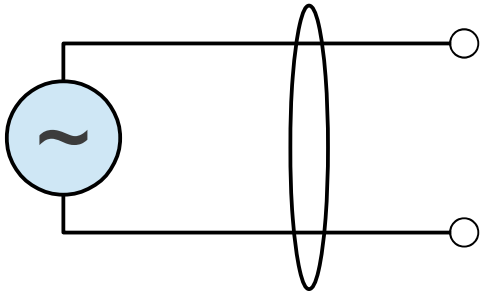
Optične komunikacije

Predavanje 9:

Lastnosti virov svetlobe

Električni vir $f < 1\text{THz}$



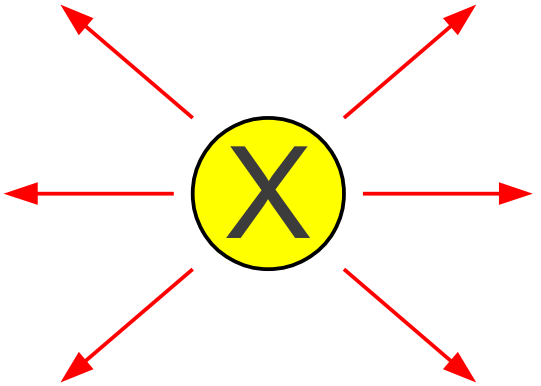
Enorodovni priključek

$\langle P \rangle \equiv$ *povprečna moč*

$u(t) \leftrightarrow F(\omega)$

Modulacija ? (*napajanje*)

Svetlobni vir $f \approx 300\text{THz}$



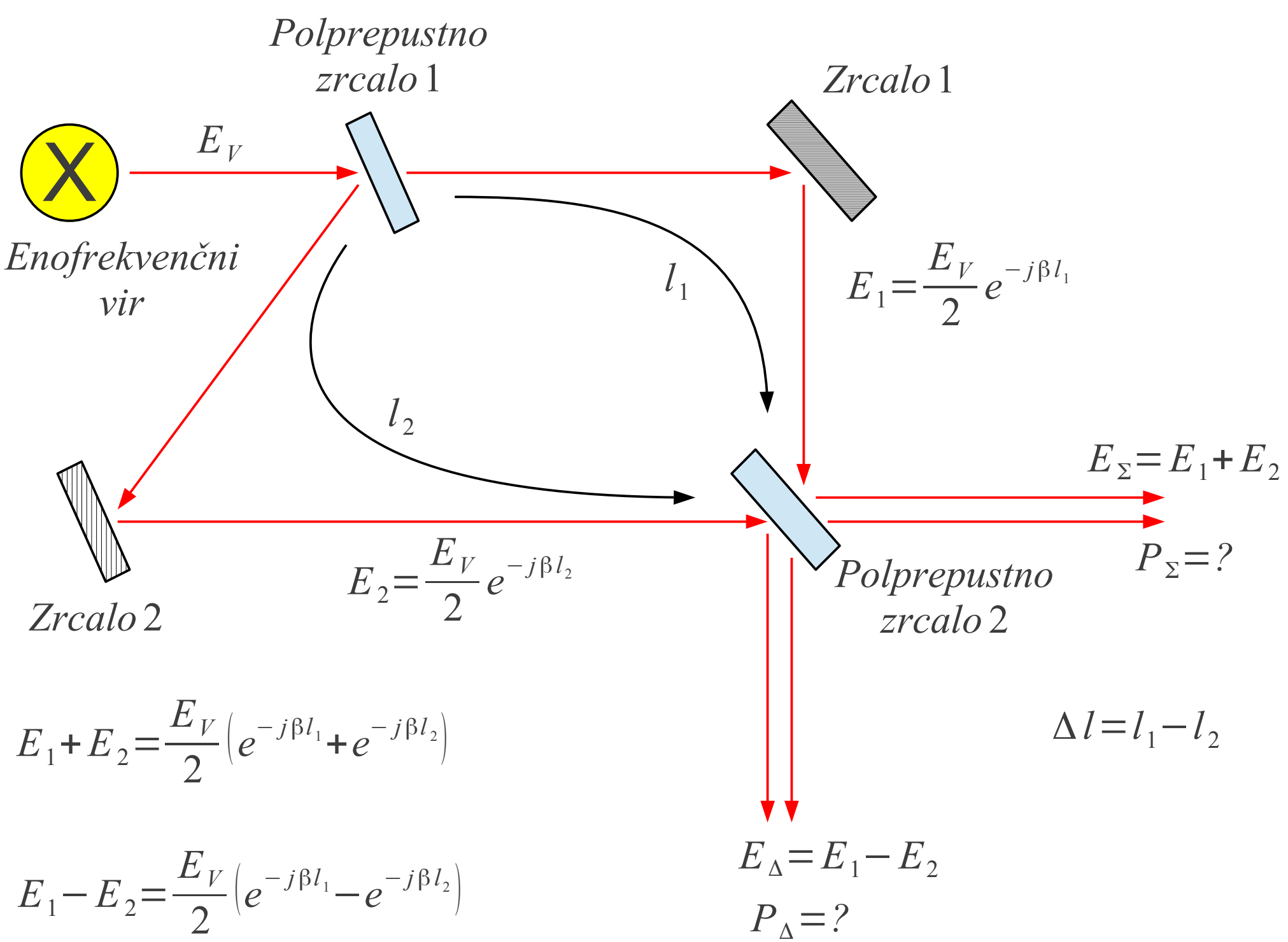
Množica rodov $\rightarrow \infty \rightarrow ? ? ?$

$\langle P \rangle \equiv$ *povprečna moč*
(*toplotni učinek , črno telo*)

$\vec{E}(t)$ *... ne znam meriti !*
(*znam polarizacijo*)

$|F(\omega)|^2$ *... znam meriti !*

Modulacija ? (*napajanje*)


Polprepustno zrcalo 1
Zrcalo 1
E_V
Enofrekvenčni vir
l_1
$E_1 = \frac{E_V}{2} e^{-j\beta l_1}$
l_2
$E_\Sigma = E_1 + E_2$
$P_\Sigma = ?$
Zrcalo 2
$E_2 = \frac{E_V}{2} e^{-j\beta l_2}$
Polprepustno zrcalo 2
$E_1 + E_2 = \frac{E_V}{2}\left(e^{-j\beta l_1} + e^{-j\beta l_2}\right)$
$\Delta l = l_1 - l_2$
$E_\Delta = E_1 - E_2$
$P_\Delta = ?$
$E_1 - E_2 = \frac{E_V}{2}\left(e^{-j\beta l_1} - e^{-j\beta l_2}\right)$

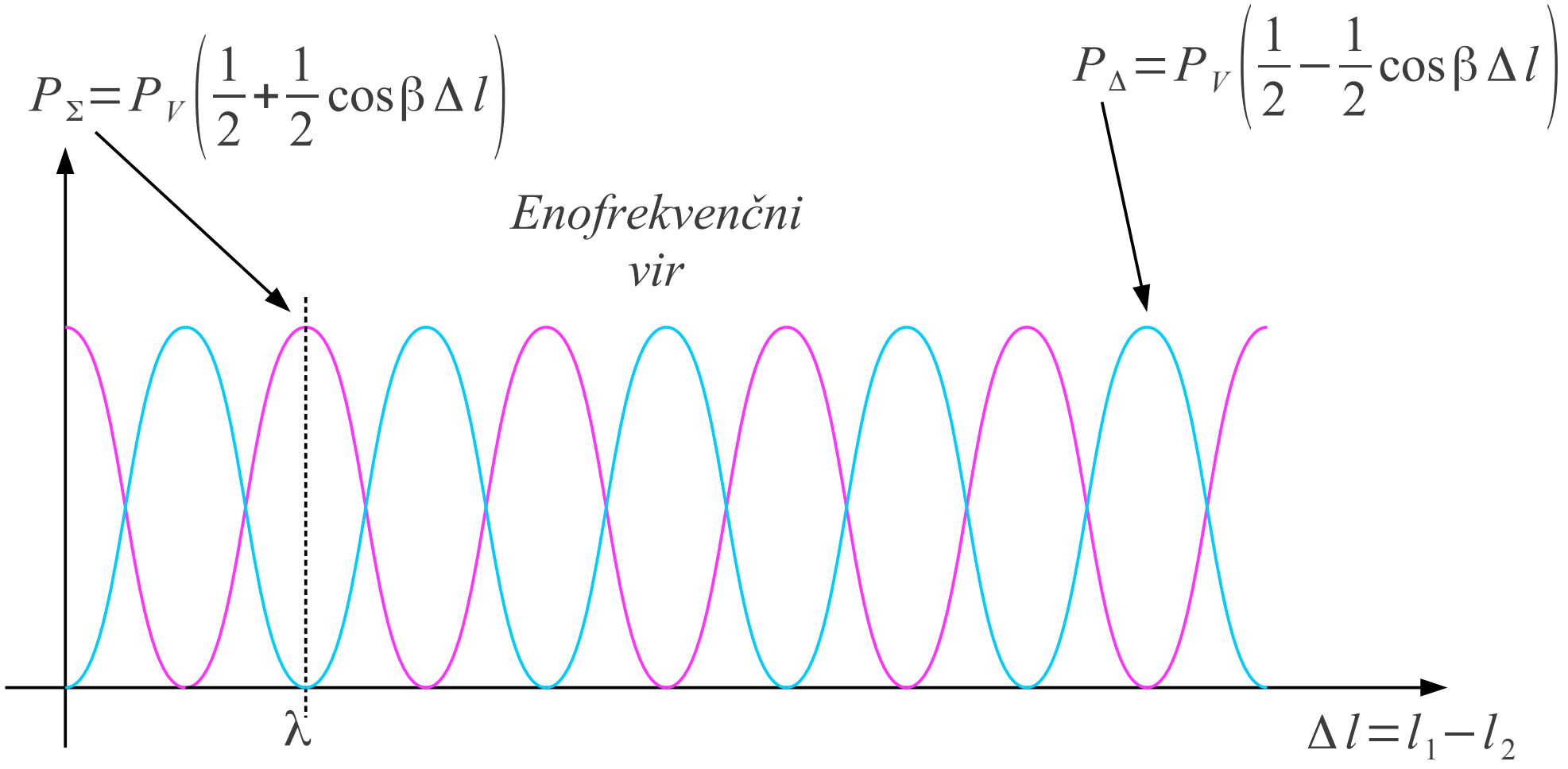
$$E_\Sigma = E_1 + E_2 = \frac{E_V}{2}\left(e^{-j\beta l_1} + e^{-j\beta l_2}\right) = E_V e^{-j\beta\frac{l_1+l_2}{2}} \cos\beta\frac{\Delta l}{2}$$

$$P = \alpha |E|^2$$

$$E_\Delta = E_1 - E_2 = \frac{E_V}{2}\left(e^{-j\beta l_1} - e^{-j\beta l_2}\right) = E_V e^{-j\beta\frac{l_1+l_2}{2}} j\sin\beta\frac{\Delta l}{2}$$

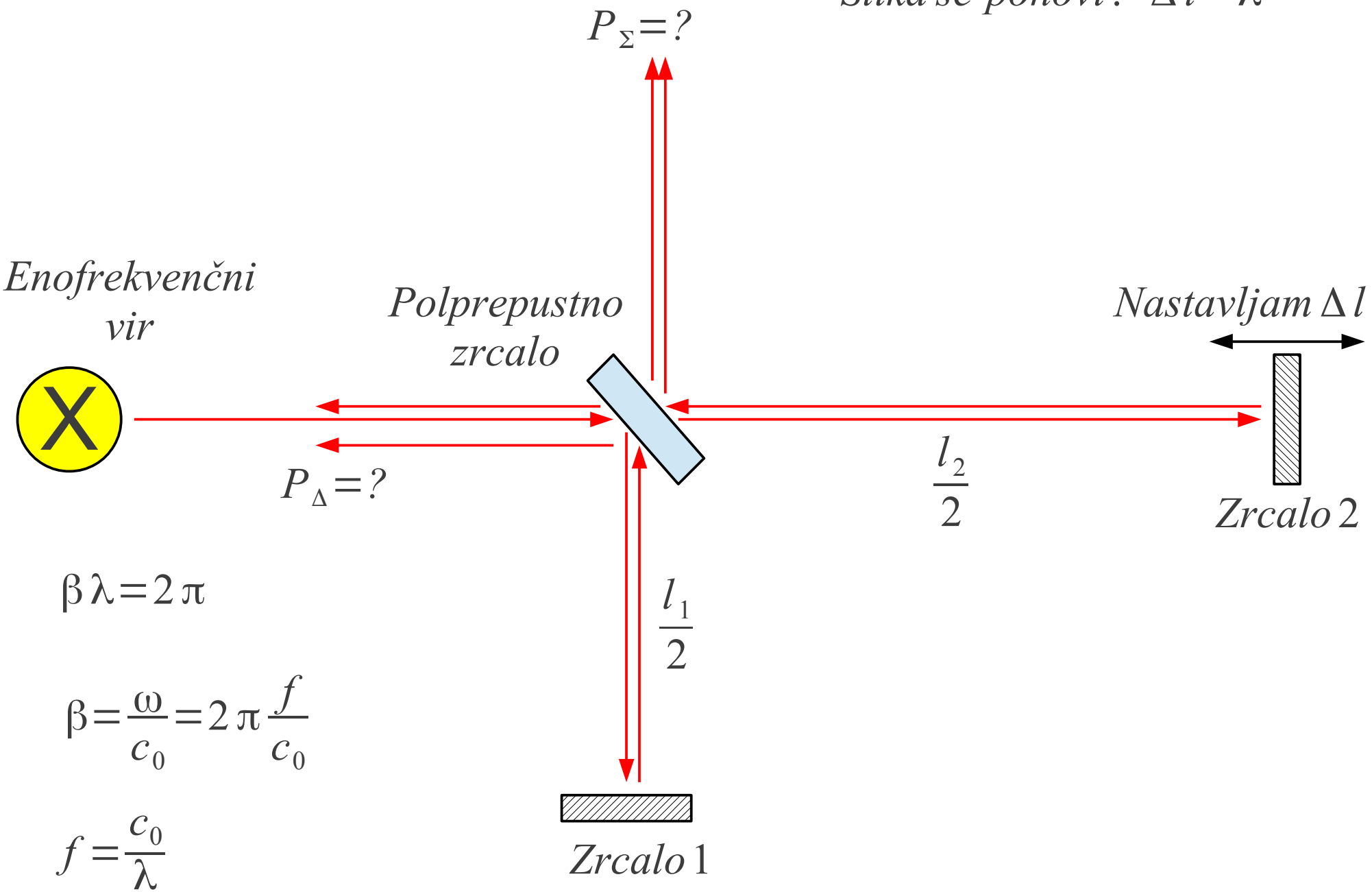
$$P_\Sigma = P_V\left(\frac{1}{2} + \frac{1}{2}\cos\beta\,\Delta l\right)$$

$$P_\Delta = P_V\left(\frac{1}{2} - \frac{1}{2}\cos\beta\,\Delta l\right)$$



Michelsonov interferometer

Slika se ponovi: $\Delta l = \lambda$



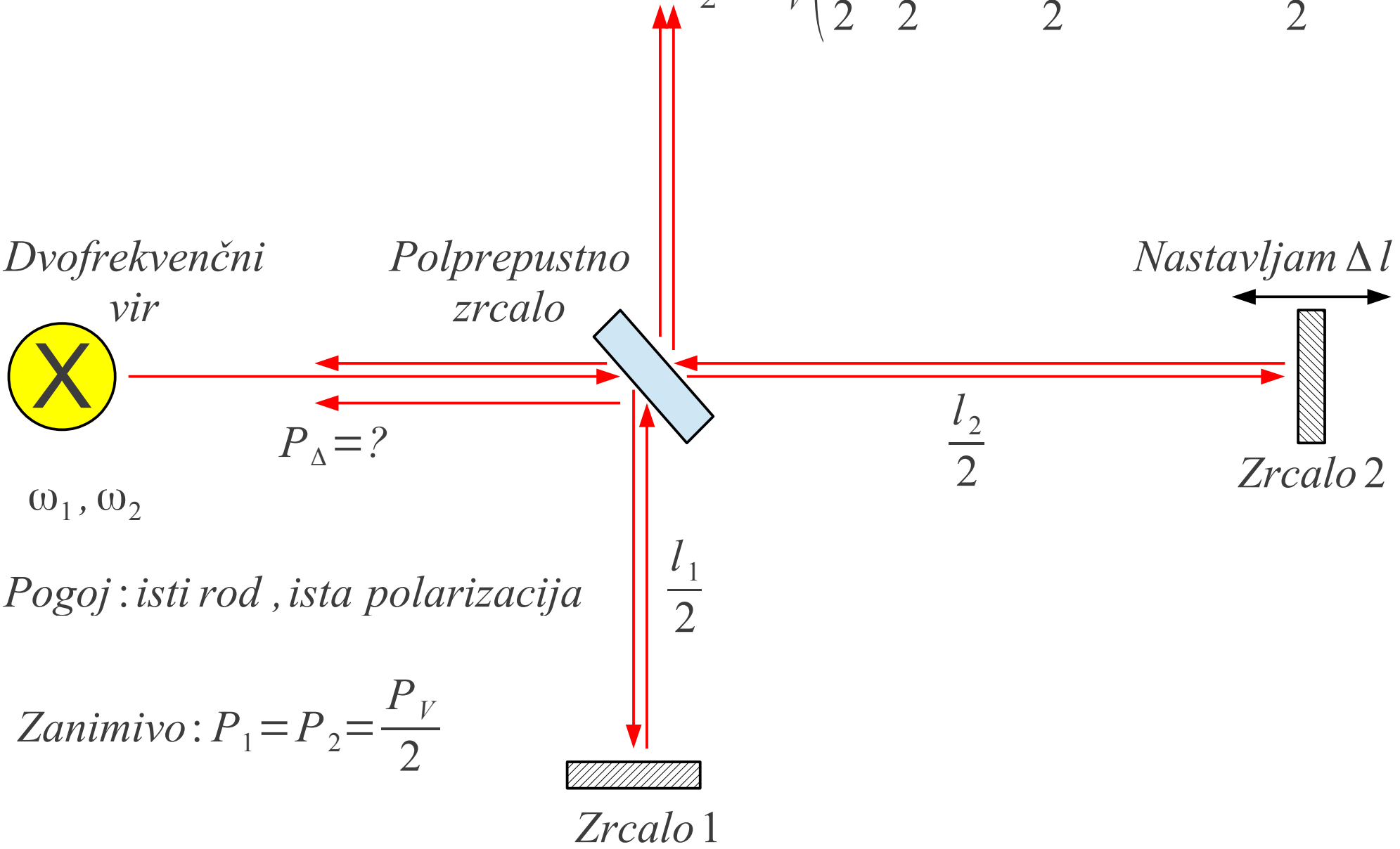
$$\beta \lambda = 2\pi$$

$$\beta = \frac{\omega}{c_0} = 2\pi \frac{f}{c_0}$$

$$f = \frac{c_0}{\lambda}$$

$$P_\Sigma = P_1\left(\frac{1}{2}+\frac{1}{2}\cos\beta_1\Delta l\right)+P_2\left(\frac{1}{2}+\frac{1}{2}\cos\beta_2\Delta l\right)$$

$$P_\Sigma = P_V\left(\frac{1}{2}+\frac{1}{2}\cos\frac{\beta_1+\beta_2}{2}\Delta l\cos\frac{\beta_1-\beta_2}{2}\Delta l\right)$$



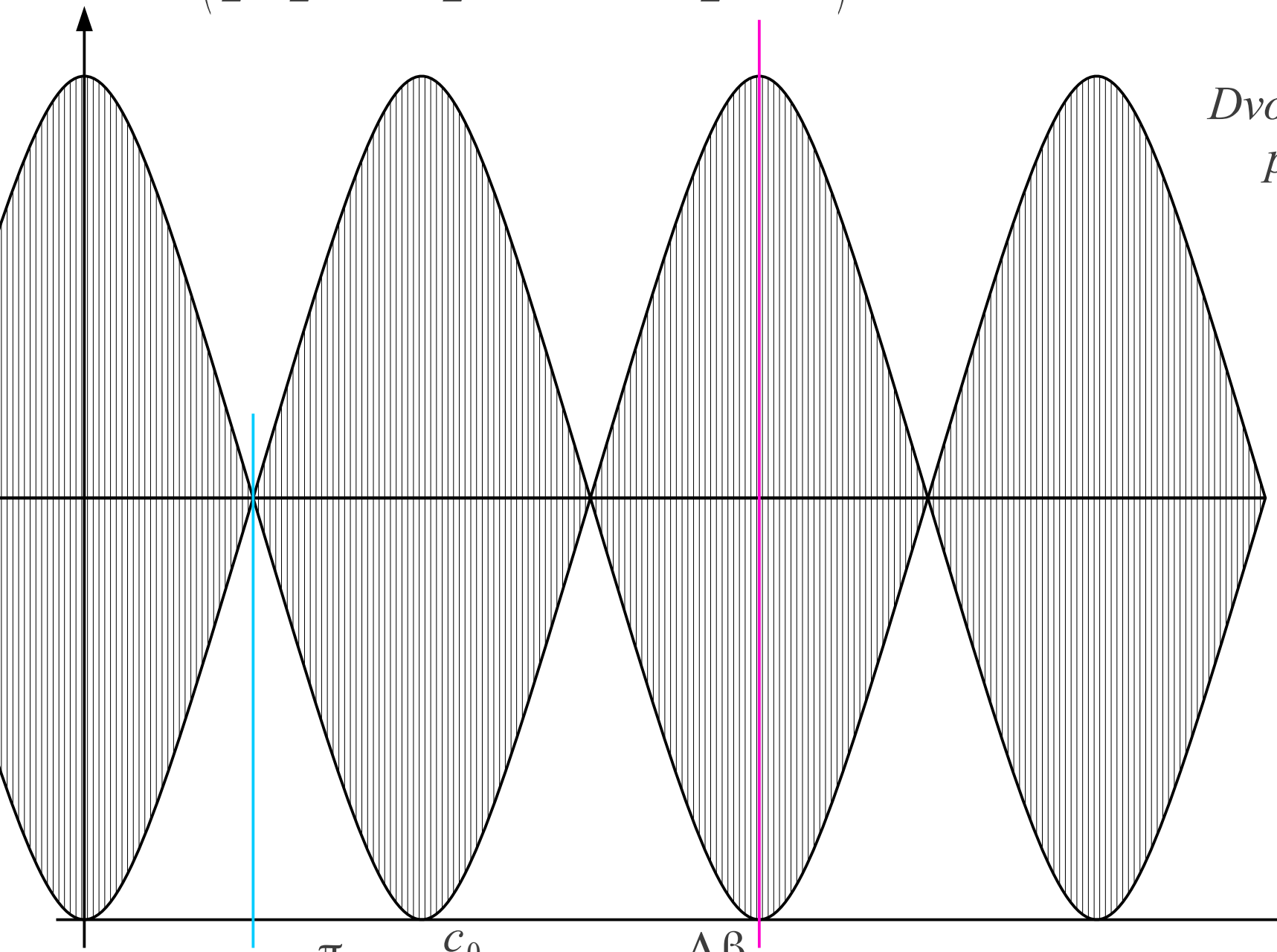
Pogoj : isti rod , ista polarizacija

Zanimivo : $P_1 = P_2 = \frac{P_V}{2}$

$$P_\Sigma = P_V\left(\frac{1}{2}+\frac{1}{2}\cos\frac{\beta_1+\beta_2}{2}\Delta l\cos\frac{\beta_1-\beta_2}{2}\Delta l\right)$$

$$\beta_1-\beta_2=\Delta\beta\ll\beta_1,\beta_2$$

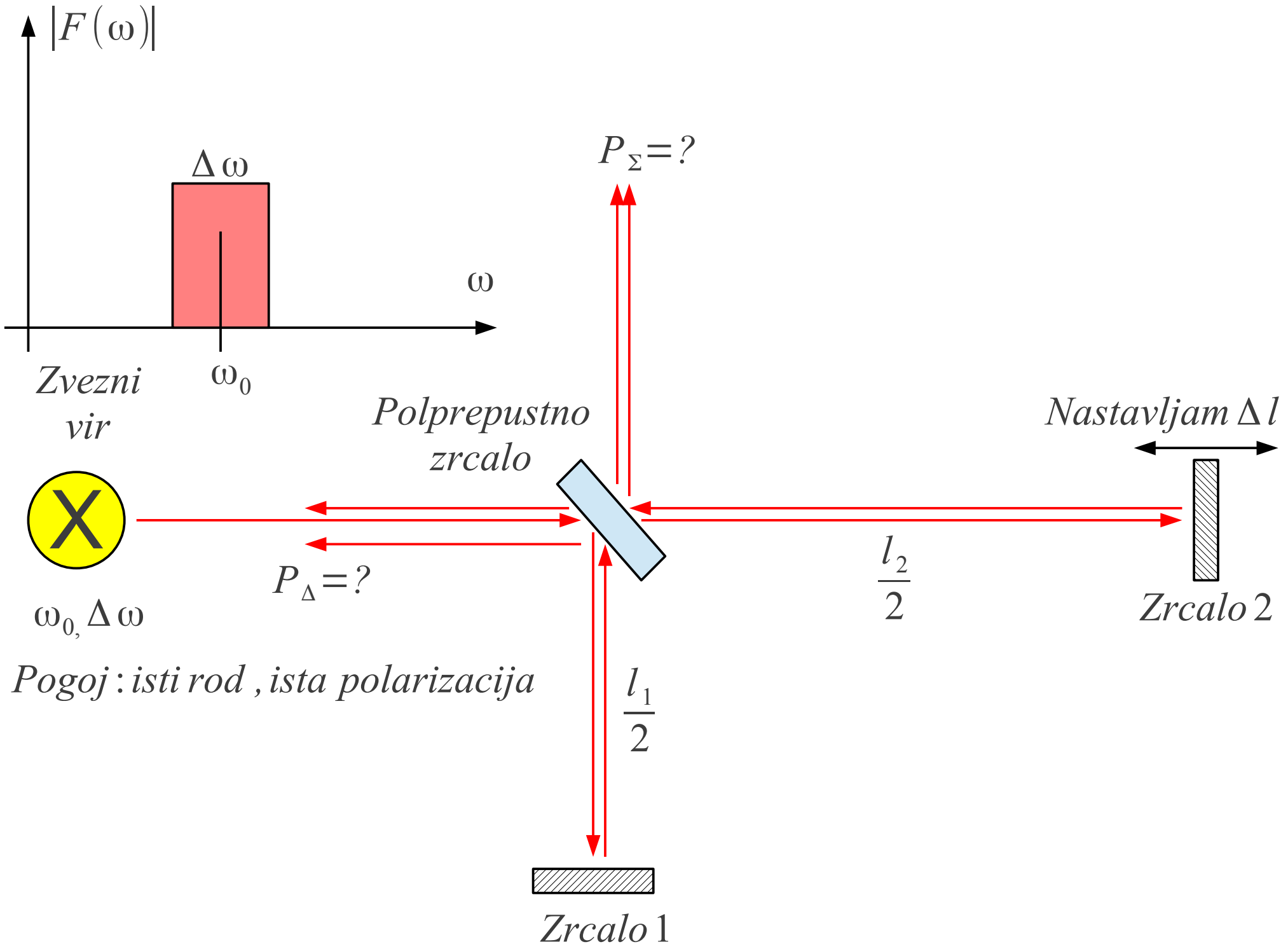
Dvorodovni HeNe polariziran !



$$\Delta l_0=\frac{\pi}{\Delta\beta}=\frac{c_0}{2\Delta f}$$

$$\frac{\Delta\beta}{2}\Delta l=2\pi$$

$$\Delta l=l_1-l_2$$


$|F(\omega)|$
$\Delta\omega$
ω
ω_0
Zvezni vir
$P_\Sigma = ?$
Polprepustno zrcalo
Nastavljam Δl
$P_\Delta = ?$
$\omega_0, \Delta\omega$
$\frac{l_2}{2}$
Zrcalo 2
Pogoj : isti rod , ista polarizacija
$\frac{l_1}{2}$
Zrcalo 1

$$P_V = \frac{dP_V}{d\omega} \cdot \Delta\omega \qquad P_\Sigma = \int_{\omega_1}^{\omega_2} \frac{dP_V}{d\omega} \left(\frac{1}{2} + \frac{1}{2} \cos \beta \Delta l \right) d\omega \qquad \beta = \frac{\omega}{c_0} = 2\pi \frac{f}{c_0}$$

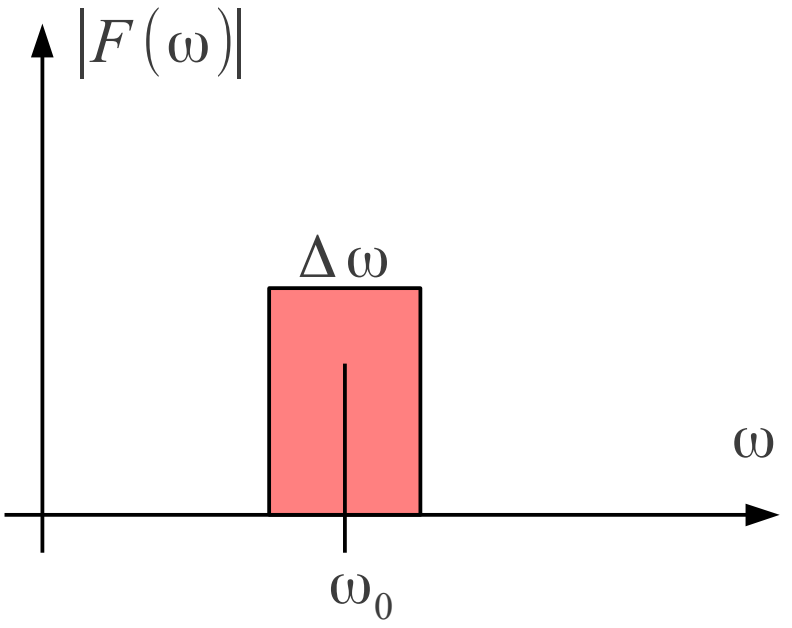
Počasen opazovalec ! ! !

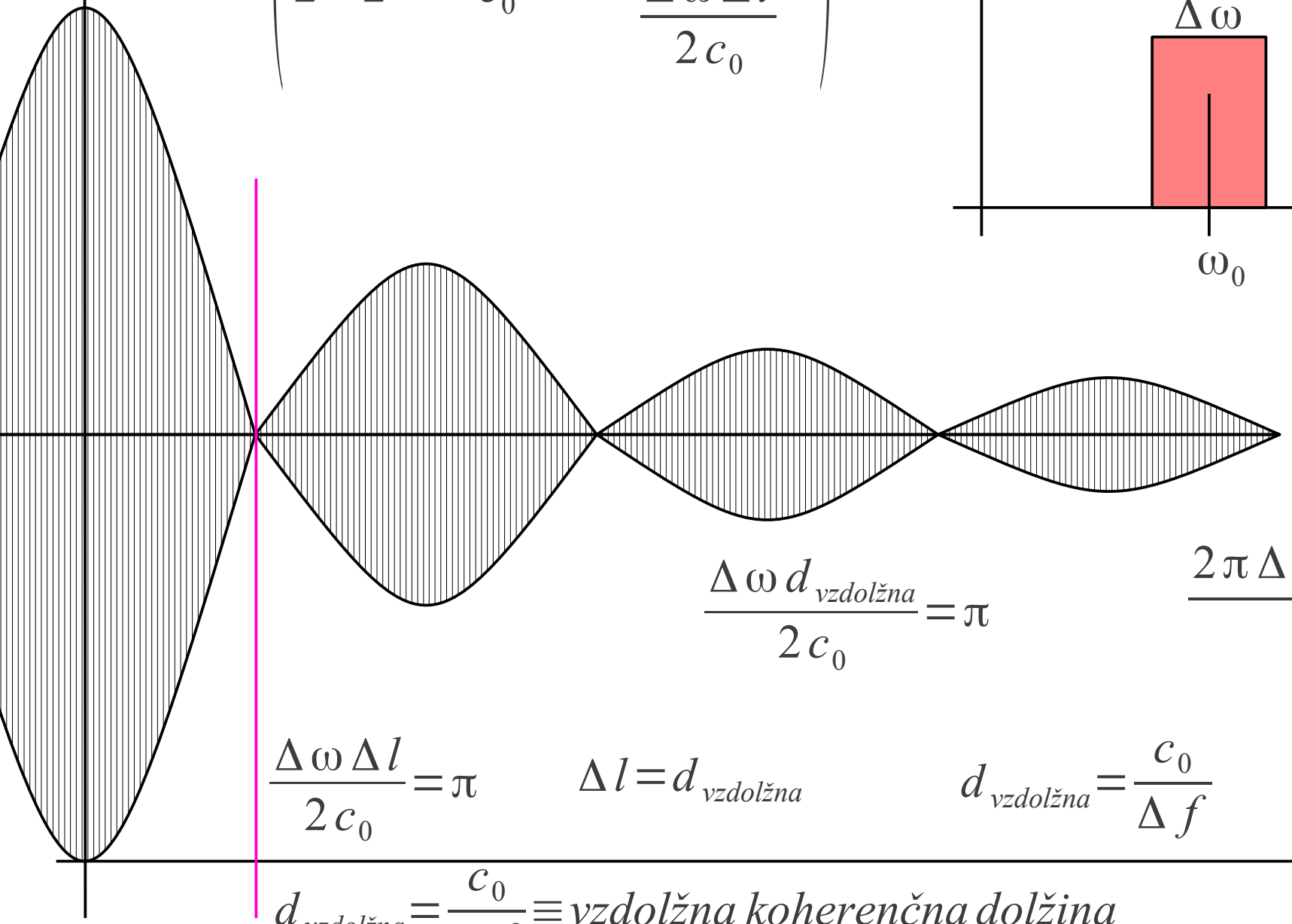
$$P_\Sigma = \frac{P_V}{\Delta\omega} \int_{\omega_1}^{\omega_2} \left(\frac{1}{2} + \frac{1}{2} \cos \frac{\omega}{c_0} \Delta l \right) d\omega$$

$$P_\Sigma = \frac{P_V}{\Delta\omega} \left(\frac{\Delta\omega}{2} + \frac{\Delta\omega}{2} \cos \frac{\omega_0}{c_0} \Delta l \cdot \frac{\sin \frac{\Delta\omega \Delta l}{2 c_0}}{\frac{\Delta\omega \Delta l}{2 c_0}} \right)$$

$$P_\Sigma = P_V \left(\frac{1}{2} + \frac{1}{2} \cos \frac{\omega_0}{c_0} \Delta l \cdot \frac{\sin \frac{\Delta\omega \Delta l}{2 c_0}}{\frac{\Delta\omega \Delta l}{2 c_0}} \right)$$

$$P_\Sigma = P_V \left(\frac{1}{2} + \frac{1}{2} \cos \frac{\omega_0}{c_0} \Delta l \cdot \frac{\sin \frac{\Delta\omega \Delta l}{2 c_0}}{\frac{\Delta\omega \Delta l}{2 c_0}} \right)$$





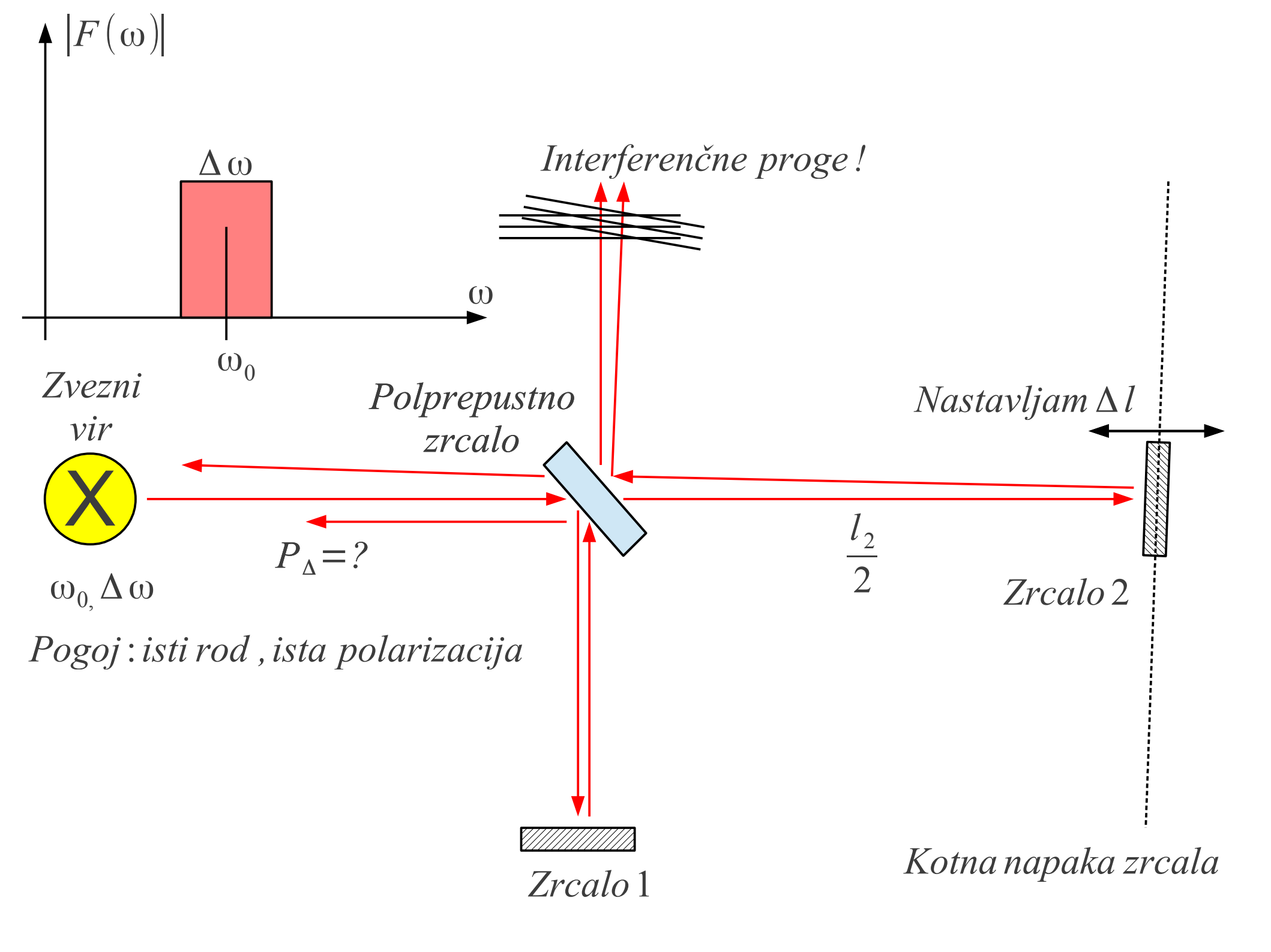
$$\frac{\Delta\omega\, d_{vzdolžna}}{2 c_0} = \pi$$

$$\frac{2\pi \Delta f\, d_{vzdolžna}}{2 c_0} = \pi$$

$$\frac{\Delta\omega \Delta l}{2 c_0} = \pi \qquad \Delta l = d_{vzdolžna} \qquad d_{vzdolžna} = \frac{c_0}{\Delta f}$$

$$d_{vzdolžna} = \frac{c_0}{\Delta f} \equiv \textit{vzdolžna koherenčna dolžina}$$

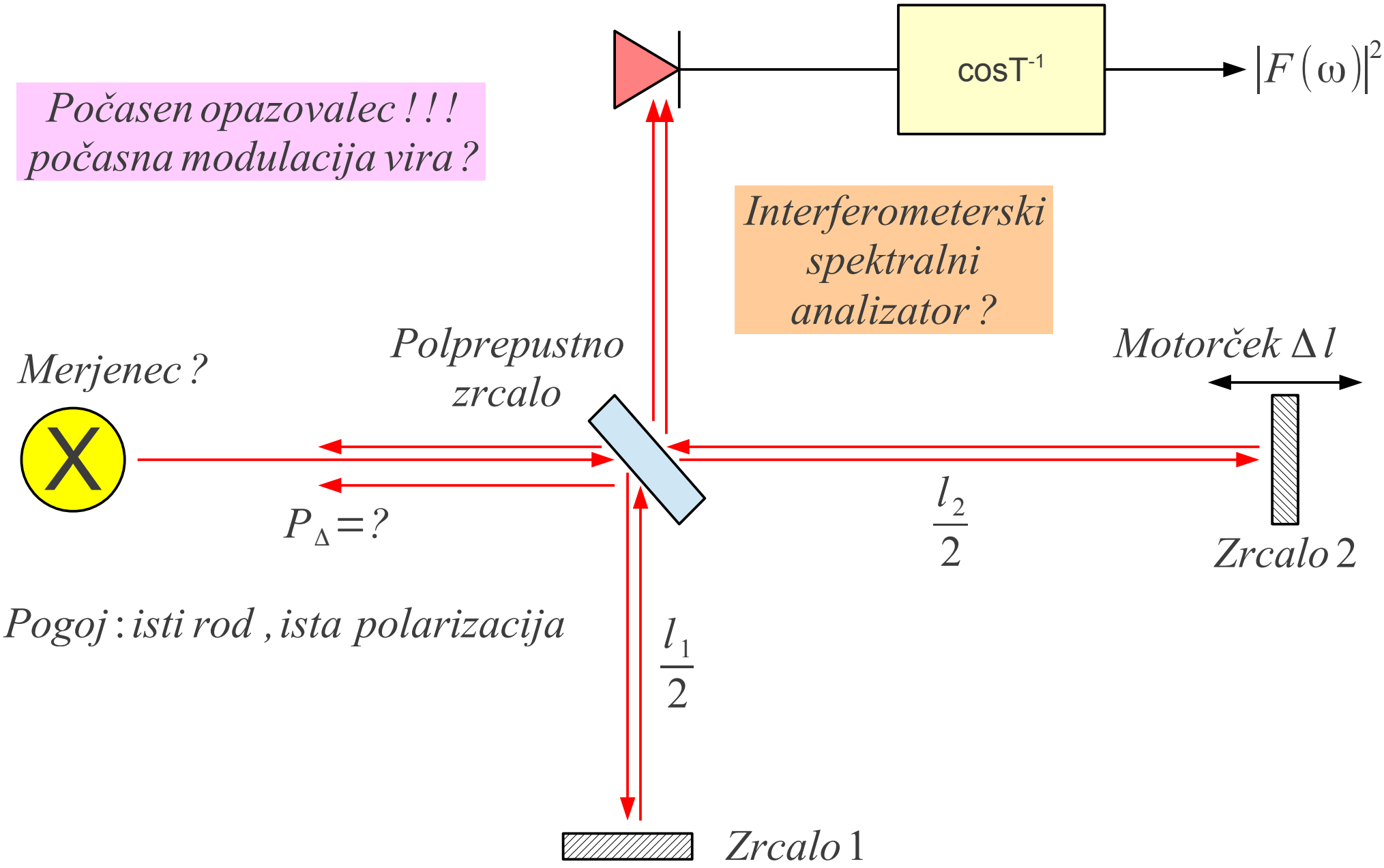
$$\Delta l = l_1 - l_2$$

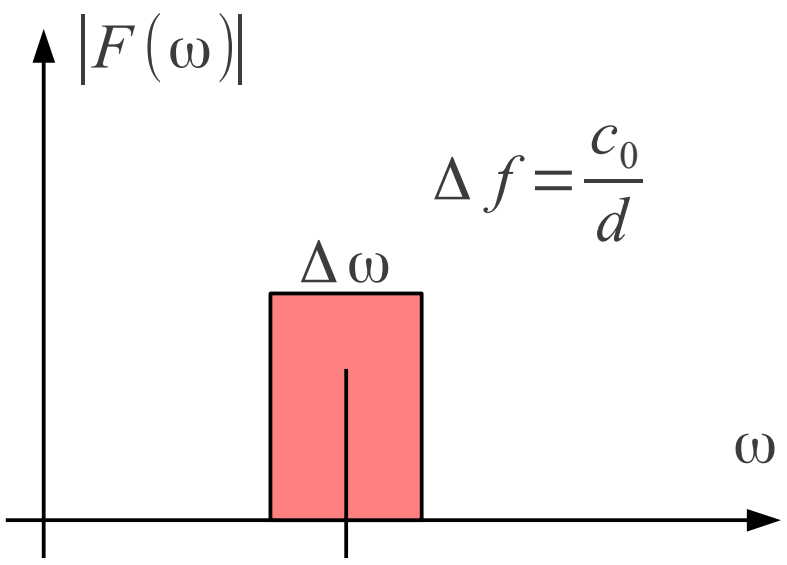

$|F(\omega)|$
$\Delta\omega$
ω
ω_0
Interferenčne proge !
Zvezni vir
Polprepustno zrcalo
Nastavljam Δl
$P_\Delta = ?$
$\frac{l_2}{2}$
Zrcalo 2
$\omega_0, \Delta\omega$
Pogoj : isti rod , ista polarizacija
Zrcalo 1
Kotna napaka zrcala

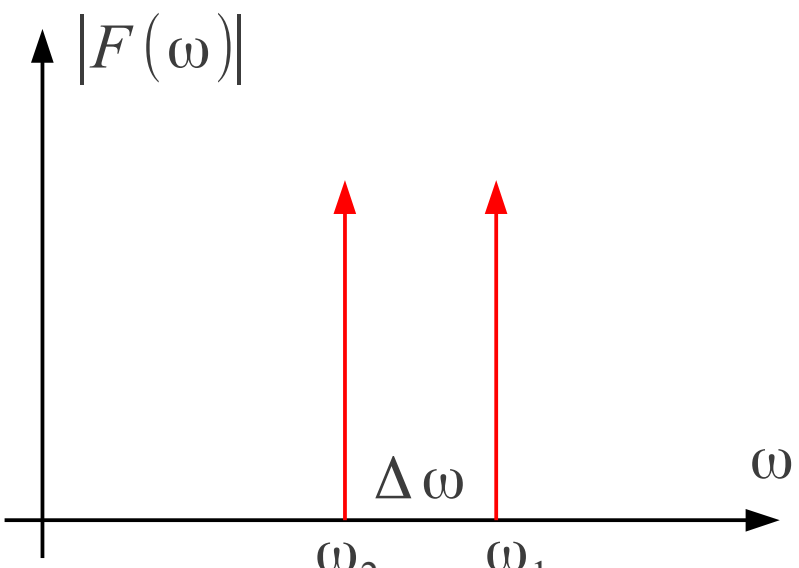
$$\frac{dP_V}{d\omega} = \alpha |F(\omega)|^2$$

$$P_\Sigma = \alpha \int_{\omega_1}^{\omega_2} |F(\omega)|^2 \left(\frac{1}{2} + \frac{1}{2} \cos \beta \Delta l \right) d\omega$$

Kosinusna transformacija







$$\Delta f = f_1 - f_2 = \frac{c_0}{2\Delta l_0}$$

$$d_{vzdolžna} = \frac{c_0}{\Delta f} \equiv \textit{vzdolžna koherenčna dolžina}\,[m]$$

$$\Delta\lambda = \frac{\lambda_0^2}{c_0}\cdot\Delta f \equiv \textit{valovnodolžinska pasovna širina}\,[m]$$

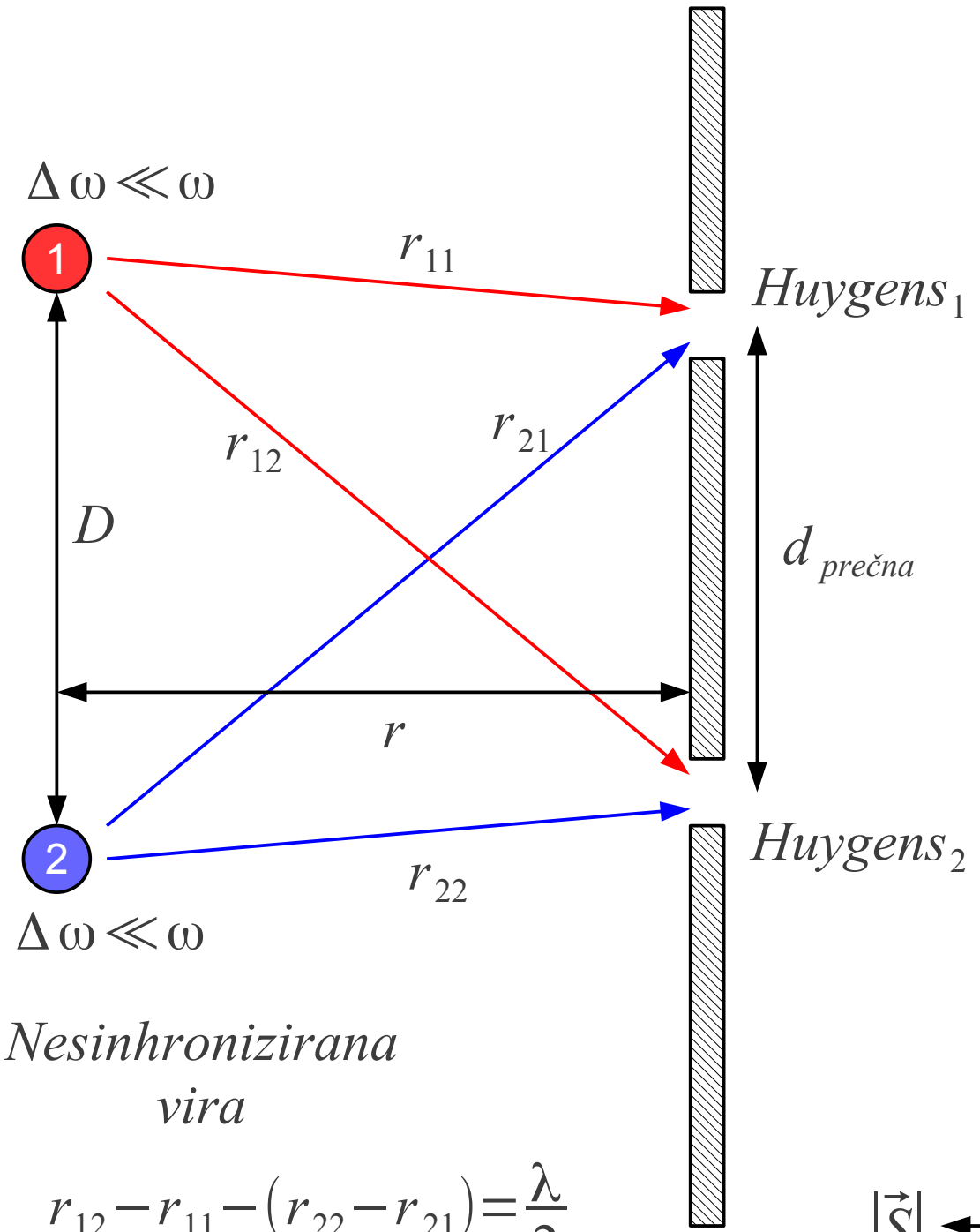
$$\Delta f \equiv \textit{frekvenčna pasovna širina}\,[Hz]$$

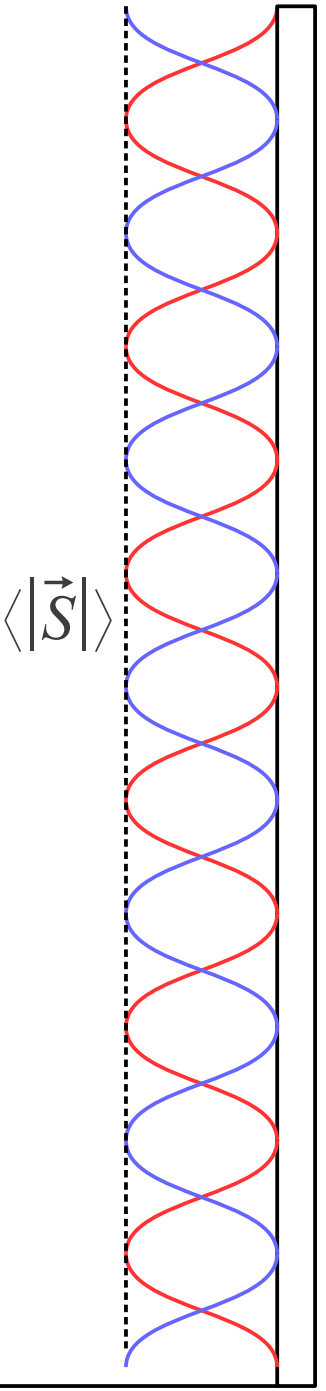
$$\Delta\lambda = \frac{\lambda_0^2}{c_0}\cdot\frac{c_0}{d_{vzdolžna}} = \frac{\lambda_0^2}{d_{vzdolžna}}$$

Množica rodov → ∞ → ? ? ?

Ovira

Počasen opazovalec ! ! !





$r \gg D\,,\, d_{prečna}$

$$d_{prečna} \approx \frac{\lambda \cdot r}{2\,D}$$

Zorni kot

$$\alpha \approx \frac{D}{r}$$

$$d_{prečna} \approx \frac{\lambda}{2\,\alpha}$$

Nesinhronizirana vira

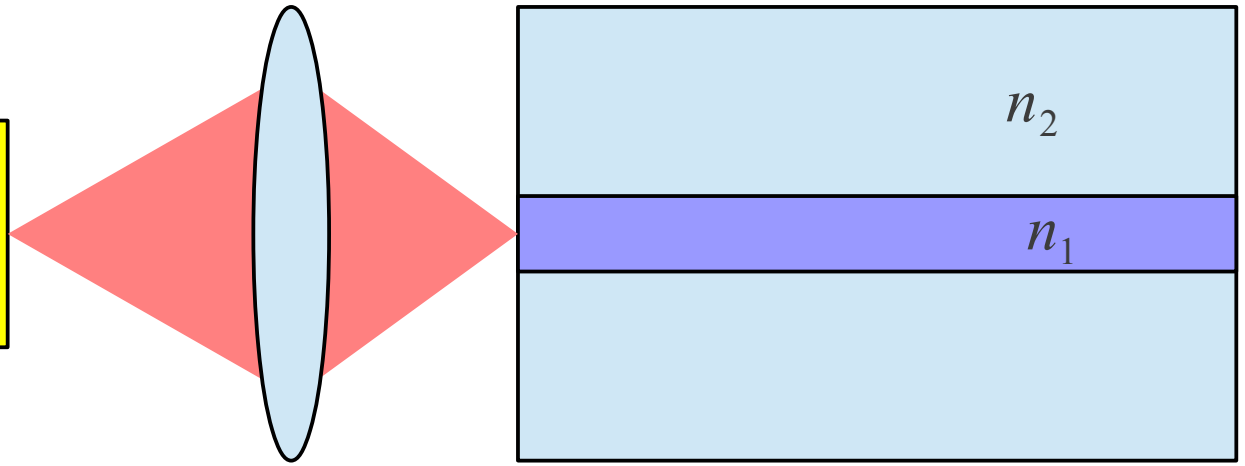
$$r_{12} - r_{11} - (r_{22} - r_{21}) = \frac{\lambda}{2}$$

$d_{prečna} \equiv$ *prečna koherenčna dolžina* $[m]$

$d_{vzdolžna} < \infty$

Enorodovno vlakno ! ! !

LASER z enim samim prečnim rodom



Visok $\eta = \frac{P_{vlakno}}{P_{LASER}} \rightarrow$ *zahteva LASER z enim samim prečnim rodom*

$d_{prečna} \rightarrow \infty$

V telekomunikacijah se običajno ne ukvarjam s prečno koherenco vira ! ! !