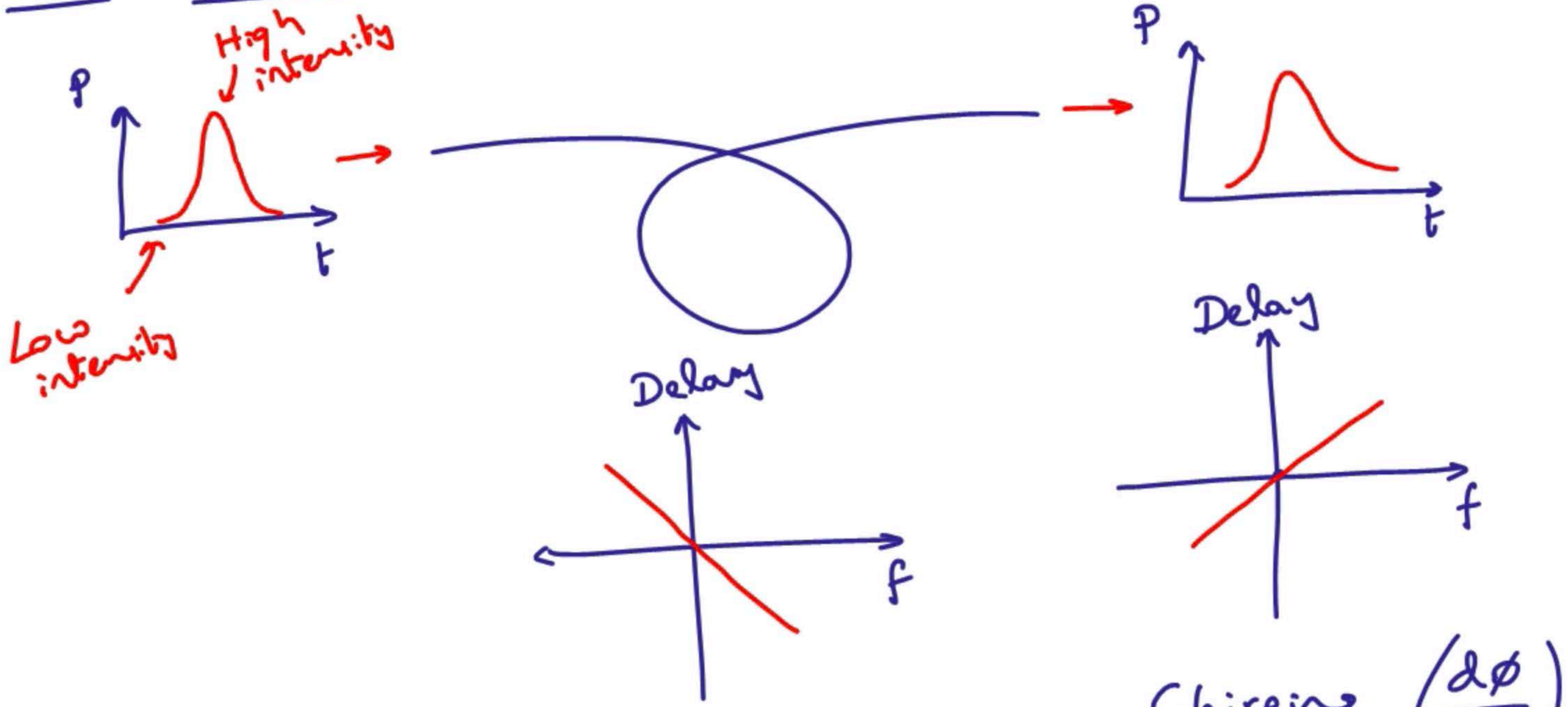
Self Phase Modulation



Dispersion + Chirping $\left(\frac{d\phi}{dt}\right)$

$\Rightarrow$ Compensation

Third order susceptibility (χ^3) $\rightarrow$ $\chi^{(3)} \mathcal{E}^3$

Energy Conservation

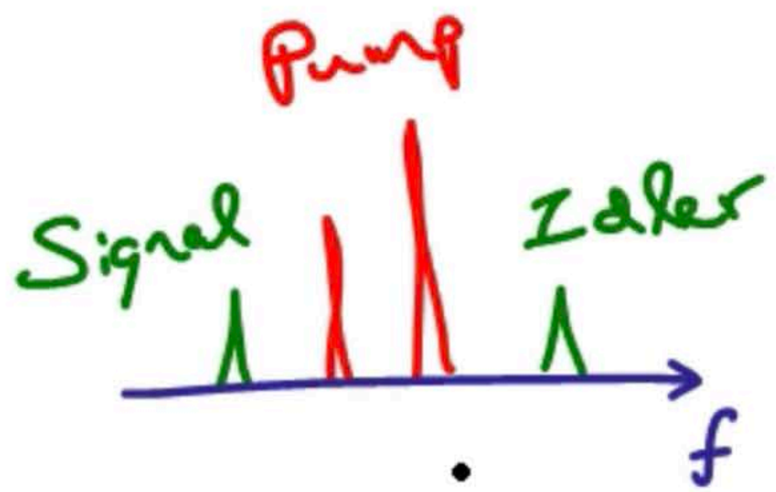
$\omega_1 + \omega_2 = \omega_3 + \omega_4$

Momentum Conservation

$\vec{K}_1 + \vec{K}_2 = \vec{K}_3 + \vec{K}_4$

$$\begin{array}{l} E(\omega_1) \rightarrow \\ E(\omega_2) \rightarrow \\ E(\omega_3) \rightarrow \end{array} \boxed{\chi^{(3)}} \rightarrow \begin{array}{l} \omega_1 + \omega_2 + \omega_3 \\ \omega_1 - \omega_2 - \omega_3 \\ \vdots \end{array}$$

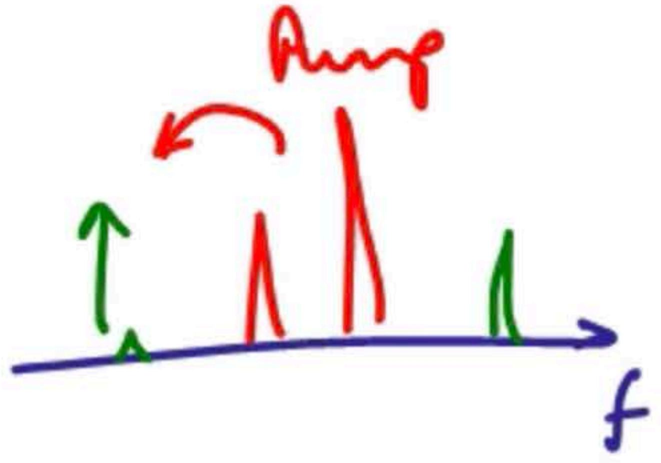
Four-wave mixing



Wavelength Conversion

Self Phase Modulation/

<u>Kerr</u> <u>effect</u>

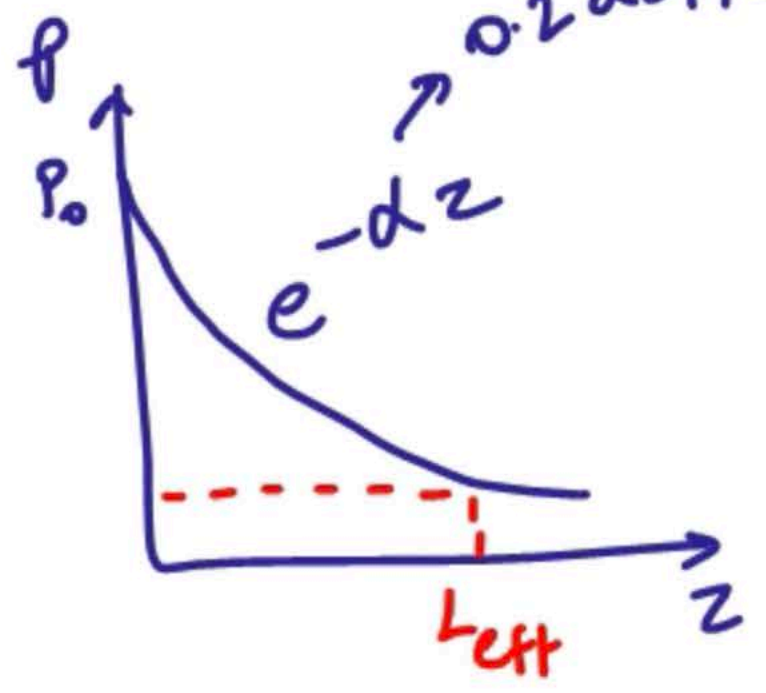


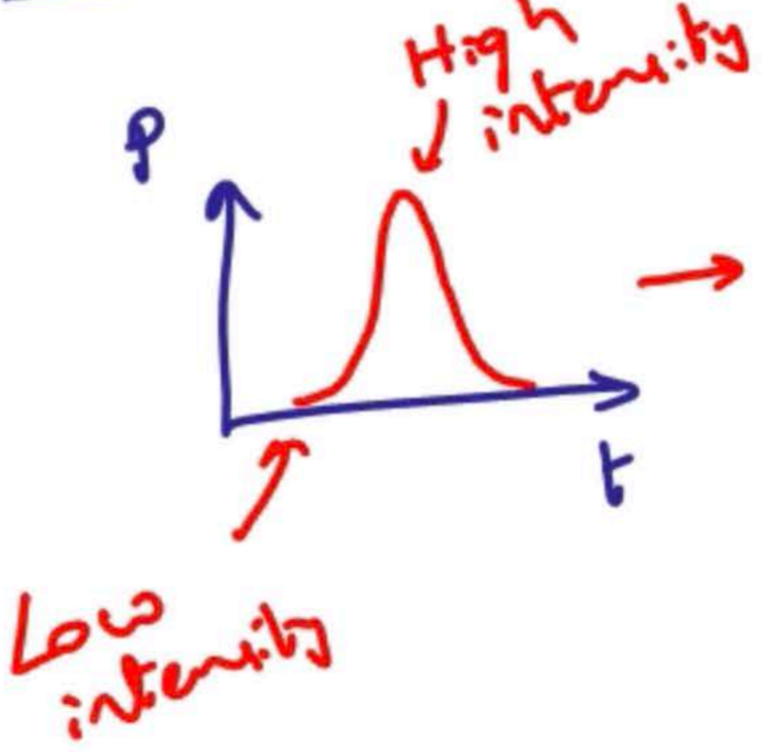
Stimulated Raman Scattering

Parametric Amplification

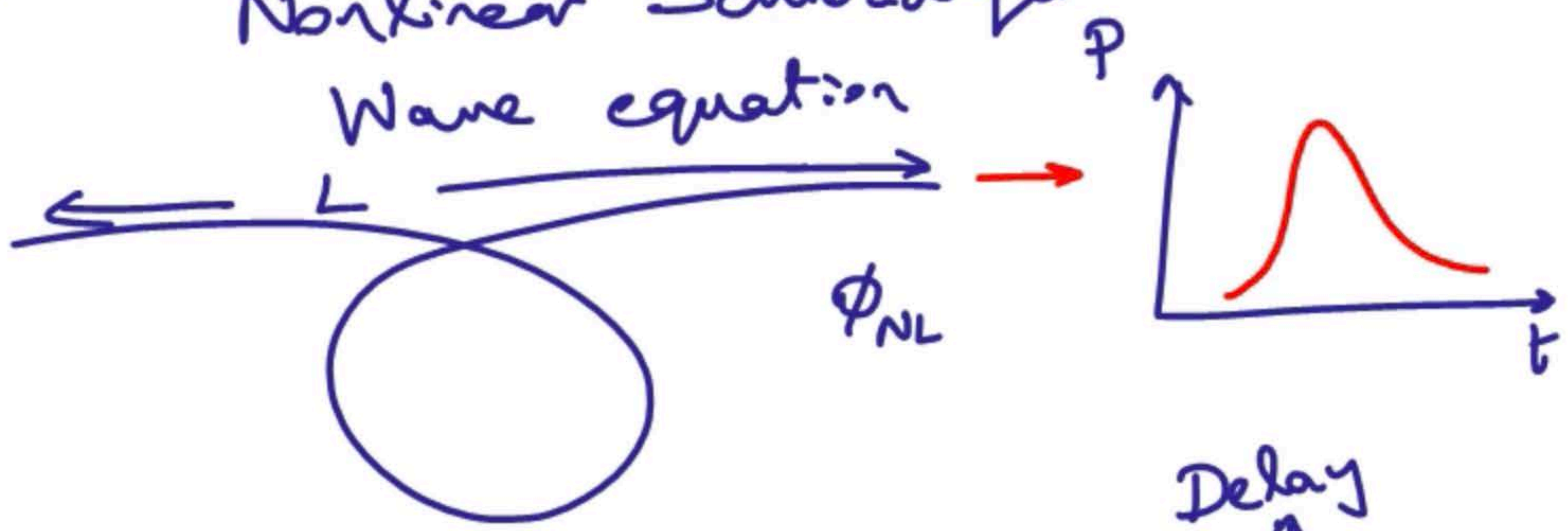
Stimulated Brillouin Scattering

Self Phase Modulation





Nonlinear Schroedinger Wave equation

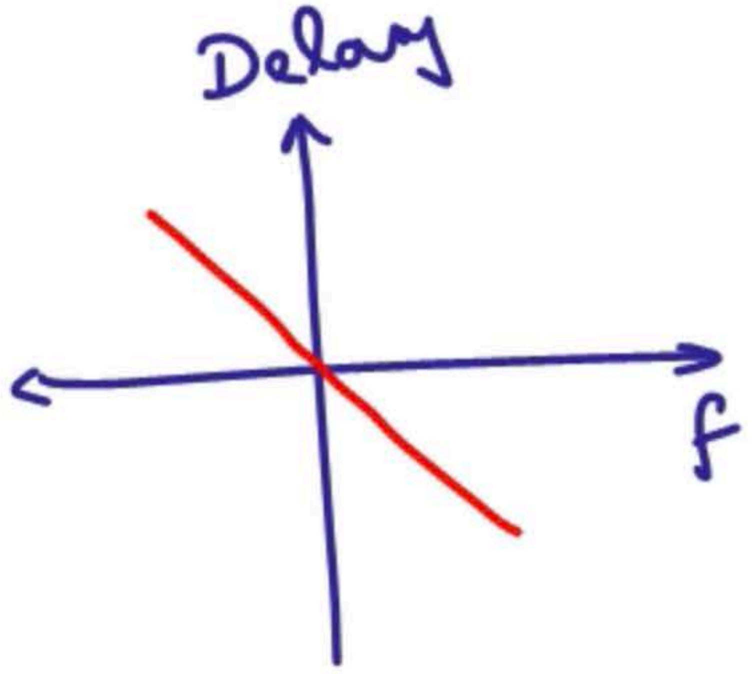


Sech²

(Soliton)

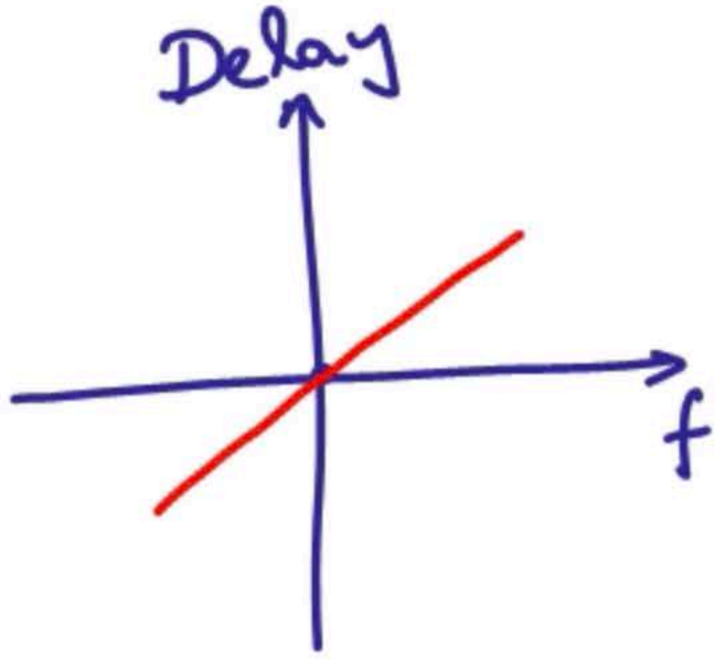
$$\phi_{NL} = \frac{2\pi}{\lambda}\cdot\frac{n_2}{A}\int_0^L P(z)\,dz \quad L_{eff}$$

$$= \frac{2\pi}{\lambda}\cdot\frac{n_2}{A}\cdot P_0\left(\frac{1-e^{-\alpha L}}{\alpha}\right)$$



Dispersion

+



Chirping $\left(\frac{d\phi}{dt}\right)$

$\Rightarrow$ Compensation

SMF-28

$\alpha = 0.2\ \text{dB/km} = \frac{0.2}{4.34}\times 10^{-3}\ \text{Np/m}$

$1/\alpha = 20\ \text{km}$

$$\alpha L \gg 1 \quad \text{or} \quad L \gg 1/\alpha$$

$$\phi_{NL} = \frac{2\pi}{\lambda} \cdot \frac{n_2}{A} \cdot P_0 \left(\frac{1 - e^{-\alpha L}}{\alpha} \right) \simeq \frac{2\pi}{\lambda} \cdot \frac{n_2}{A} \cdot P_0 \cdot \frac{1}{\alpha}$$

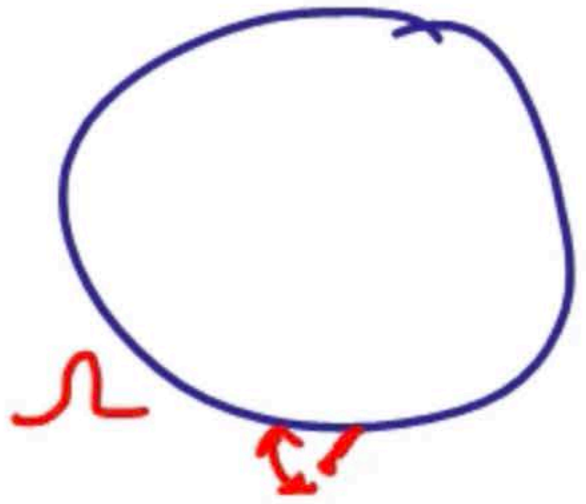
$n_2 = 10^{-14}\ m^2/W$

$A_{eff} = 50\ \mu m^2$

$\lambda = 1.5\ \mu m$

$1/\alpha = 21.7\ km$

$\phi_{NL} = \underline{0.58\,\pi}$ for $P_0 = 1\ mW$

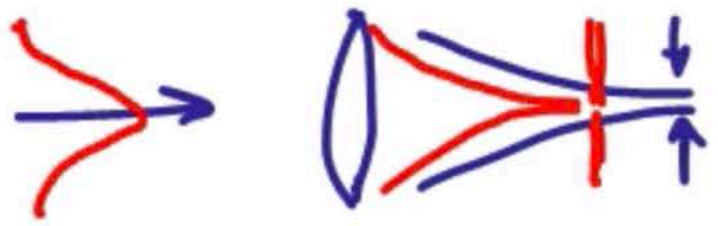


Optical fiber communications

$P < 1\ mW$

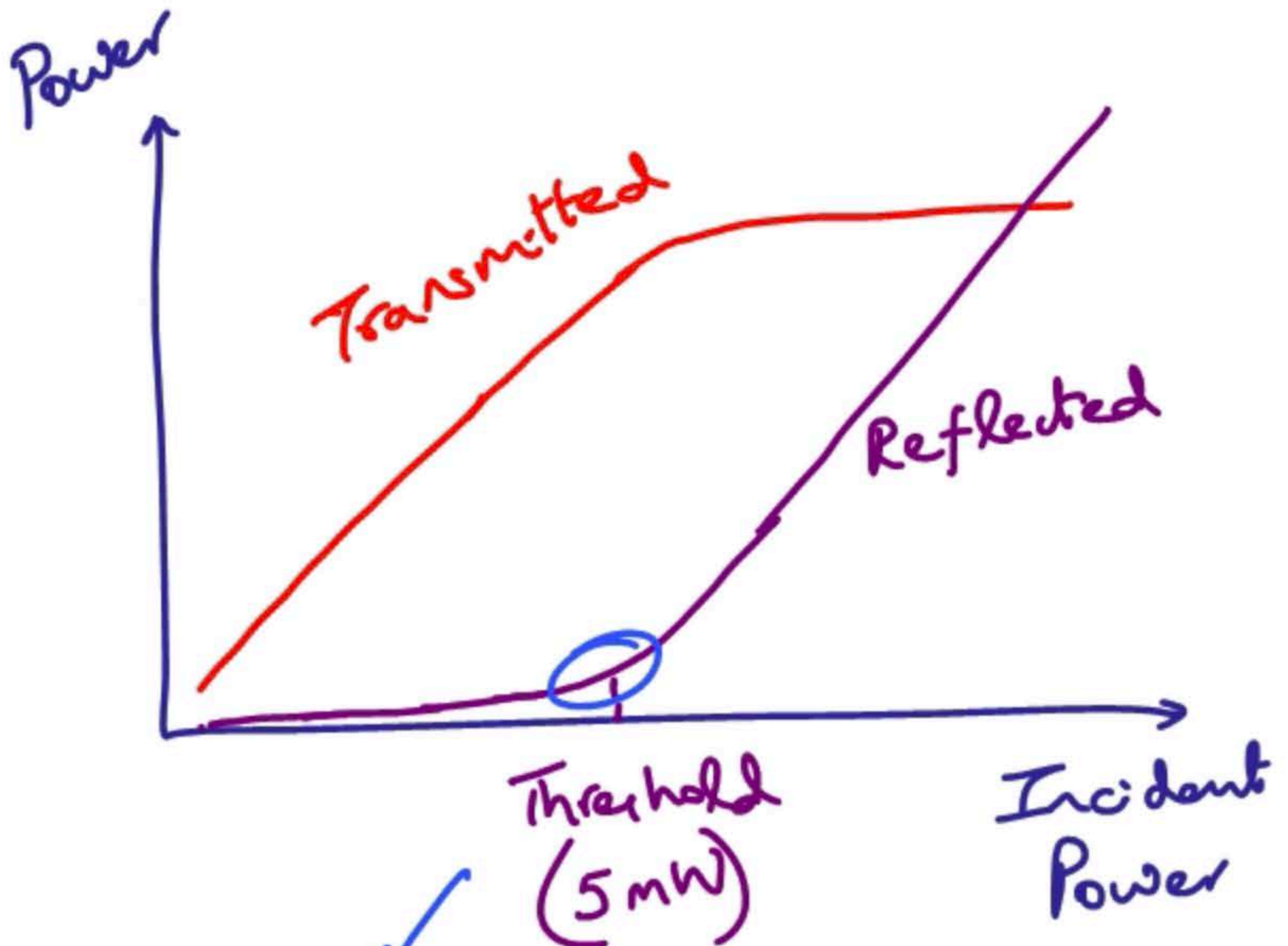
Kerr Lens Modelocking

Self-focusing



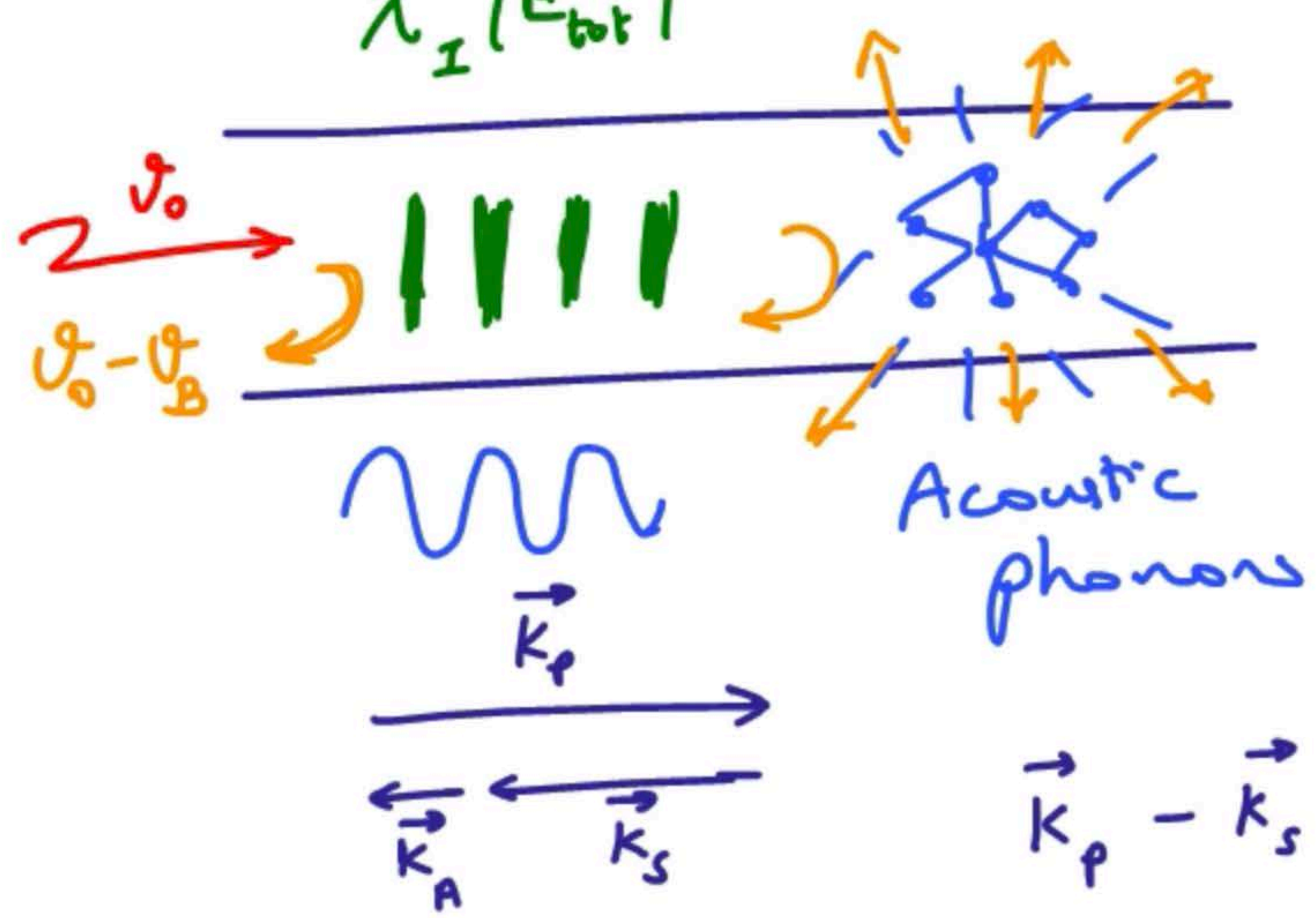
Intensity-based loss

Stimulated Brillouin Scattering



If source is highly coherent

$\chi^{(3)}_{I} |E_{tot}|^2$



$$\vec{K}_p - \vec{K}_s = \vec{K}_A$$

If $|K_p| \simeq |K_s|$ $\quad 2|K_p| = |K_A|$

$$2 \cdot \frac{\cancel{2\pi}}{\lambda_p} n_{eff} = \frac{\cancel{2\pi}\, \nu_B}{V_A}$$

$$\boxed{\nu_B = \frac{2 \cdot n_{eff} V_A}{\lambda_p}}$$

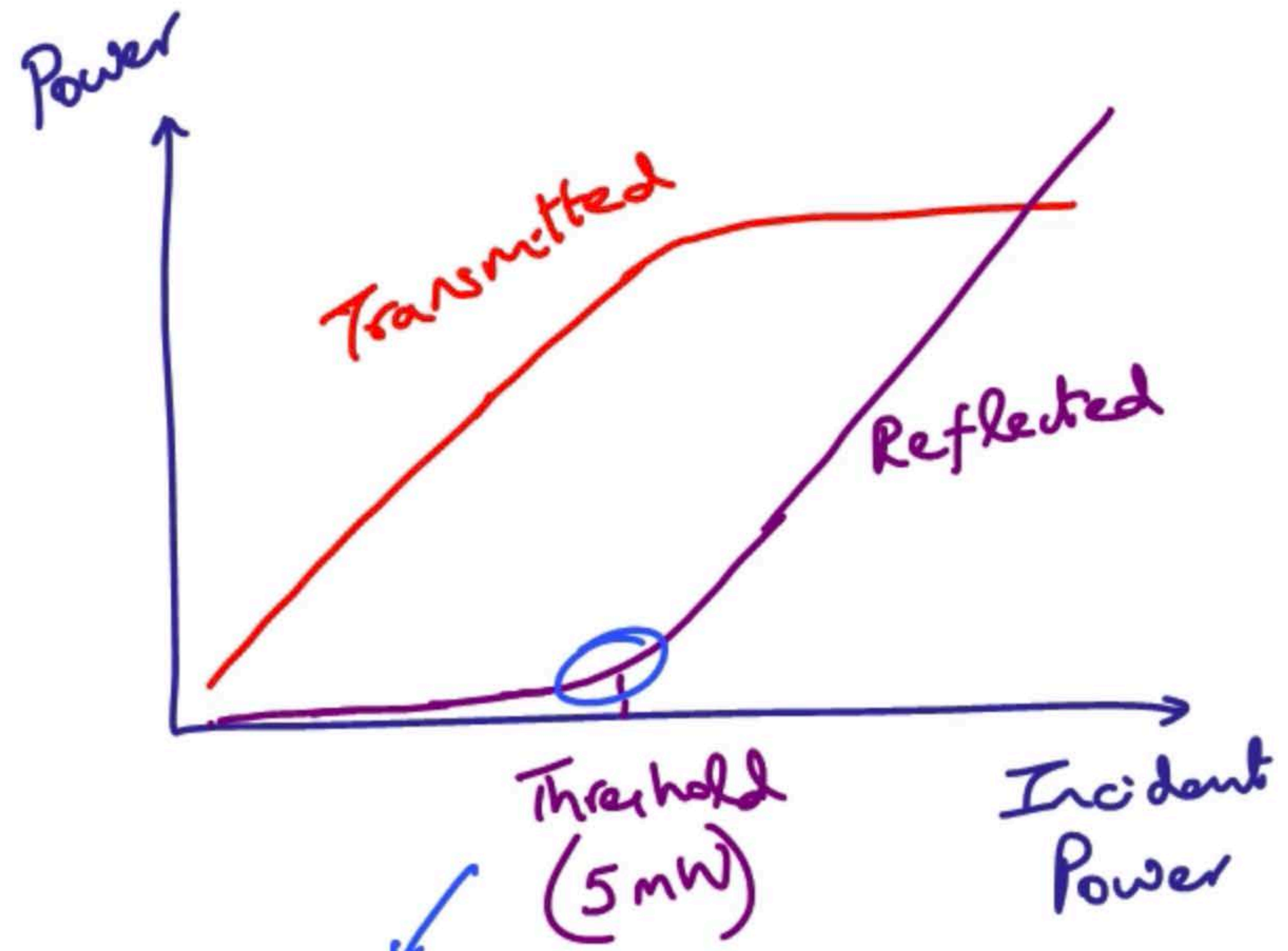
$n_{eff} \simeq 1.5$

$V_A = 6 \text{ km/s}$

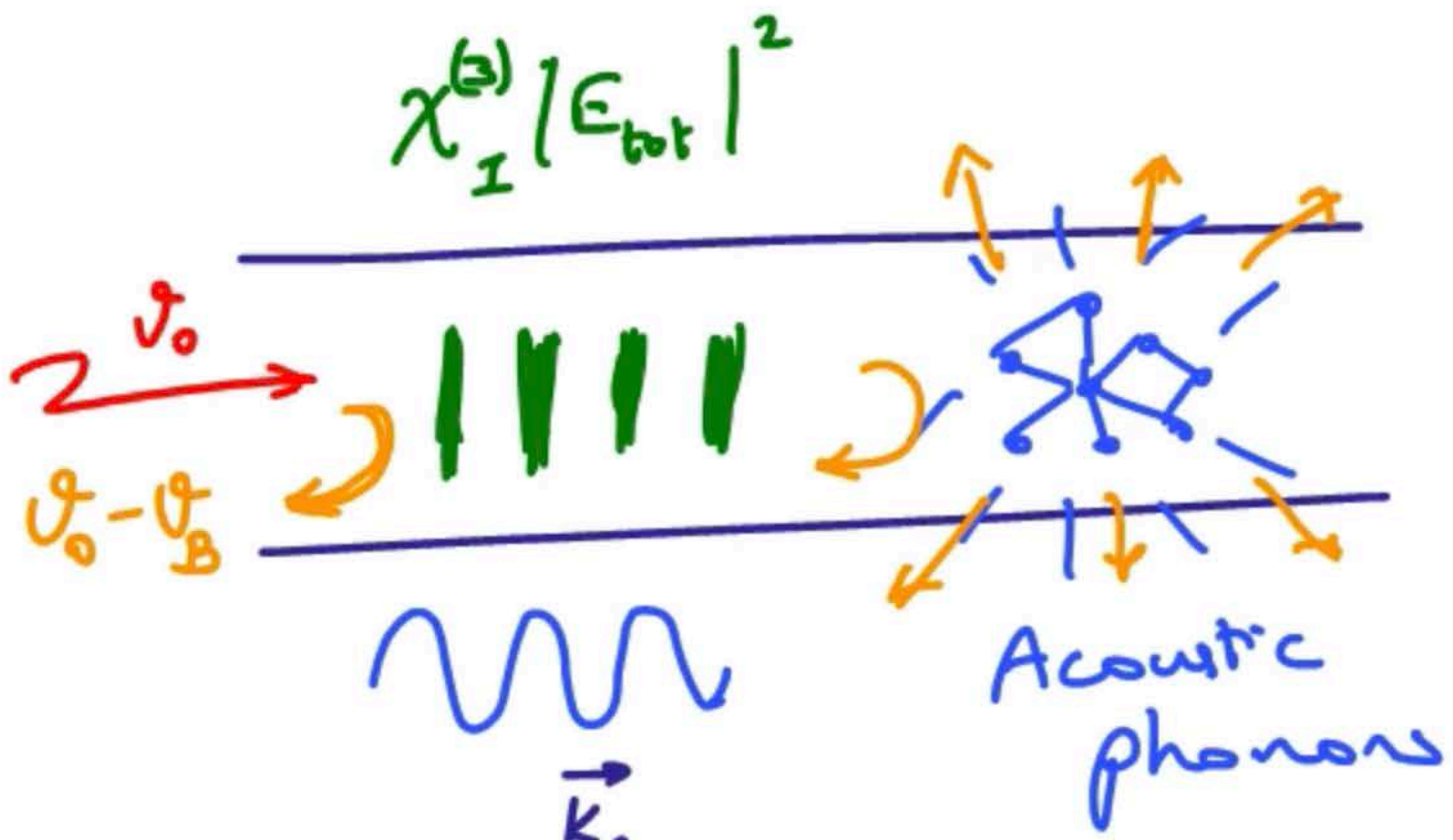
$\lambda_p = 1.5 \ \mu m$

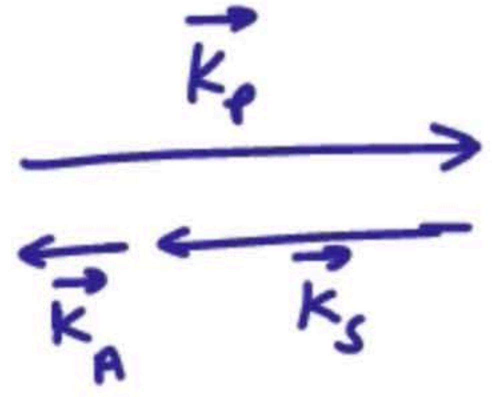
$\Rightarrow \nu_B = 12 \text{ GHz}$

Stimulated Brillouin Scattering



If source is highly coherent





$$\vec{k}_p - \vec{k}_s = \vec{k}_A$$

If $|k_p| \simeq |k_s|$ $\quad 2|k_p| = |k_A|$

$$2 \cdot \frac{\cancel{2\pi}}{\lambda_p} n_{eff} = \frac{\cancel{2\pi}\, \nu_B}{V_A}$$

$n_{eff} \simeq 1.5$

$V_A = 6 \text{ km/s}$

$\lambda_p = 1.5\ \mu m$

$\Rightarrow \nu_B = 12 \text{ GHz}$

$$\boxed{\nu_B = \frac{2 n_{eff} V_A}{\lambda_p}}$$