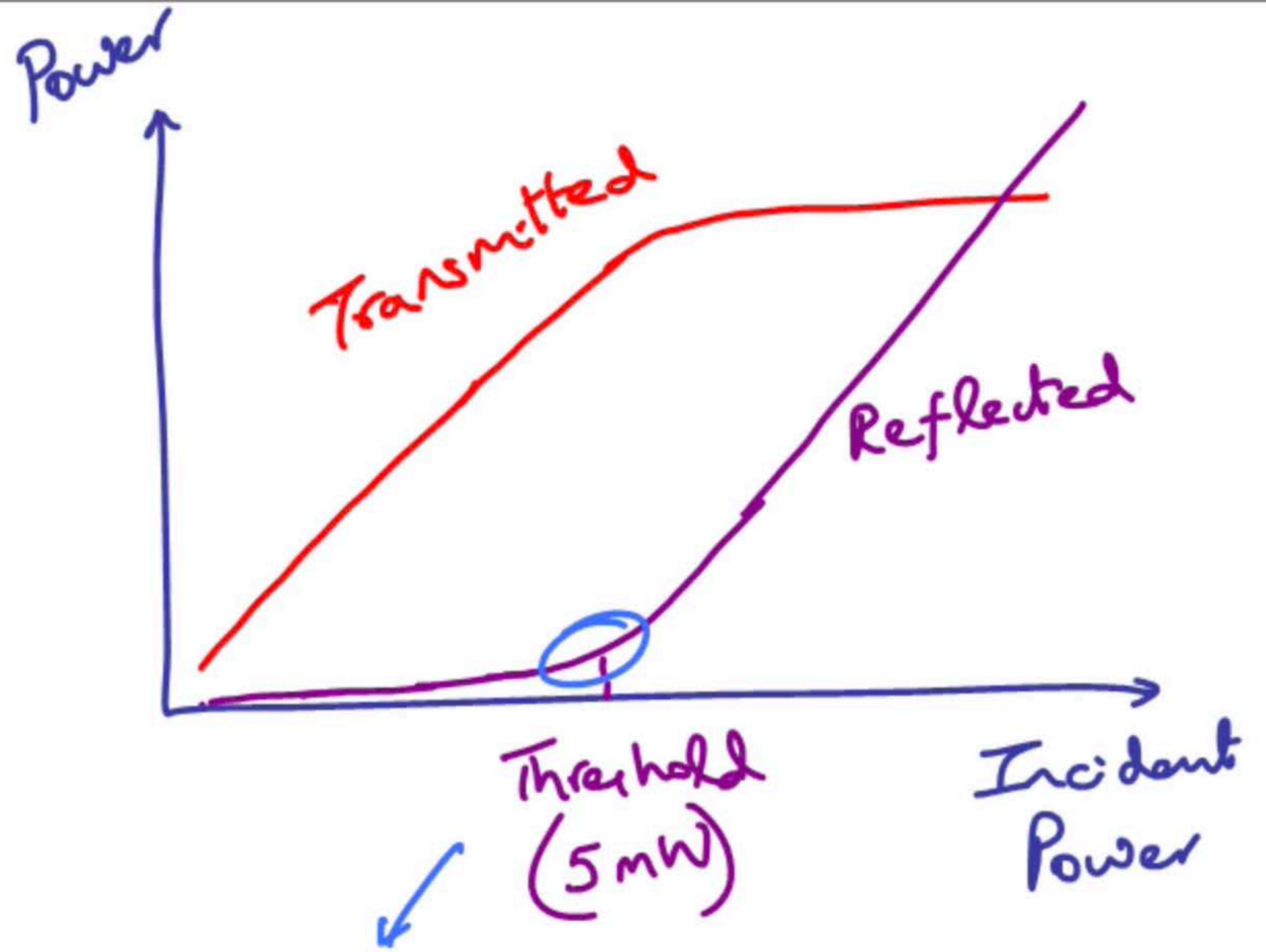
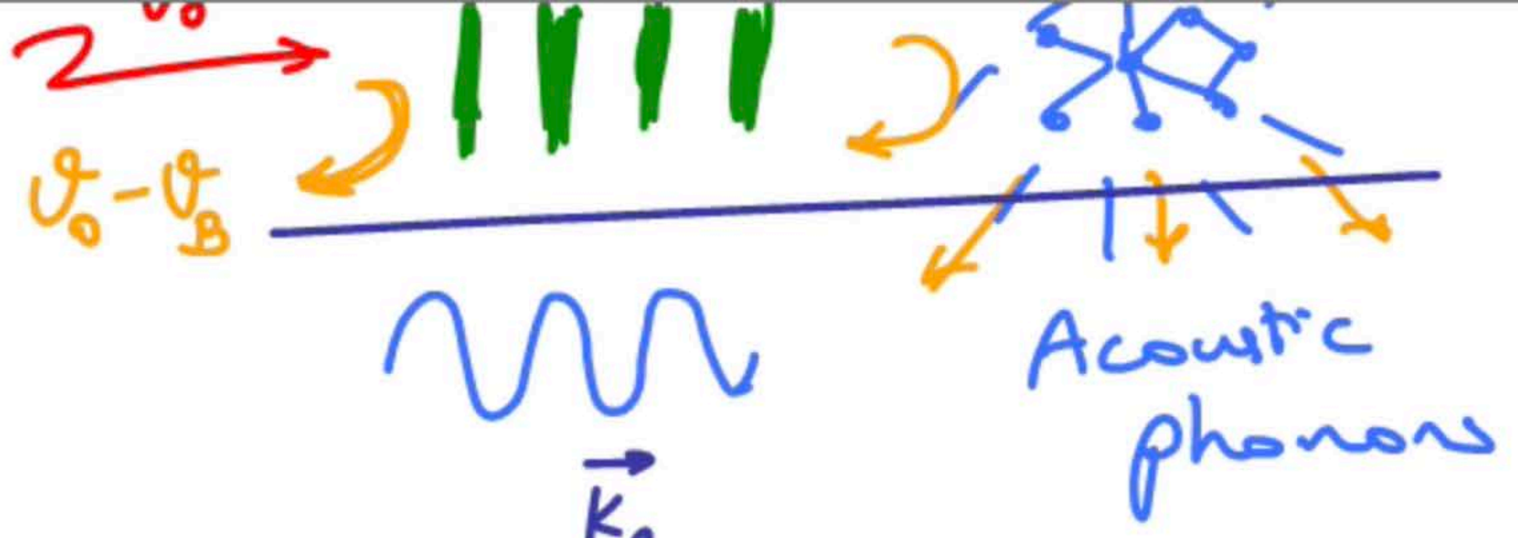
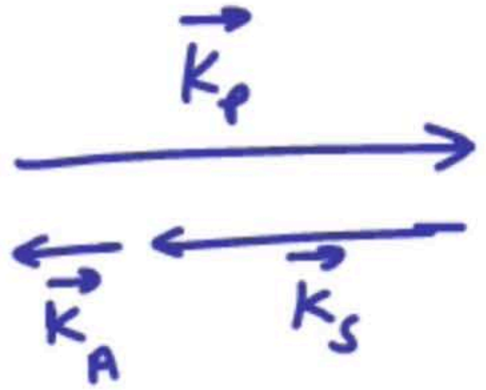


If source is highly coherent





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

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

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

$n_{eff} \simeq 1.5$

$V_A = 6$ km/s

$\lambda_p = 1.5\ \mu m$

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

$\Rightarrow \nu_B = 12$ GHz

Energy Conservation

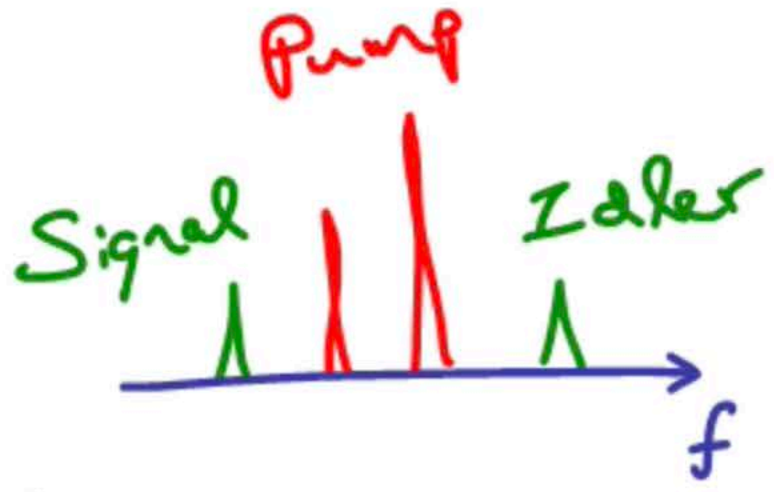
$\omega_1 + \omega_2 = \omega_3 + \omega_4$

Momentum Conservation

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

$E(\omega_1) \rightarrow$, $E(\omega_2) \rightarrow$, $E(\omega_3) \rightarrow$ $\boxed{\chi^{(3)}}$ $\rightarrow$ $\omega_1 + \omega_2 + \omega_3$, $\omega_1 - \omega_2 - \omega_3$, $\vdots$

Four-wave mixing



Wavelength Conversion

Self Phase Modulation / Kerr effect

Stimulated Raman Scattering

Parametric Amplification

Stimulated Brillouin Scattering

Energy Conservation

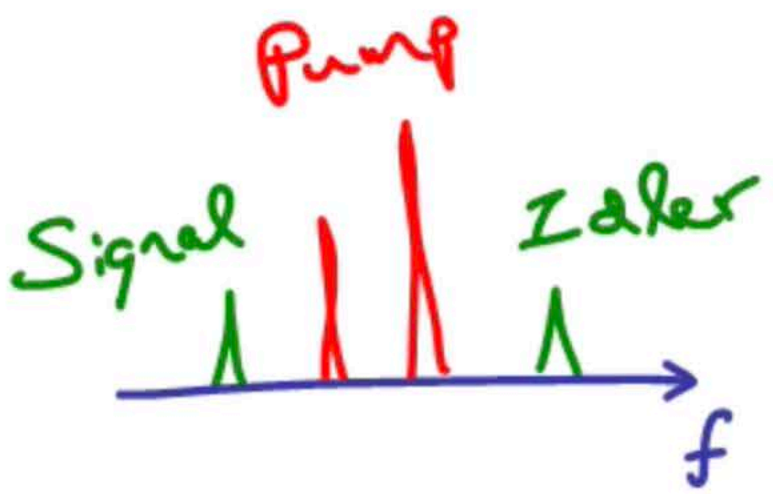
$\omega_1 + \omega_2 = \omega_3 + \omega_4$

Momentum Conservation

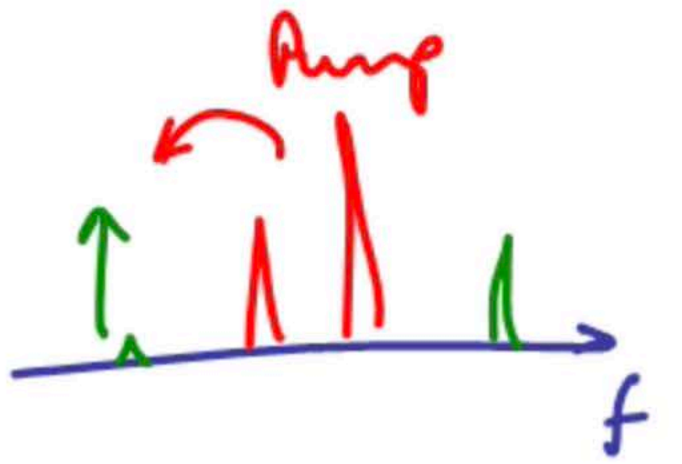
$\vec{K}_1 + \vec{K}_2 = \vec{K}_3 + \vec{K}_4$

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

- ✓ Four-wave mixing
- ✓ Self Phase Modulation / Kerr effect
- ✓ Stimulated Raman Scattering
- ✓ Stimulated Brillouin Scattering

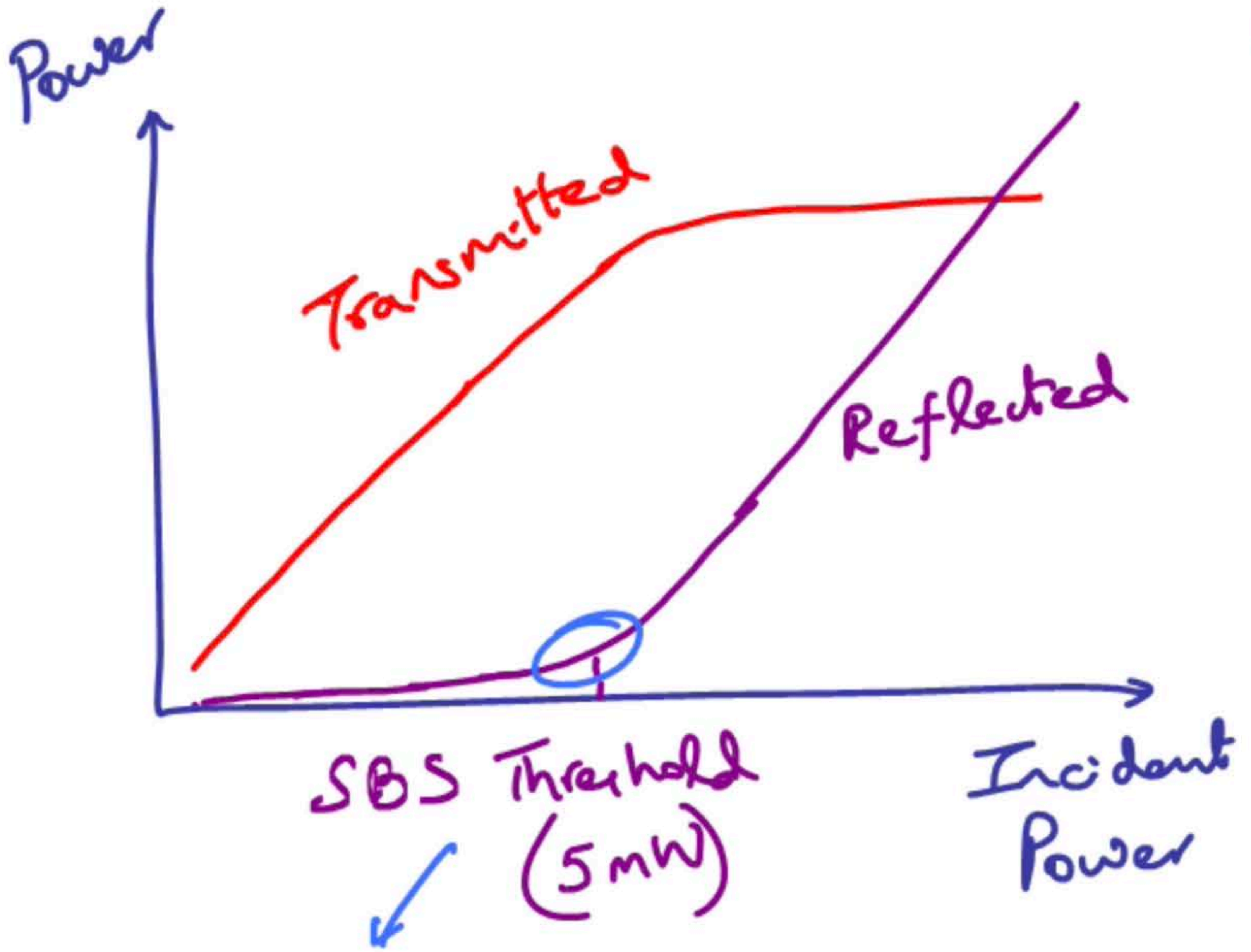


Wavelength Conversion



Parametric Amplification

Stimulated Brillouin Scattering

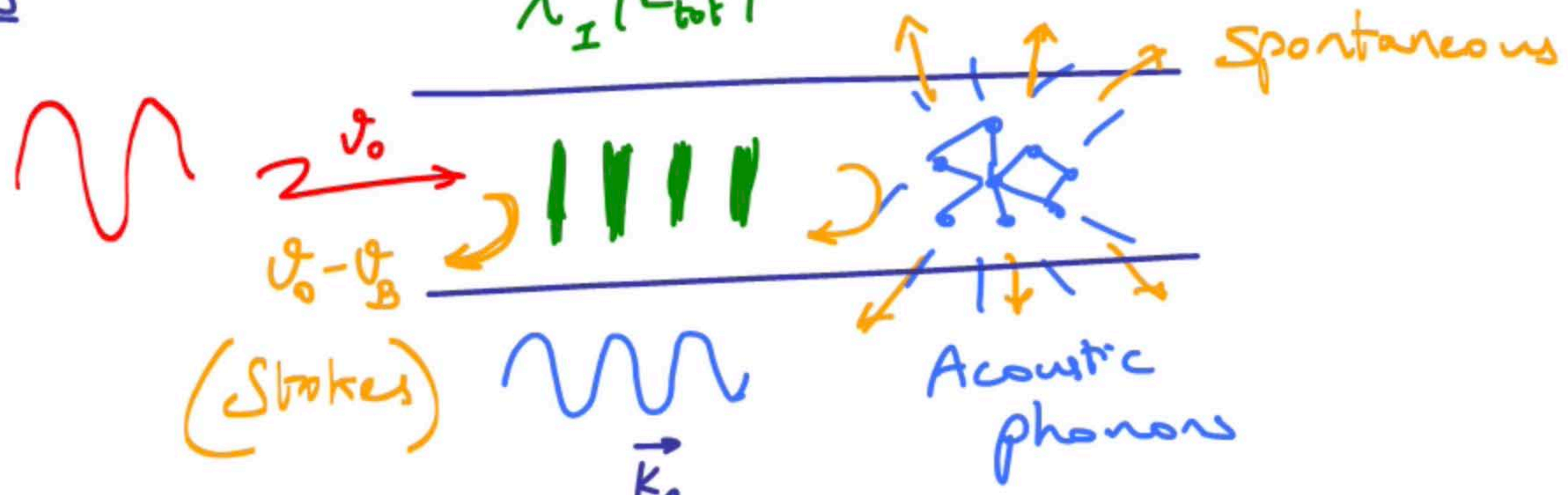


If source is highly coherent

Optical Communications

Optical Sensing

$\chi^{(3)}_I |E_{tot}|^2 \rightarrow$ Electrostriction



$\vec{k}_p$

$\vec{k}_A \quad \vec{k}_s$

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

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

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

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

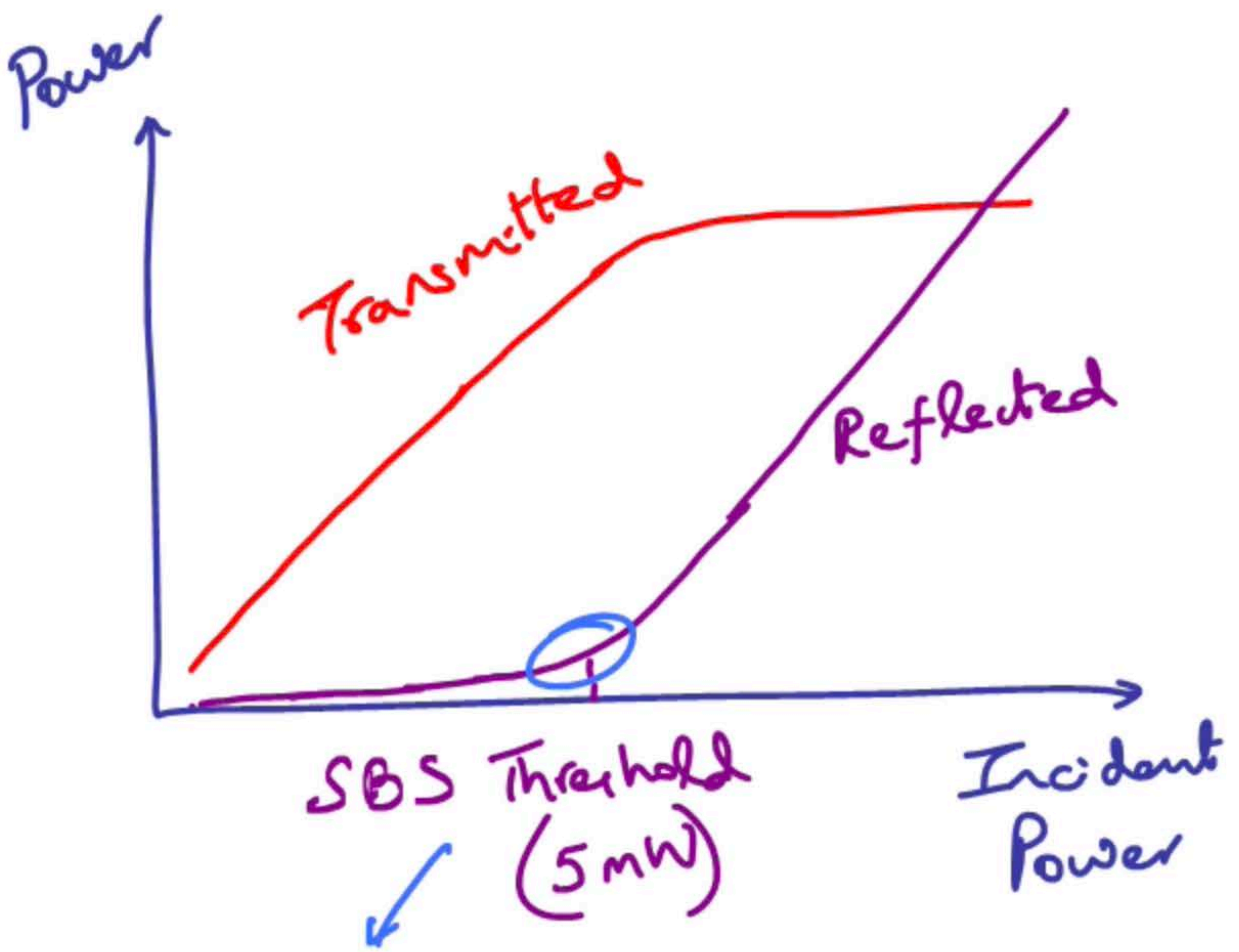
$n_{eff} \simeq 1.5$

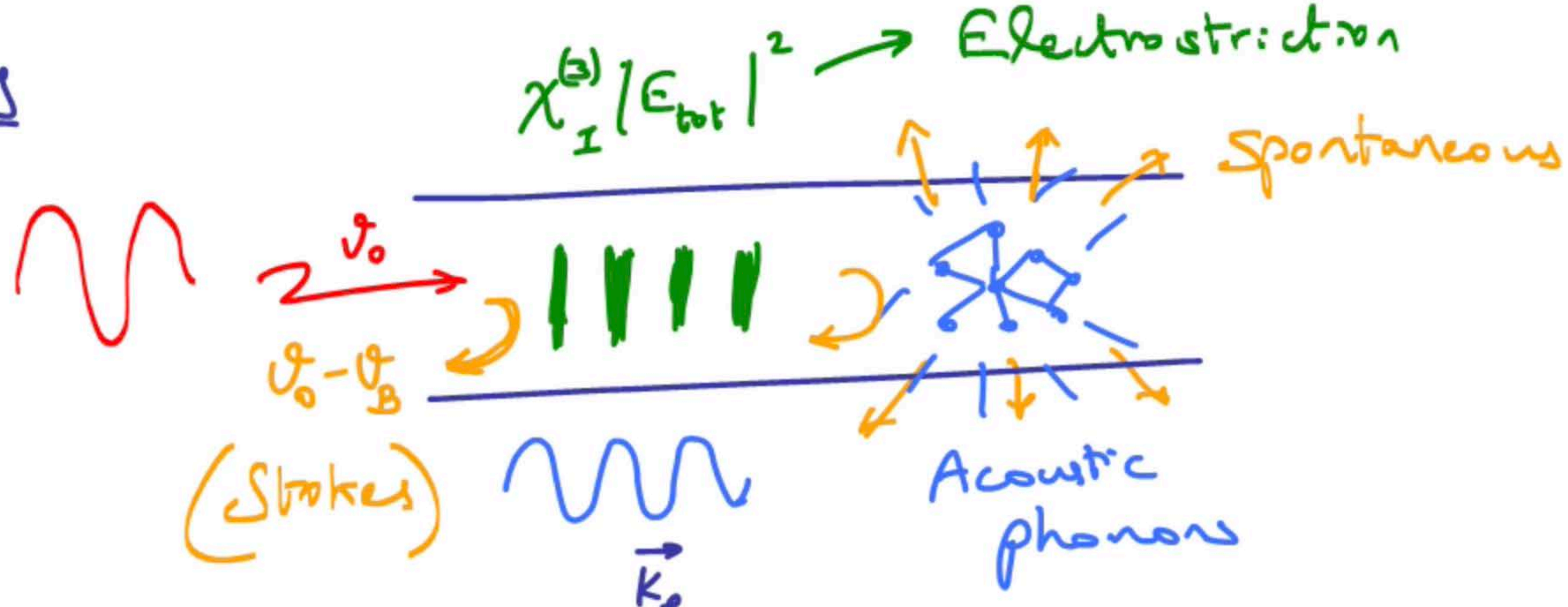
$V_A = 6$ km/s

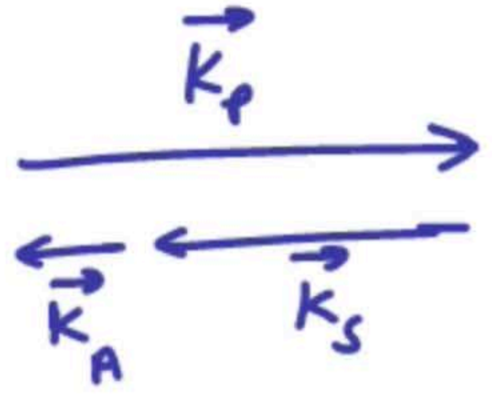
$\lambda_p = 1.5\ \mu m$

$\Rightarrow \nu_B = 12$ GHz

Stimulated Brillouin Scattering







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

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

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

If source is highly coherent

Optical Communications

Optical Sensing

$n_{eff} \simeq 1.5$

$V_A = 6$ km/s

$\lambda_p = 1.5$ μm

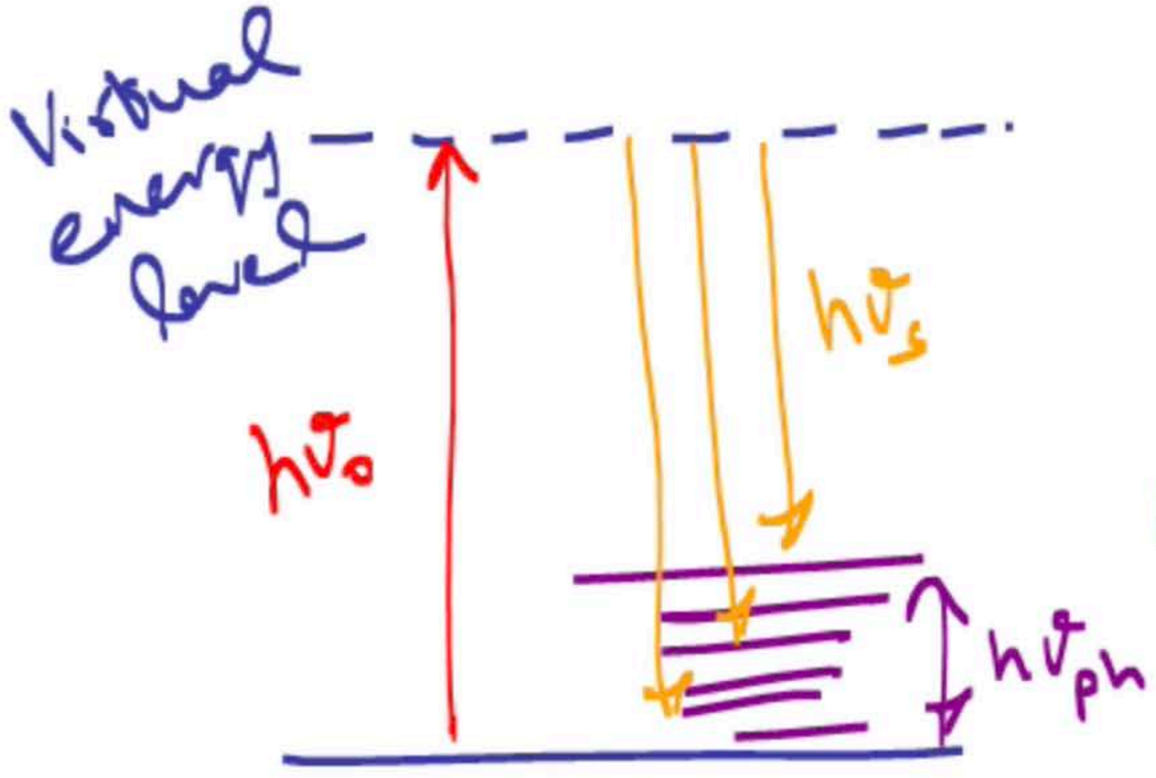
$\Rightarrow \nu_B = 12$ GHz

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

Stimulated Raman Scattering

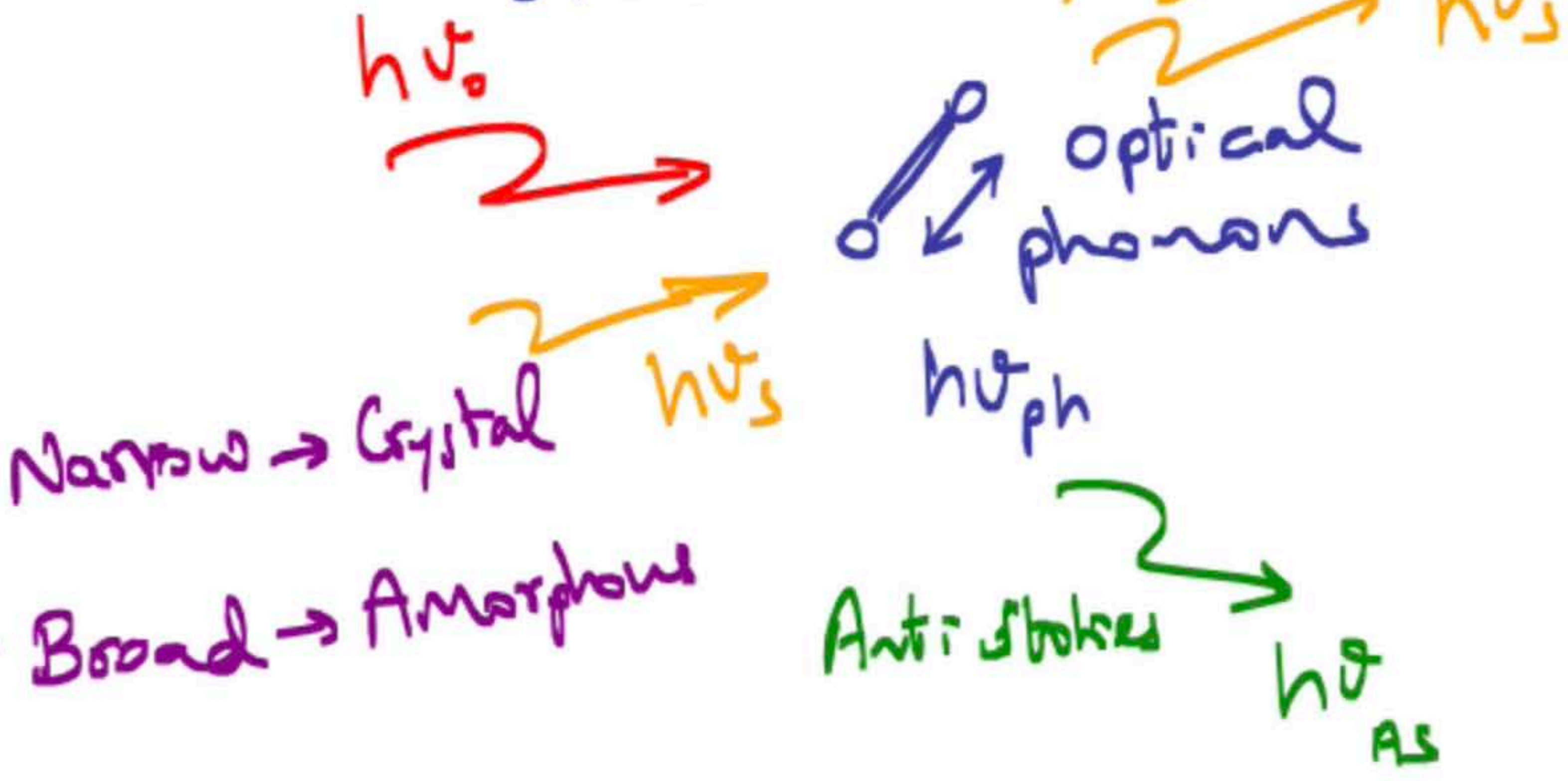
→ Spectroscopy
→ Temperature
→ Communications

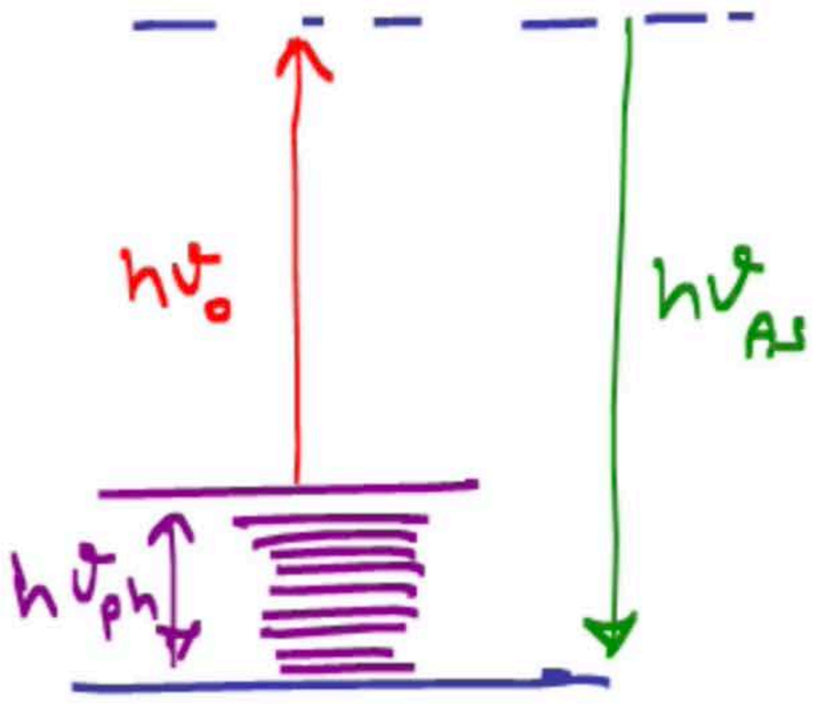
(Amplification)

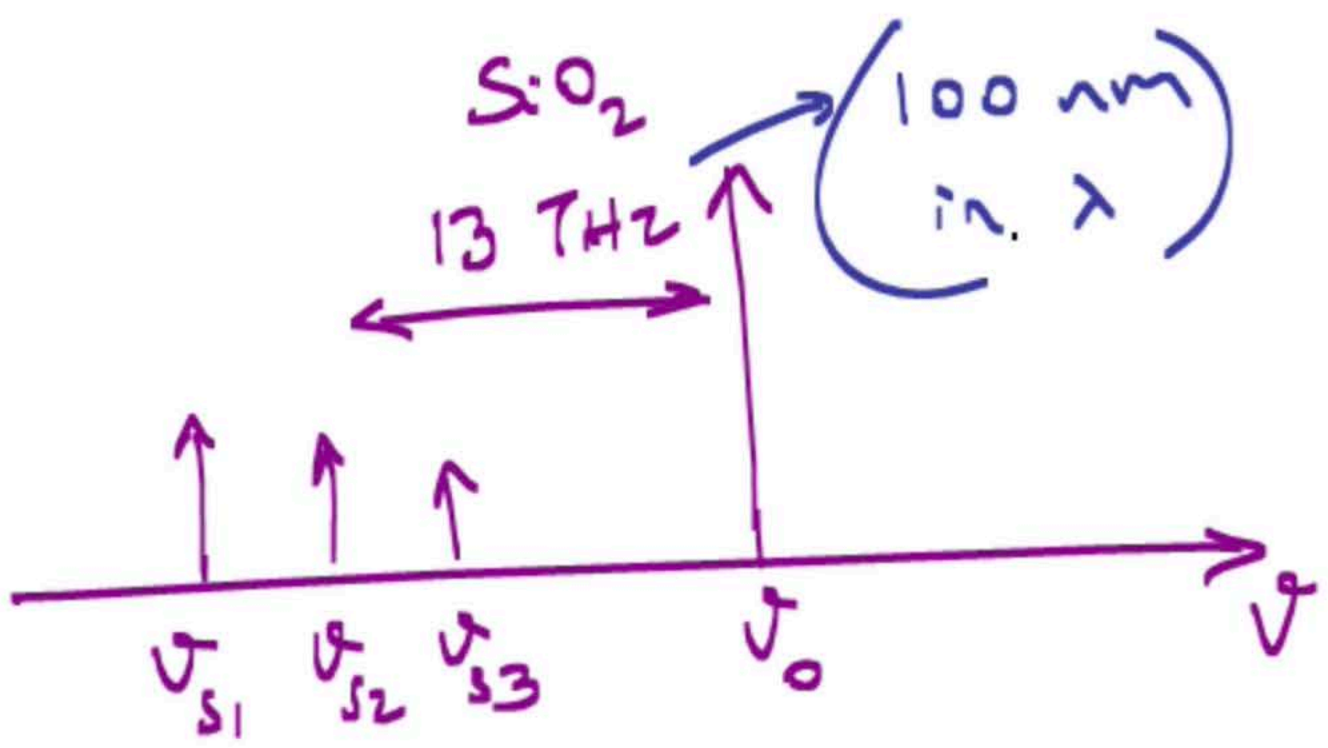


Stokes scattering

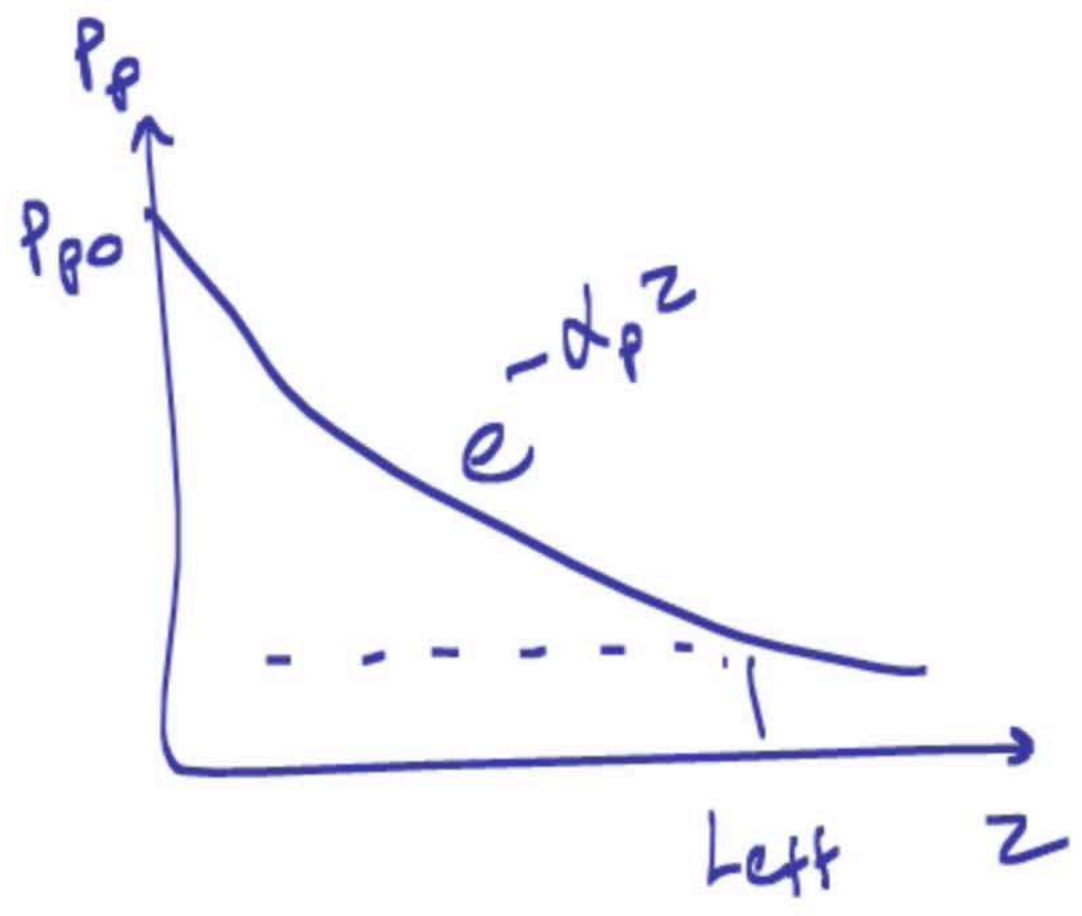
(10^{-7})







$$R = \frac{P_{AS}}{P_s} = \left(\frac{\lambda_s}{\lambda_{AS}}\right)^4 \exp\left(-\frac{h\nu_{ph}}{K_B T}\right)$$



SRS Attenuation

$$\frac{dP_s}{dz} = g_R \frac{P_p}{A_{eff}} \cdot P_s - \alpha_s P_s$$

Amplifier gain $G_R = \exp\left(\frac{g_R}{A_{eff}} P_{p0} \cdot L_{eff}\right)$

To achieve 20 dB gain,

$g_R = 6 \times 10^{-14}$ m/W

$g_B = 6 \times 10^{-11}$ m/W

$L_{eff} = 20$ km

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

$P_{p0} = 0.2$ W