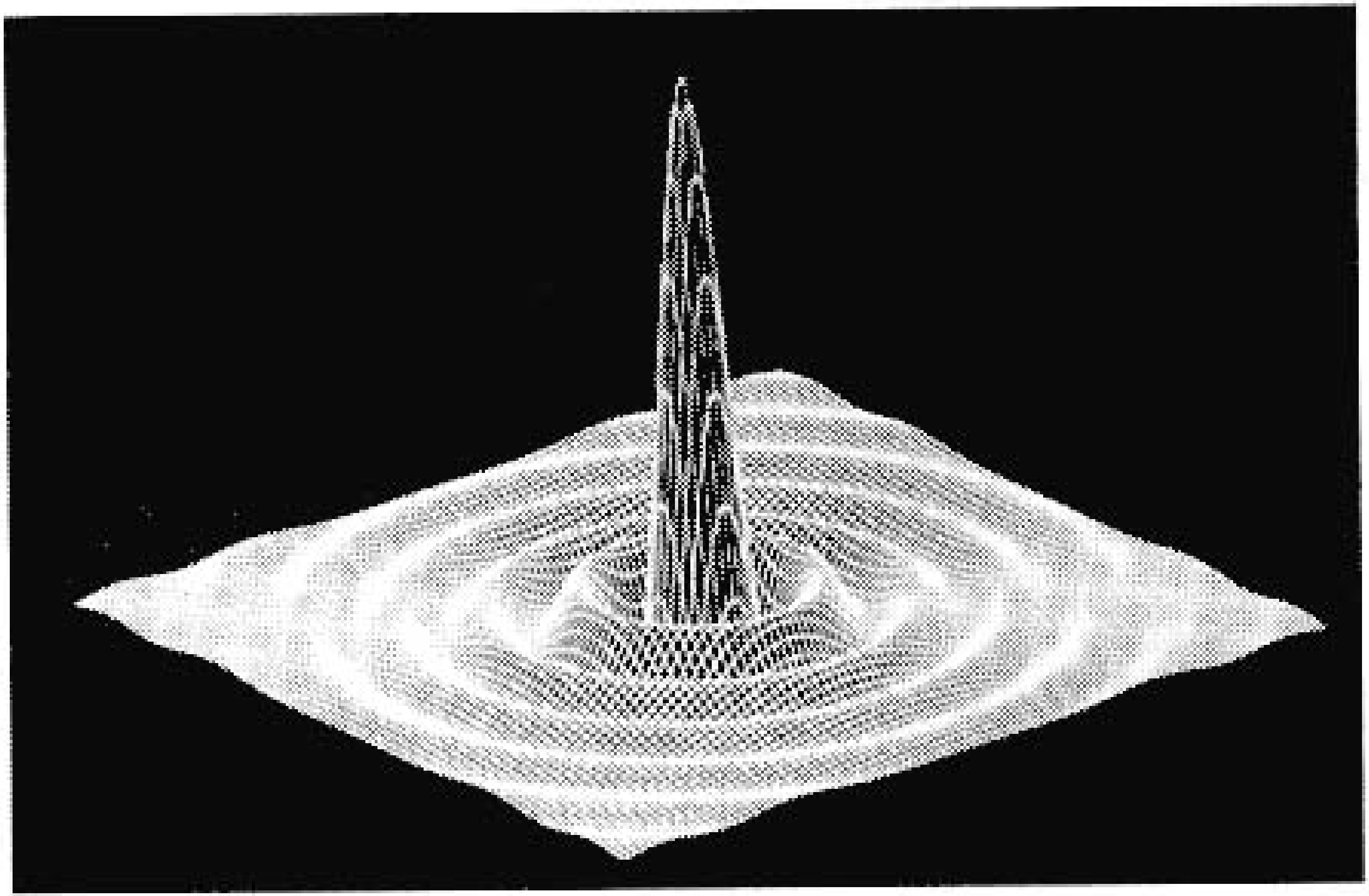
Fraunhofer elhajlás résen



Fraunhofer elhajlás résen



Fraunhofer elhajlás kör alakú nyíláson



(b)

Optikai eszközök feloldóképessége

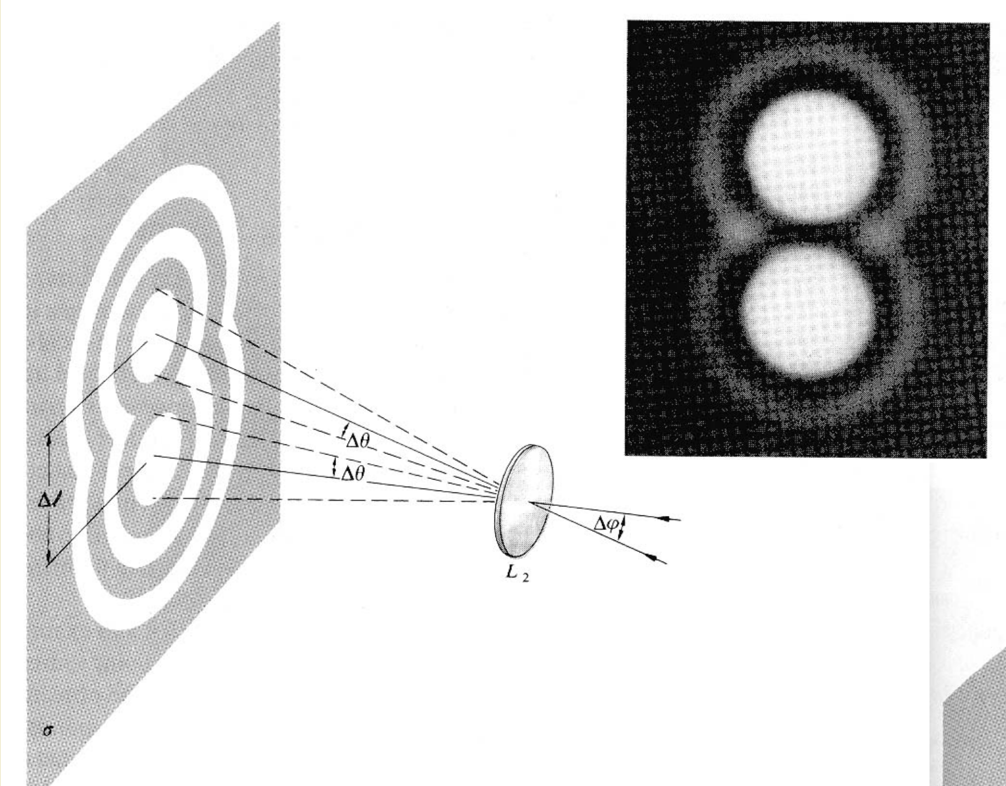
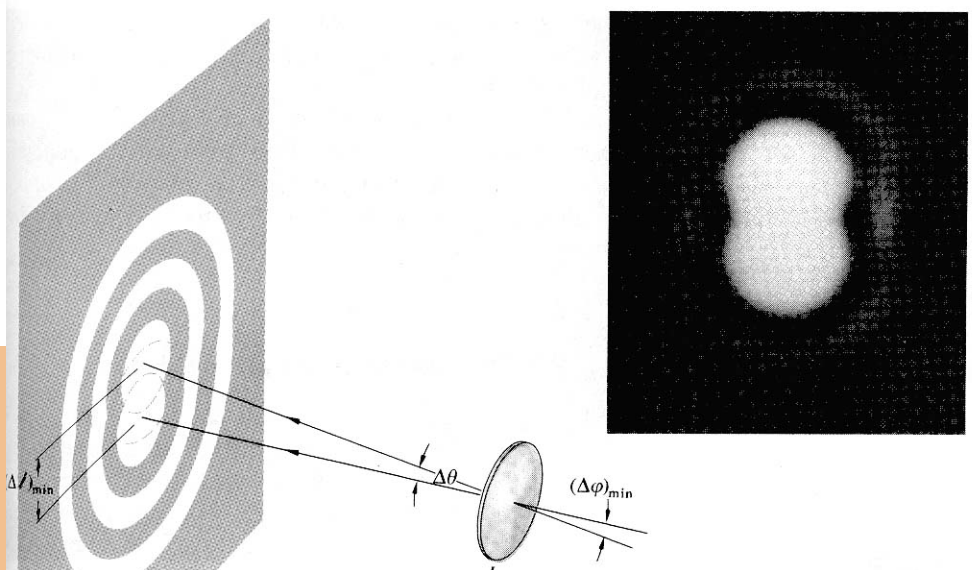


Figure 10.24 Overlapping images.



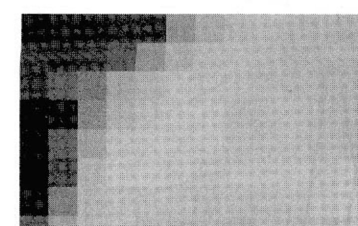
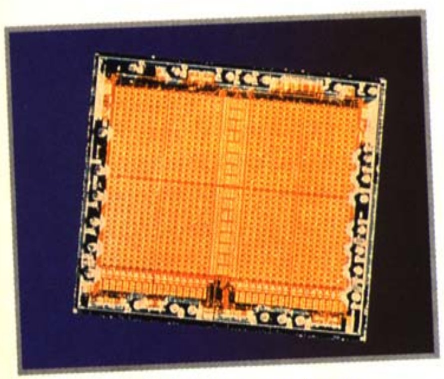


Figure 10.25 Overlapping images.

Nagyfeloldású fotolitográfia

Az első tranzisztor (1948)

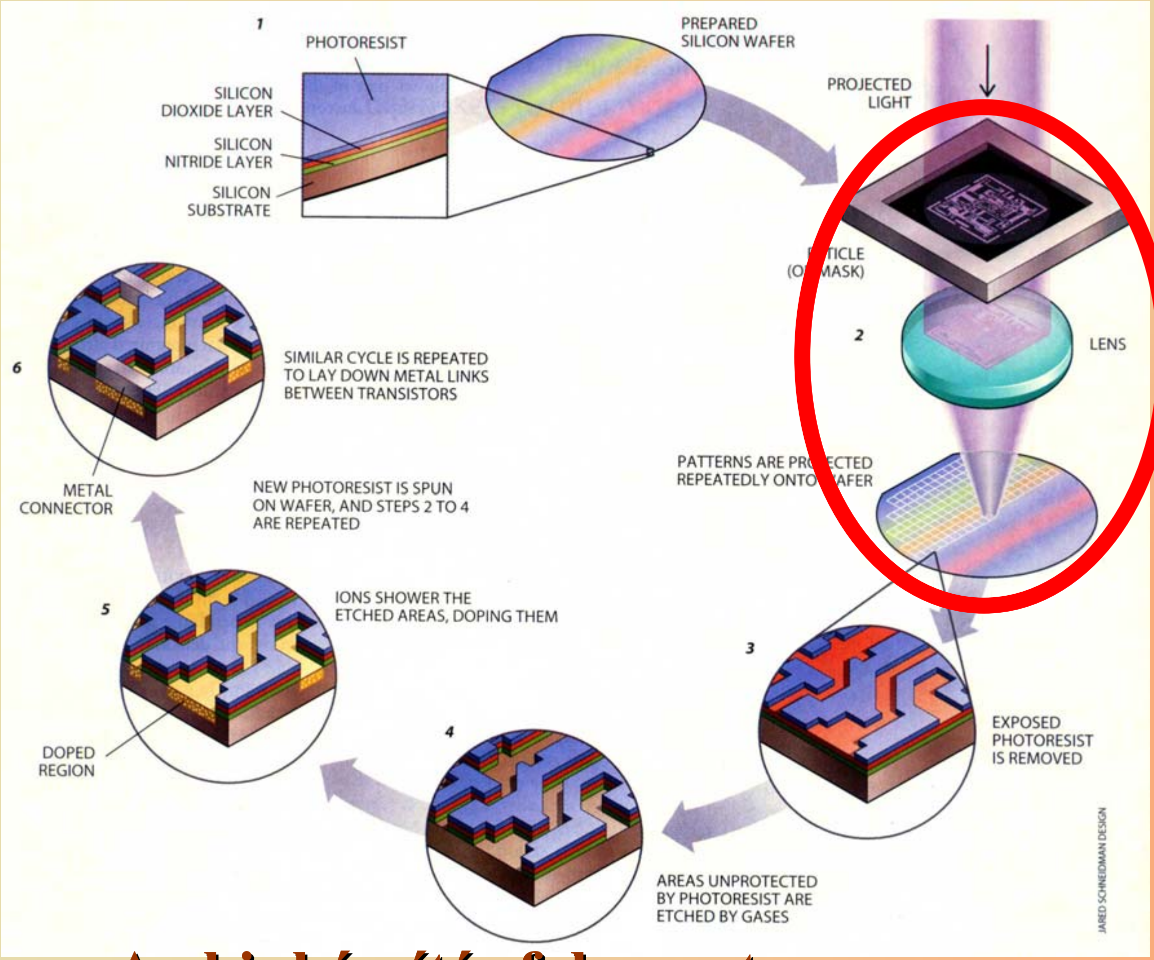
„Sókristály” tranzisztorok (1964)

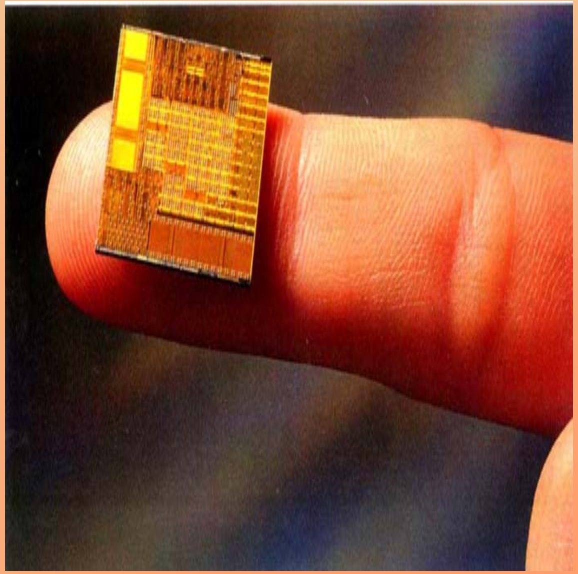


Korai IC (1973)

Memória chip (1997)

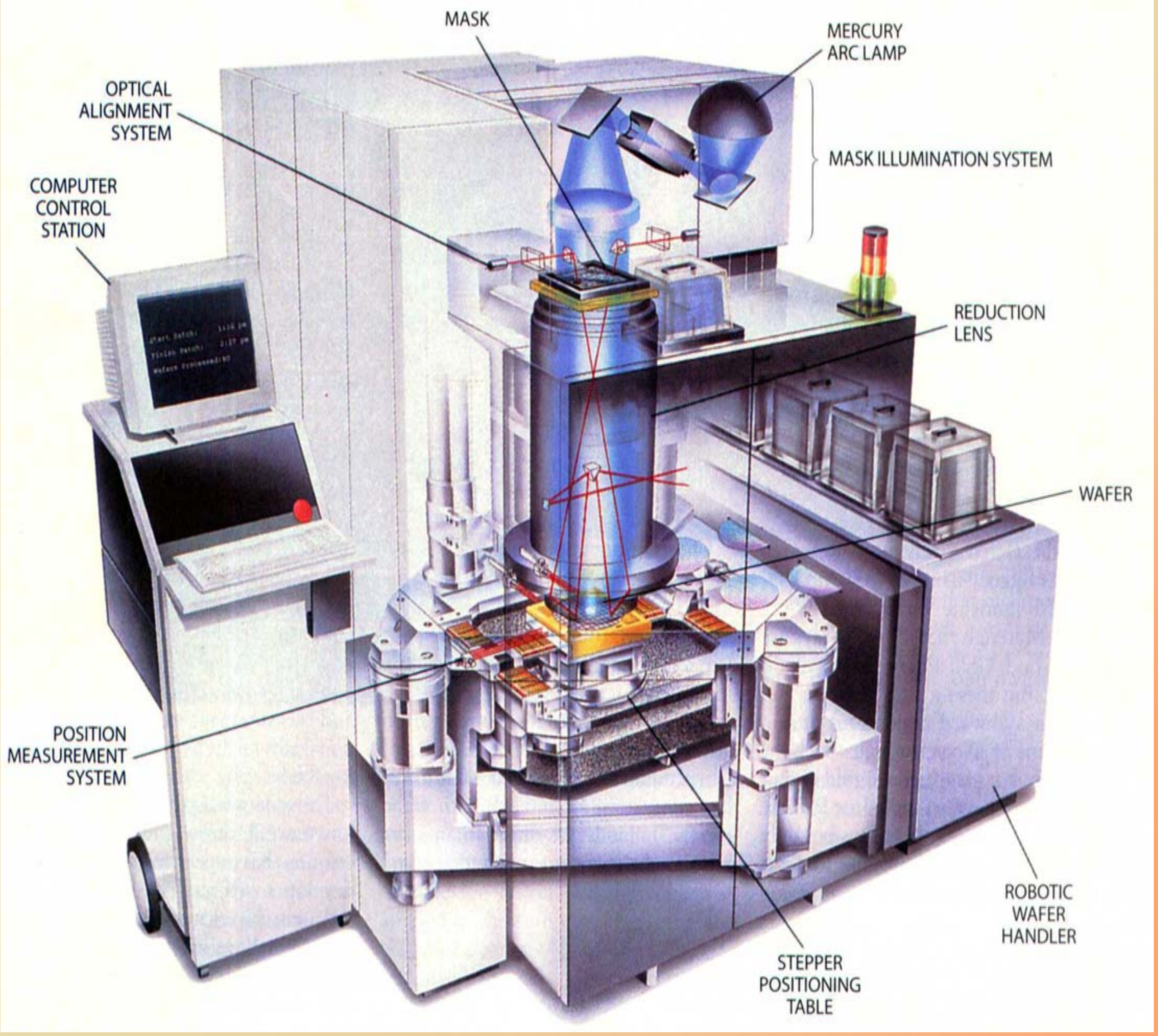
Nagyfeloldású fotolitográfia





A chipkészítés folyamata

Nagyfeloldású fotolitográfia



Stepper

Nagyfeloldású fotolitográfia

Feloldóképesség:

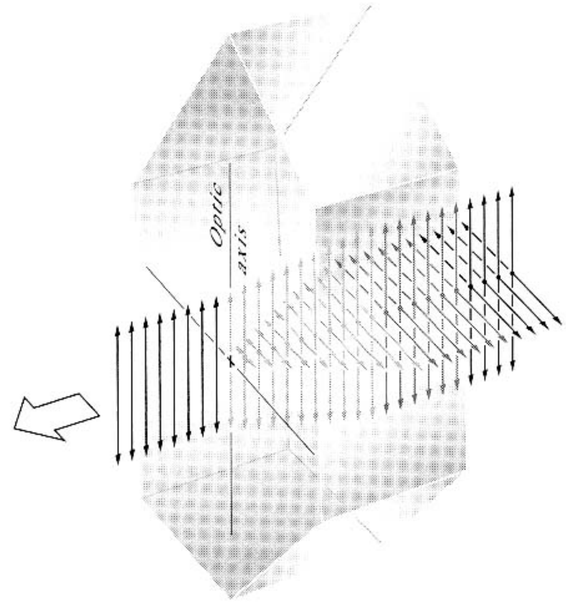
$$w = k_1 \frac{\lambda}{NA}$$

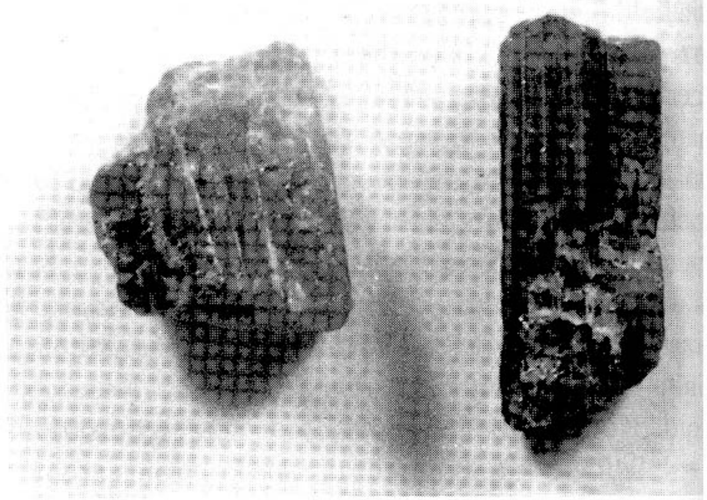
Mélységélesség:

$$DOF = k_2 \frac{\lambda}{NA^2}$$

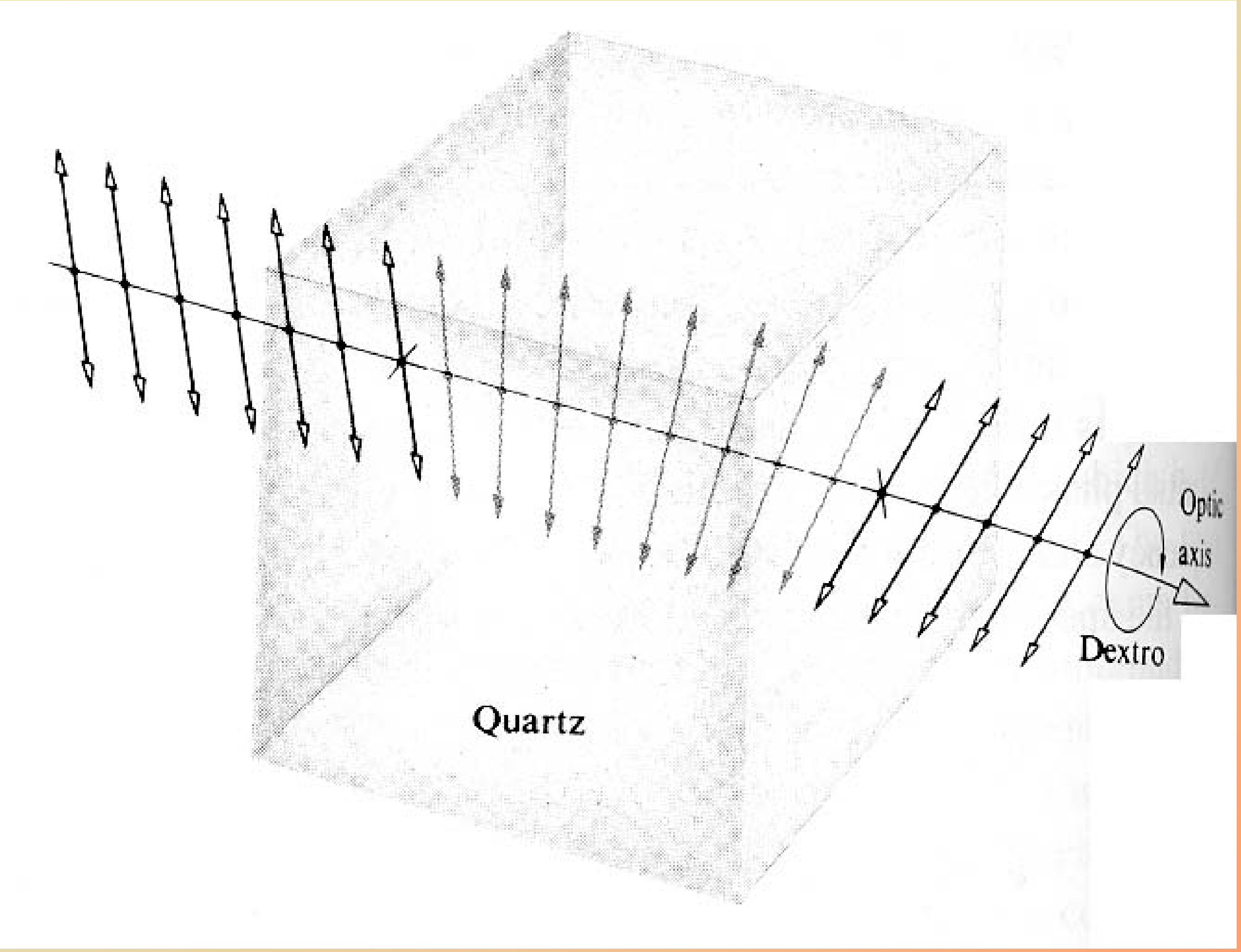
A fény polarizációja

A fény polarizációja



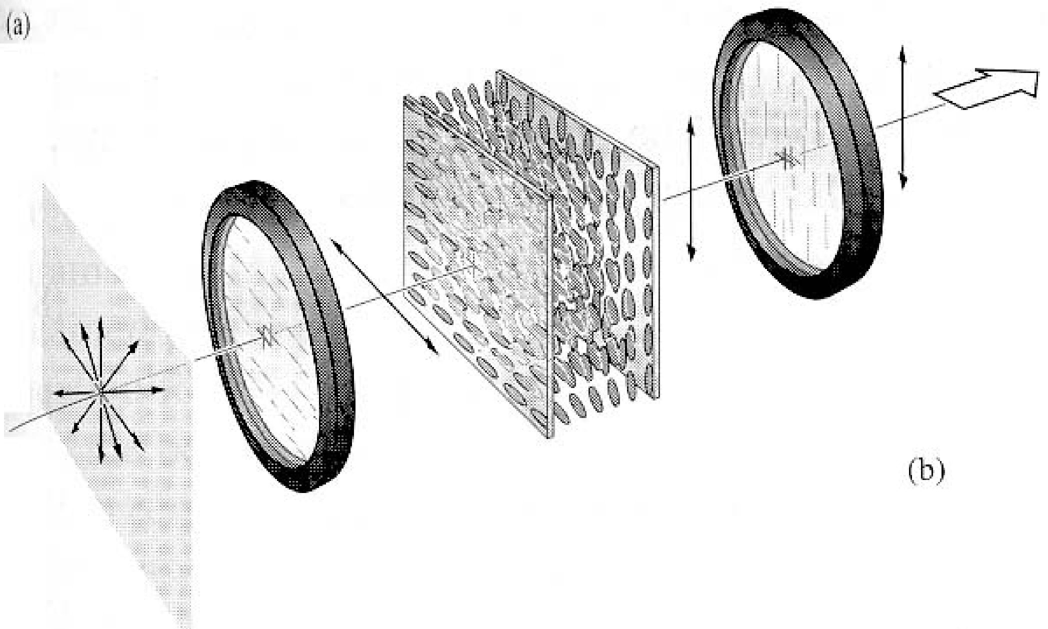


Optikai aktivitás

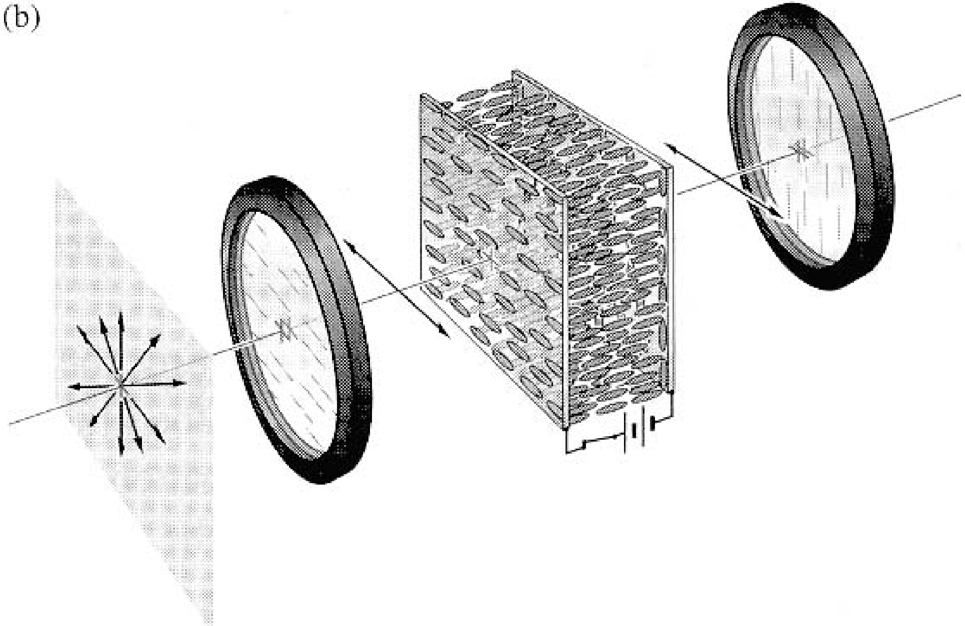


LCD kijelzők működése

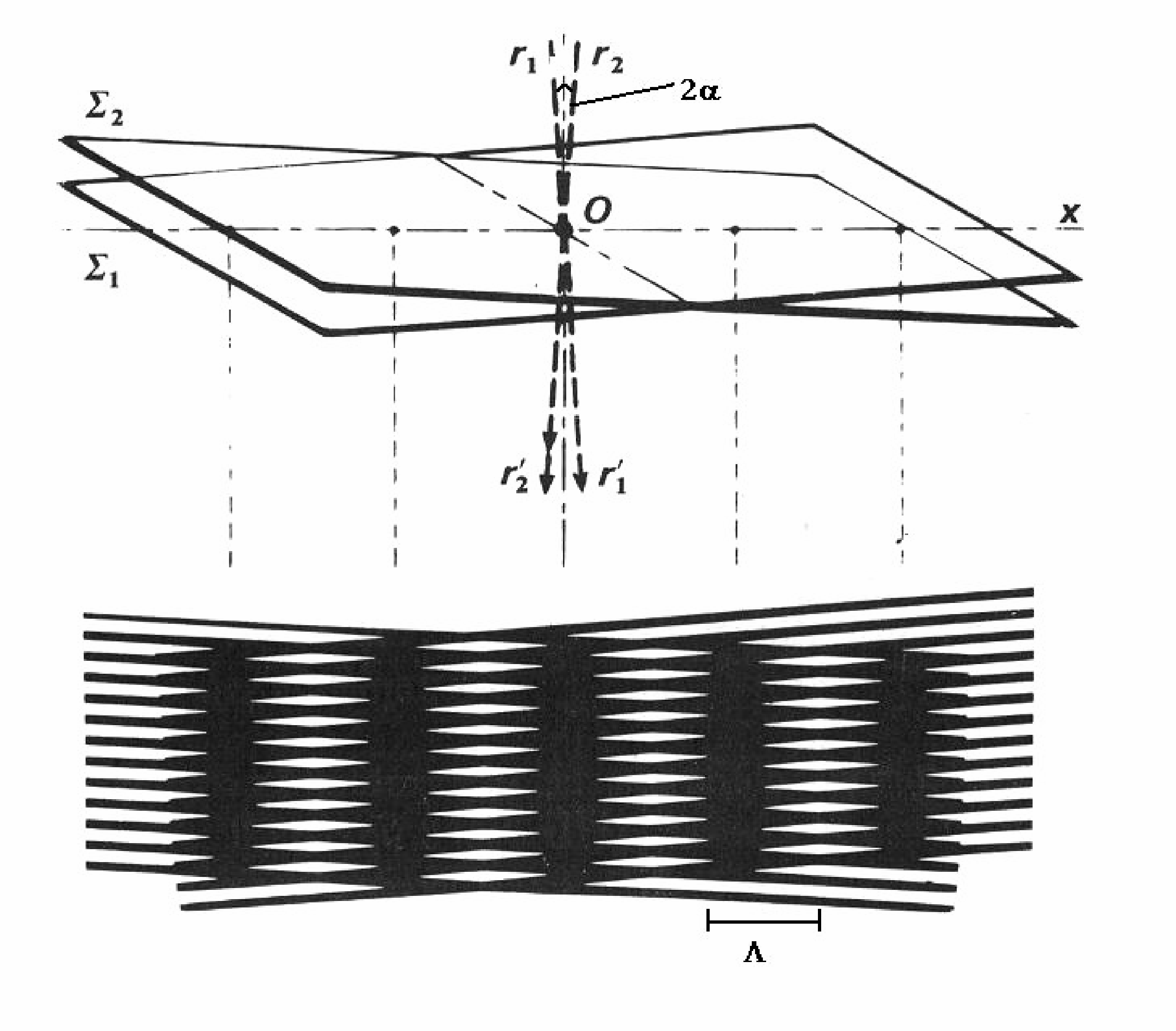
(a)



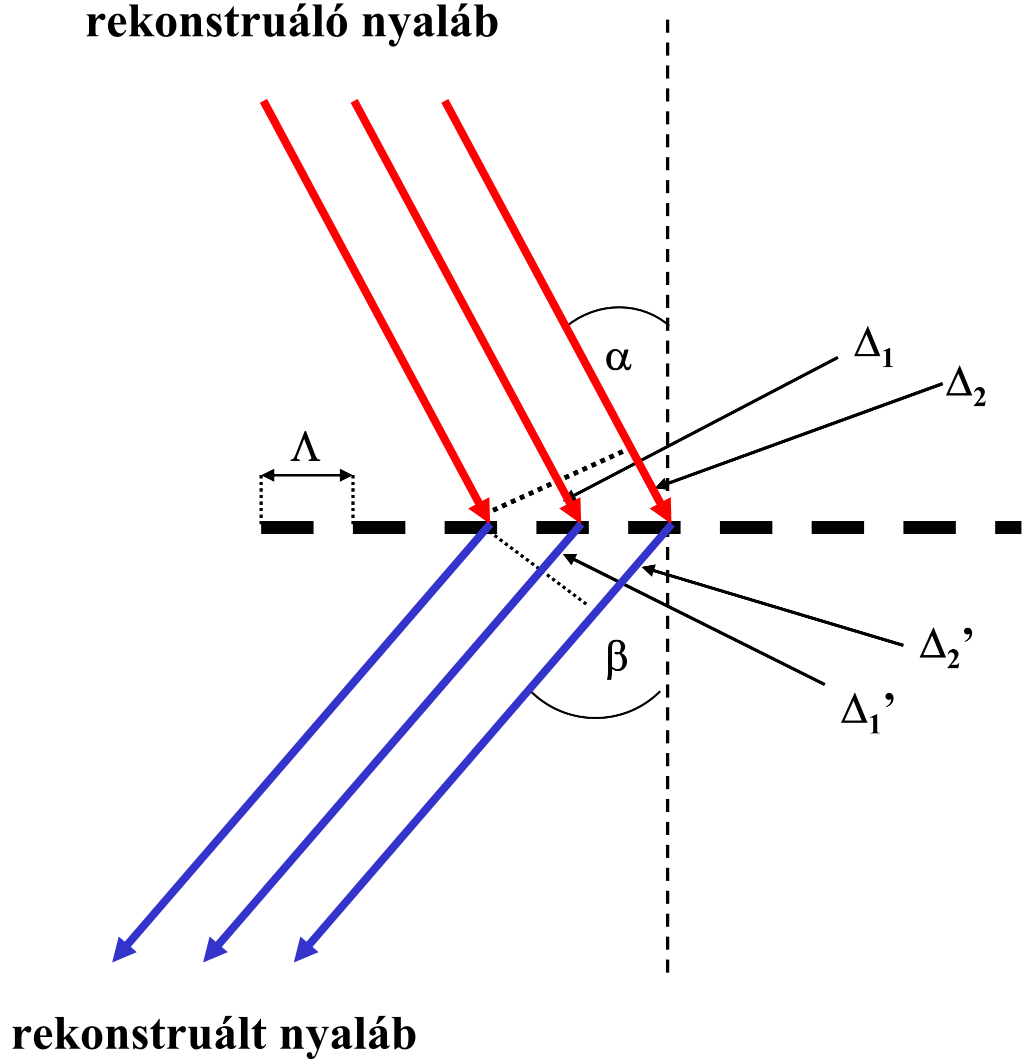
(b)



A holográfia alapjai



$$\Lambda = \frac{\lambda}{2\sin\alpha}$$


rekonstruáló nyaláb
α
Δ1
Δ2
Λ
Δ2'
β
Δ1'
rekonstruált nyaláb

Az erősítés feltétele: $\Delta_1 + \Delta'_1 = \lambda$

$$\Delta_1 = \Lambda \sin\alpha \qquad \Delta'_1 = \Lambda \sin\beta$$

Tehát:

$$\Lambda \sin\alpha + \Lambda \sin\beta = \lambda$$

$$\sin\alpha \frac{\lambda}{2\sin\alpha} + \sin\beta \frac{\lambda}{2\sin\alpha} = \lambda \quad \Rightarrow \quad \alpha = \beta$$

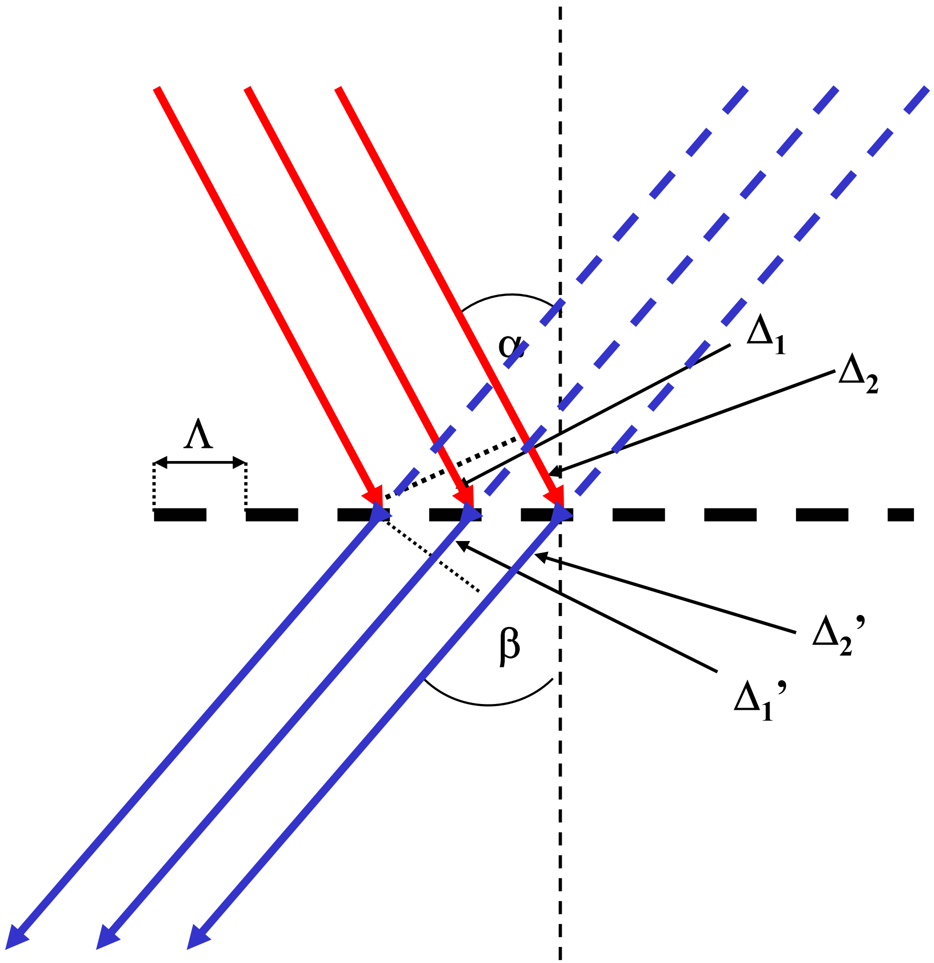
Mi a helyzet a második szomszédokkal?

$\Delta_2 = 2\Lambda \sin \alpha$ $\Delta'_2 = 2\Lambda \sin \beta$

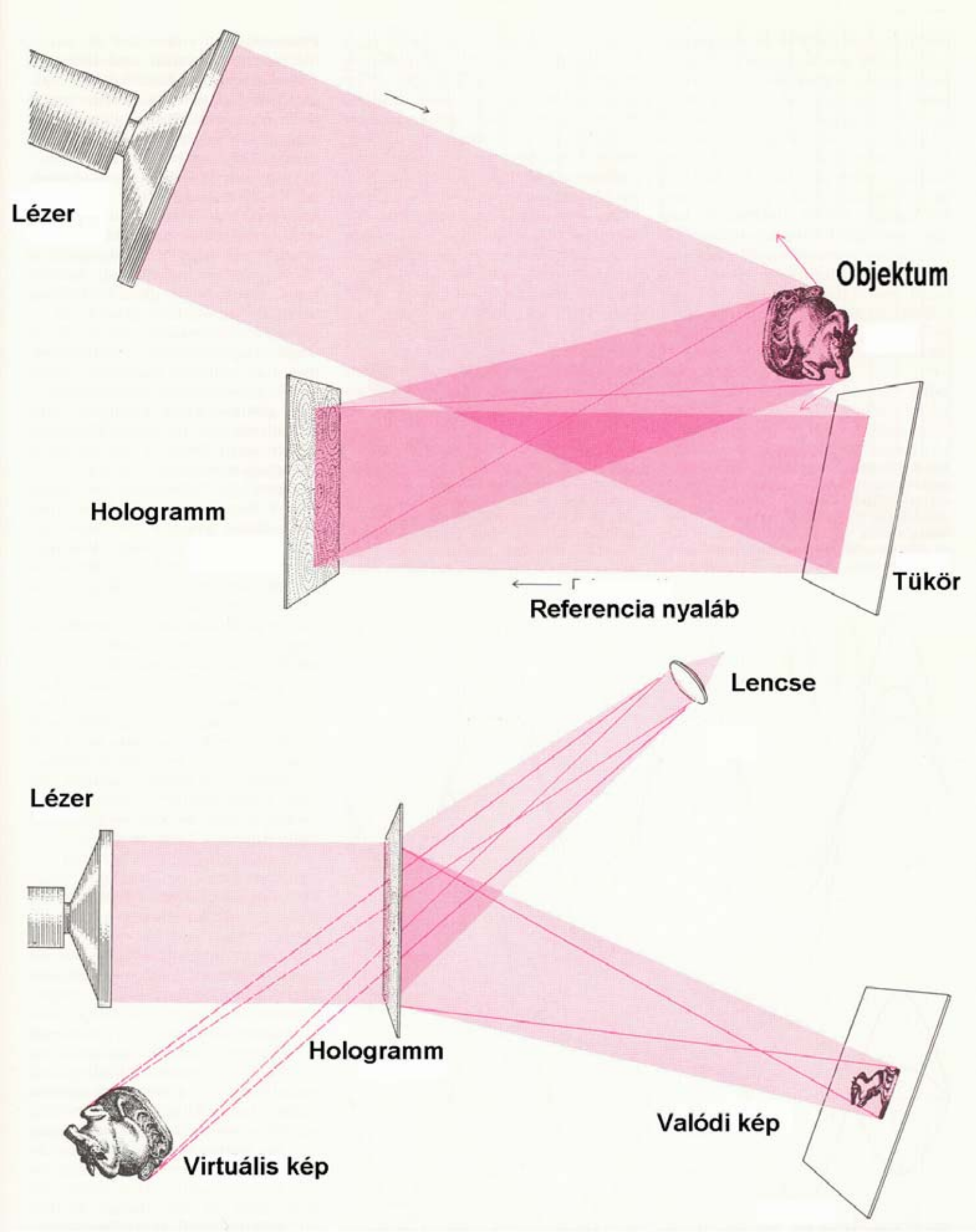
Tehát:

$$2\Lambda \sin \alpha + 2\Lambda \sin \beta = 2\lambda$$

Szintén erősítés!



rekonstruált nyaláb


Lézer
Objektum
Hologramm
Tükör
Referencia nyaláb
Lencse
Lézer
Hologramm
Valódi kép
Virtuális kép