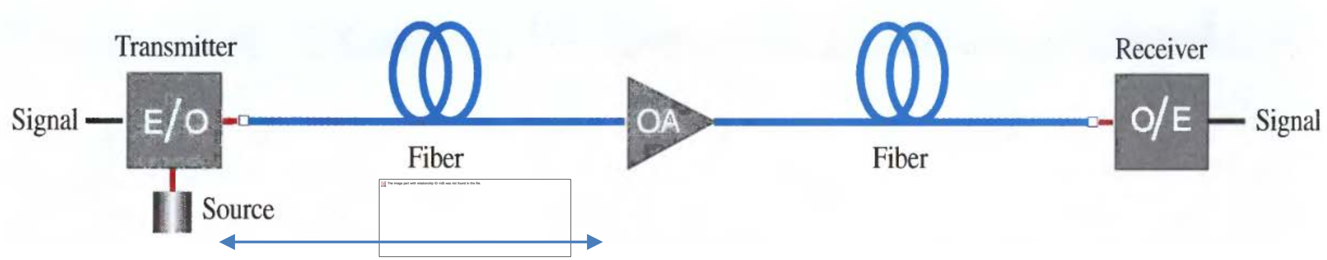
Fiber Optic Communications
Lecture 8

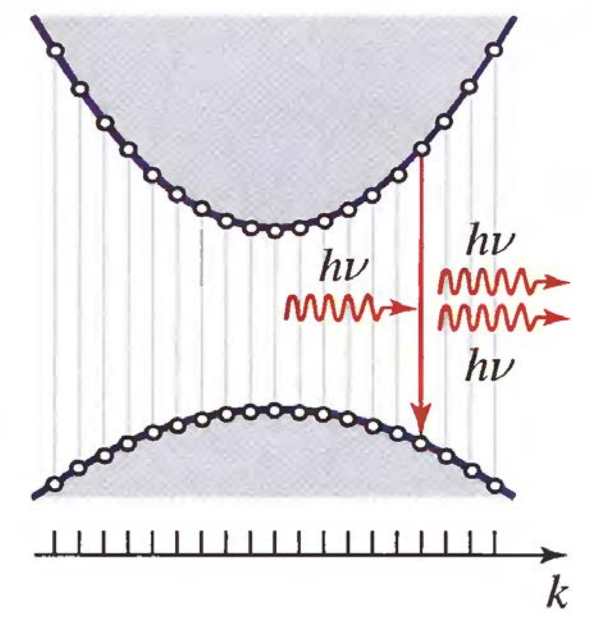
- Optical amplifier principles
- Optical amplifier hardware

Recap: Optical Amplifiers



Stimulated Emission

In lasers, recall that stimulated emission dominates performance



SOA

Optical Amplifiers

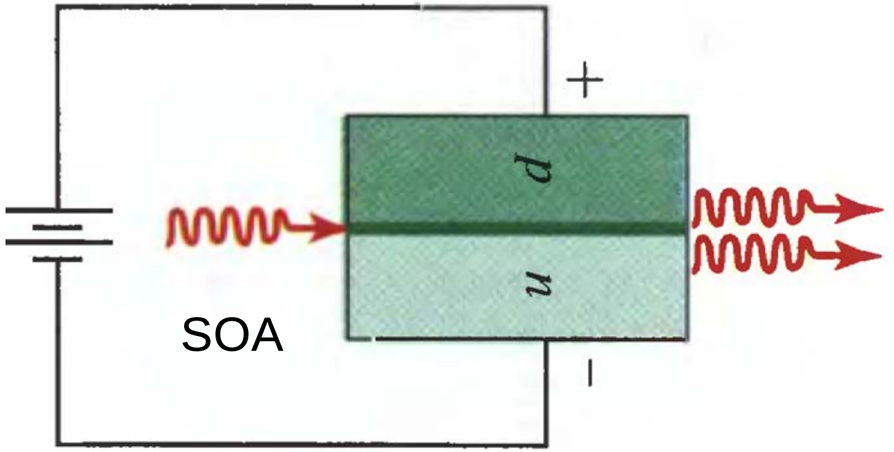
Also operate using stimulated emission, and see a reverse Beer's law:

$$\frac{dP}{dz} = gP$$

This yields

$$P(z) = P_{in}\, e^{gL}$$

Difference from lasers: <u>lack of feedback</u>



Gain Saturation

Also operate using stimulated emission, and see a reverse Beer's law:

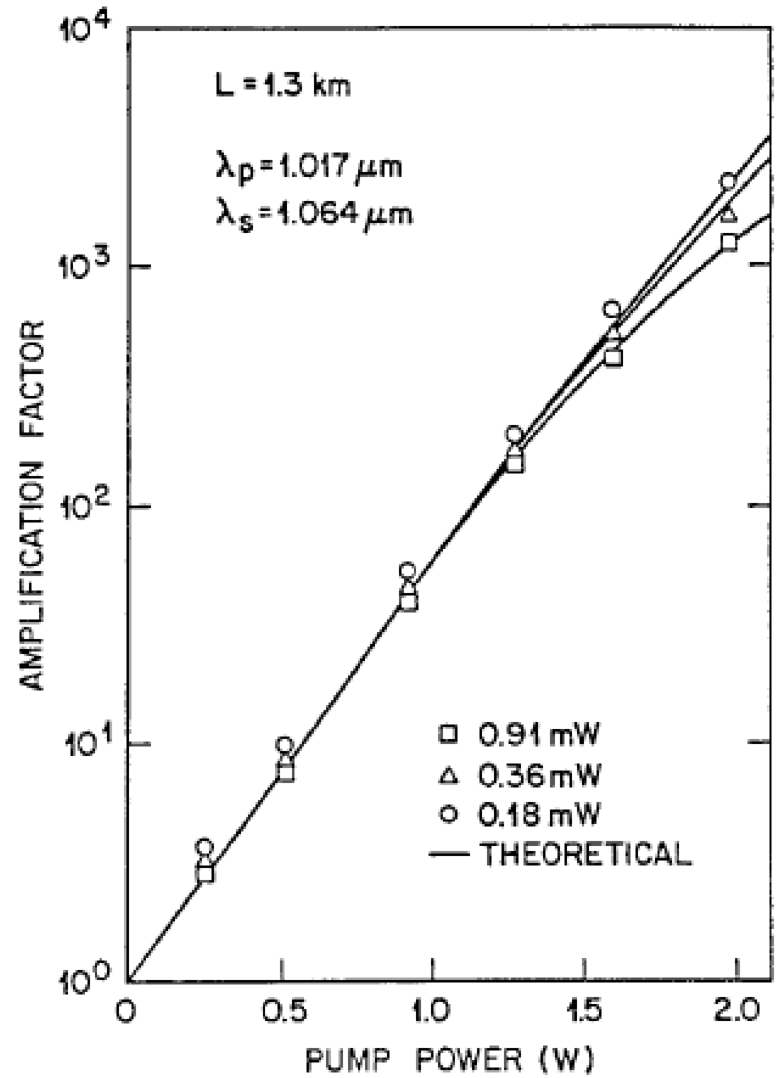
$$\frac{dP}{dz} = \frac{g_o P}{1 + P/P_s}$$

This yields

$$P(z) = P_{in}\, e^{gL}$$

Gain Saturation

- Experimental data shows that saturation can kick in at 1 W (or less)
- The curve follows theoretical equation closely



Amplifier Noise

Noise increases with gain and amplification, according to:

$$S(\nu) = (G - 1)\frac{N_2}{N}\, h\nu$$

SNR given by:

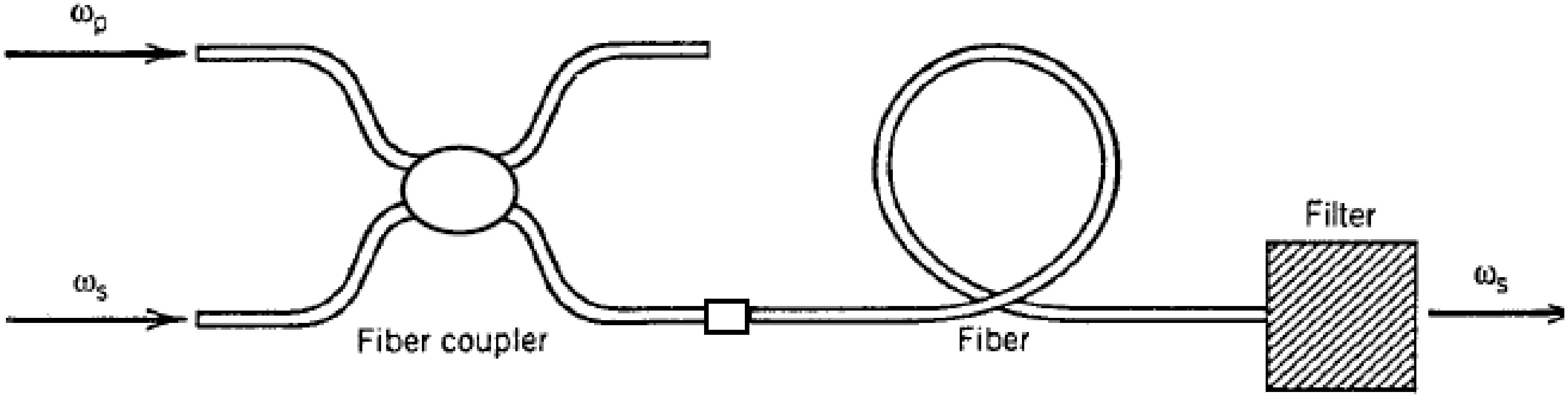
$$SNR = \frac{GP_{in}}{4S_{sp}\Delta f}$$

Thus, SNR is degraded by 3 dB, even for an ideal amplifier with full inversion

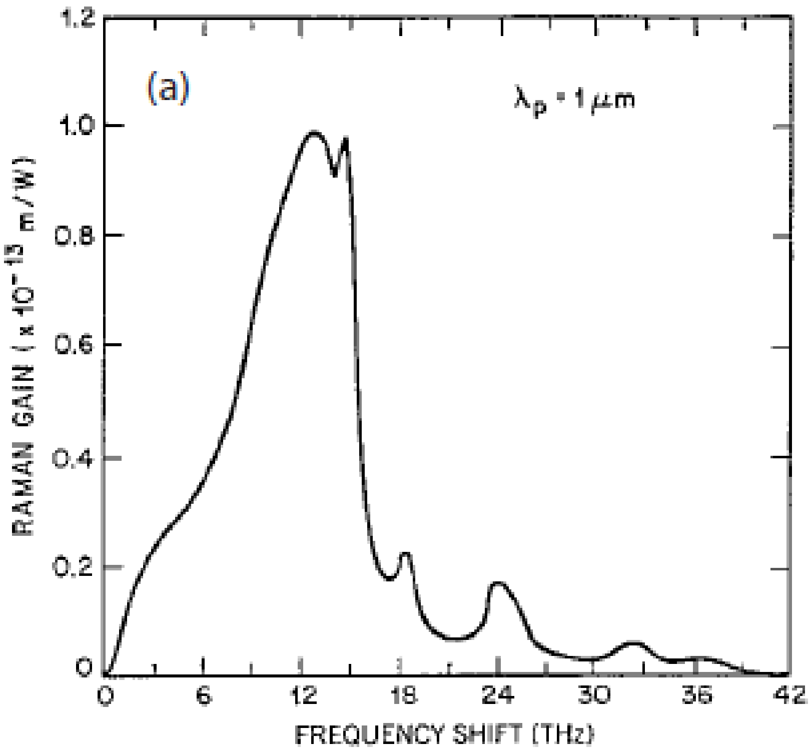
Fiber Optic Communications
Lecture 8

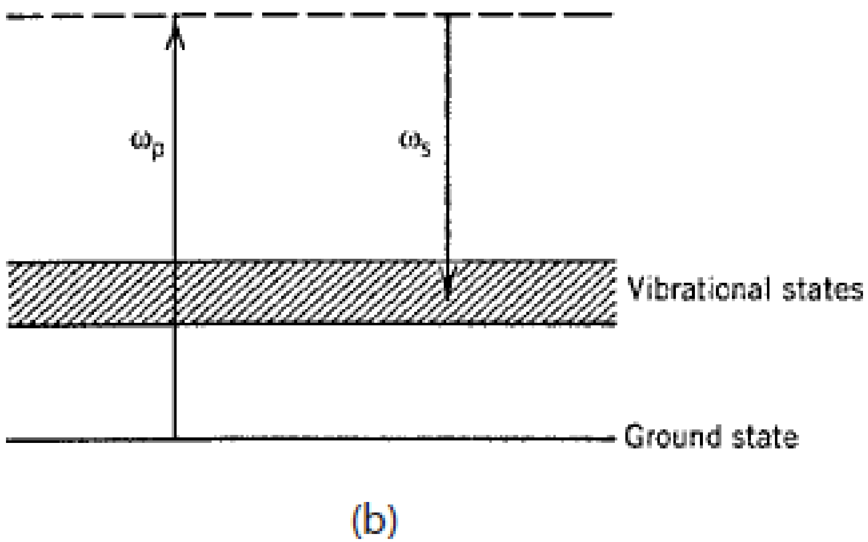
- Optical amplifier principles
- Optical amplifier hardware

Raman Amplifiers

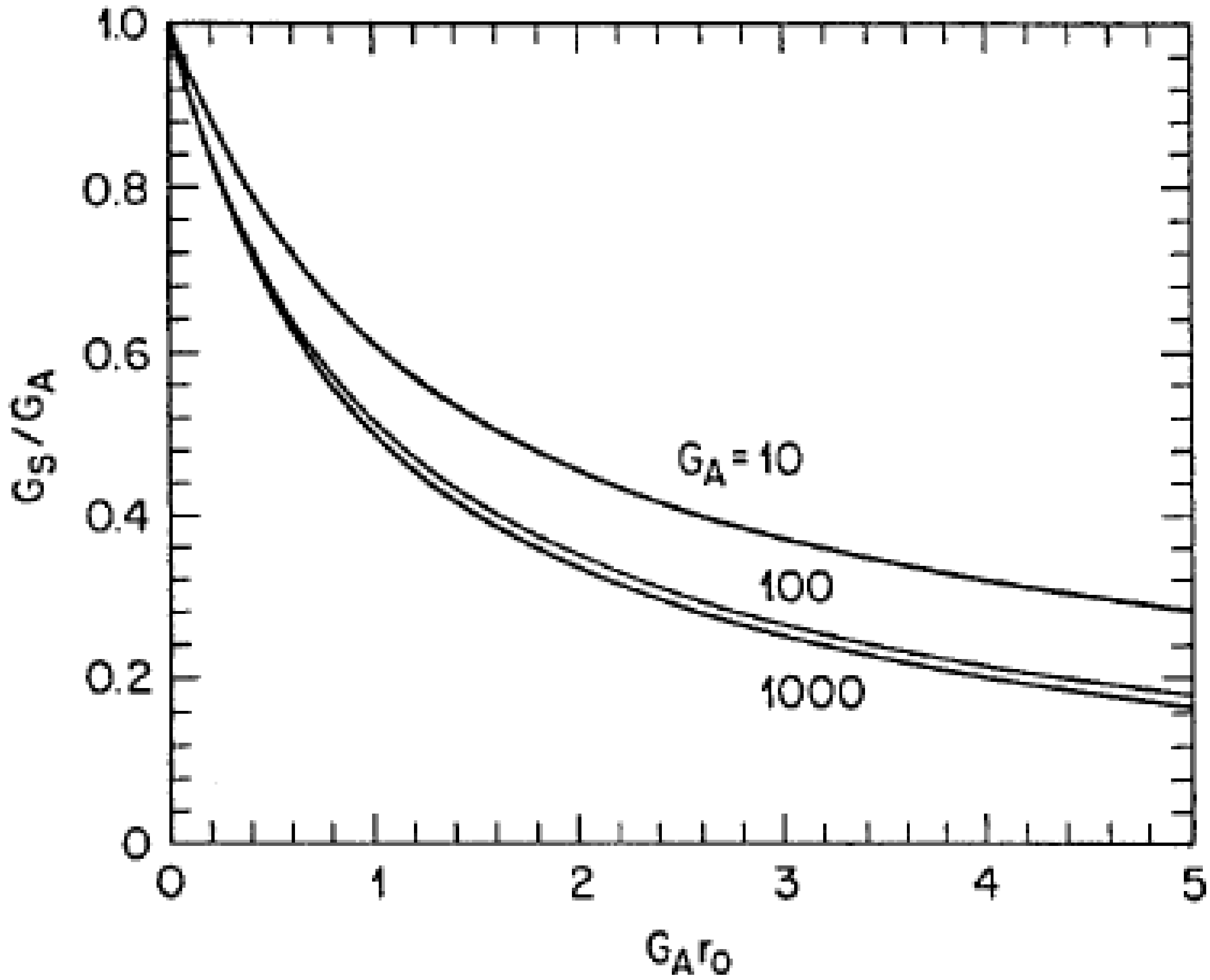


Raman Amplifiers

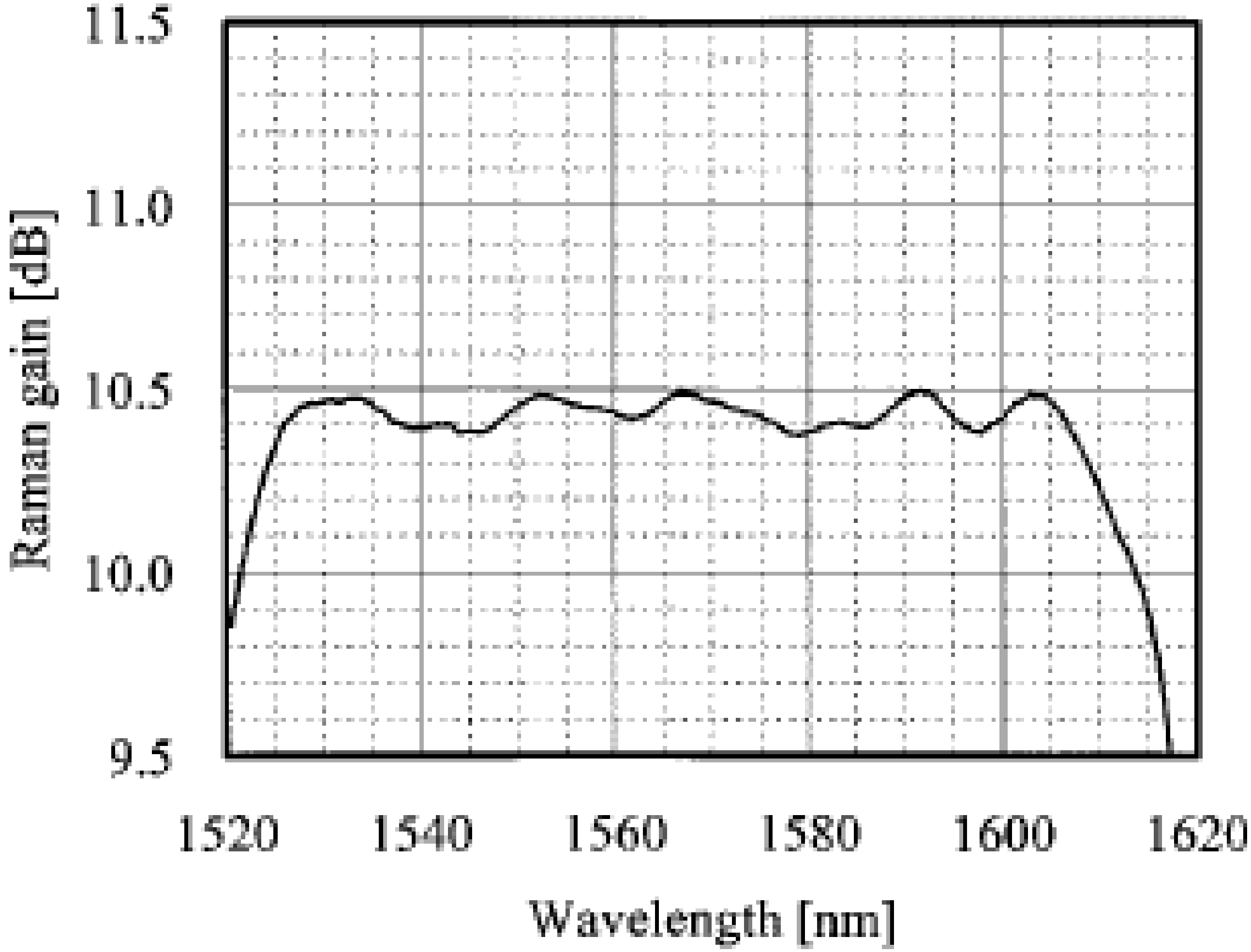




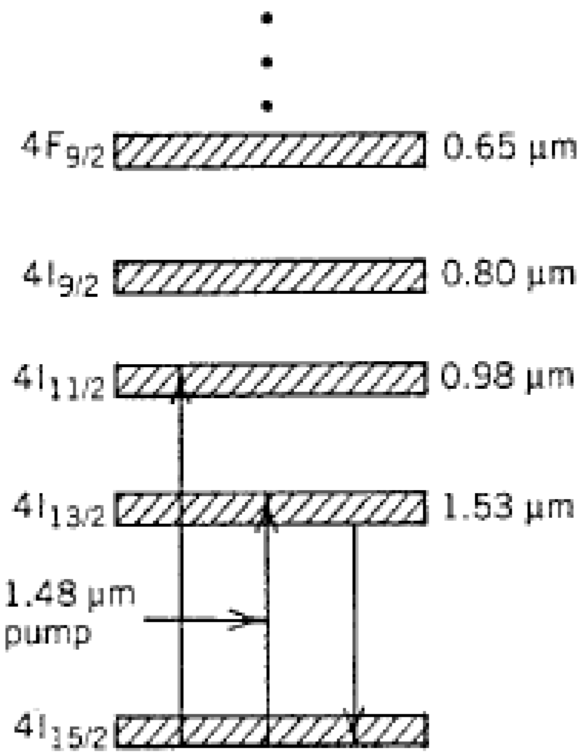
Raman Amplifiers: Saturation

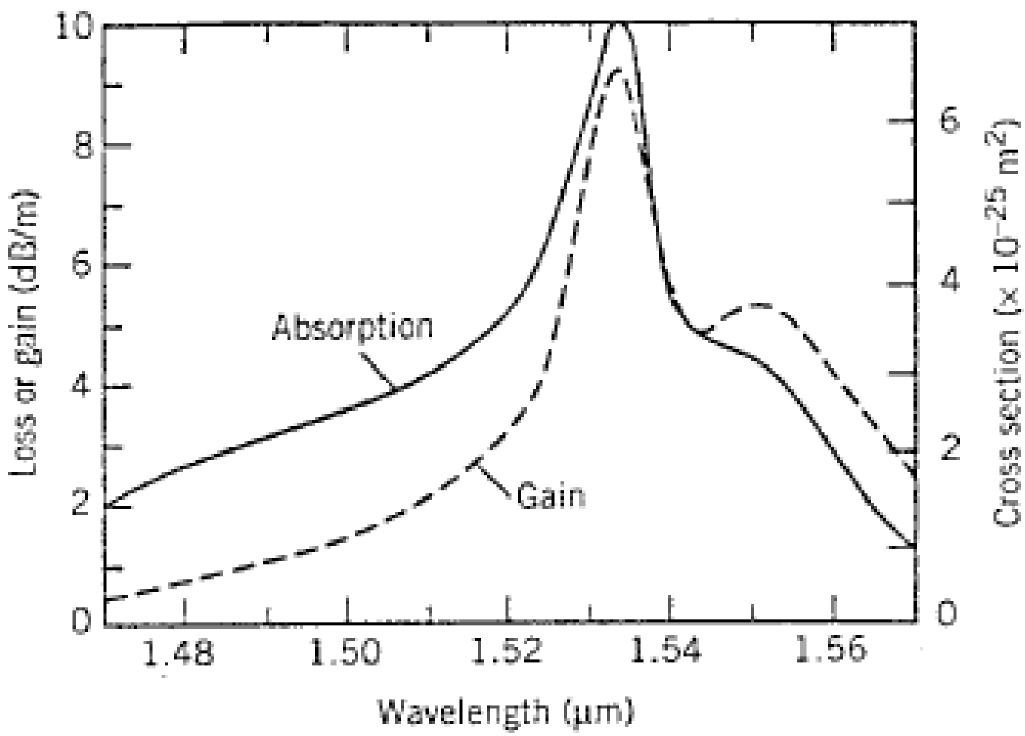


Raman Amplifiers: Gain Spectrum

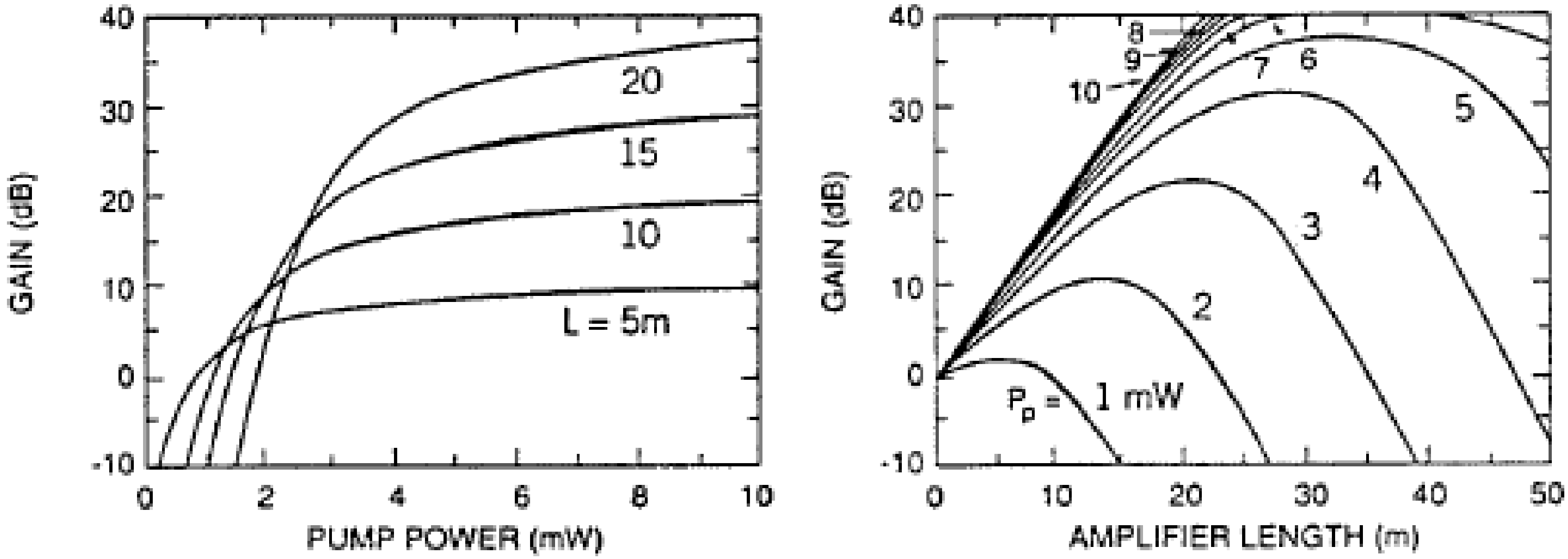


Erbium-Doped Fiber Amplifiers

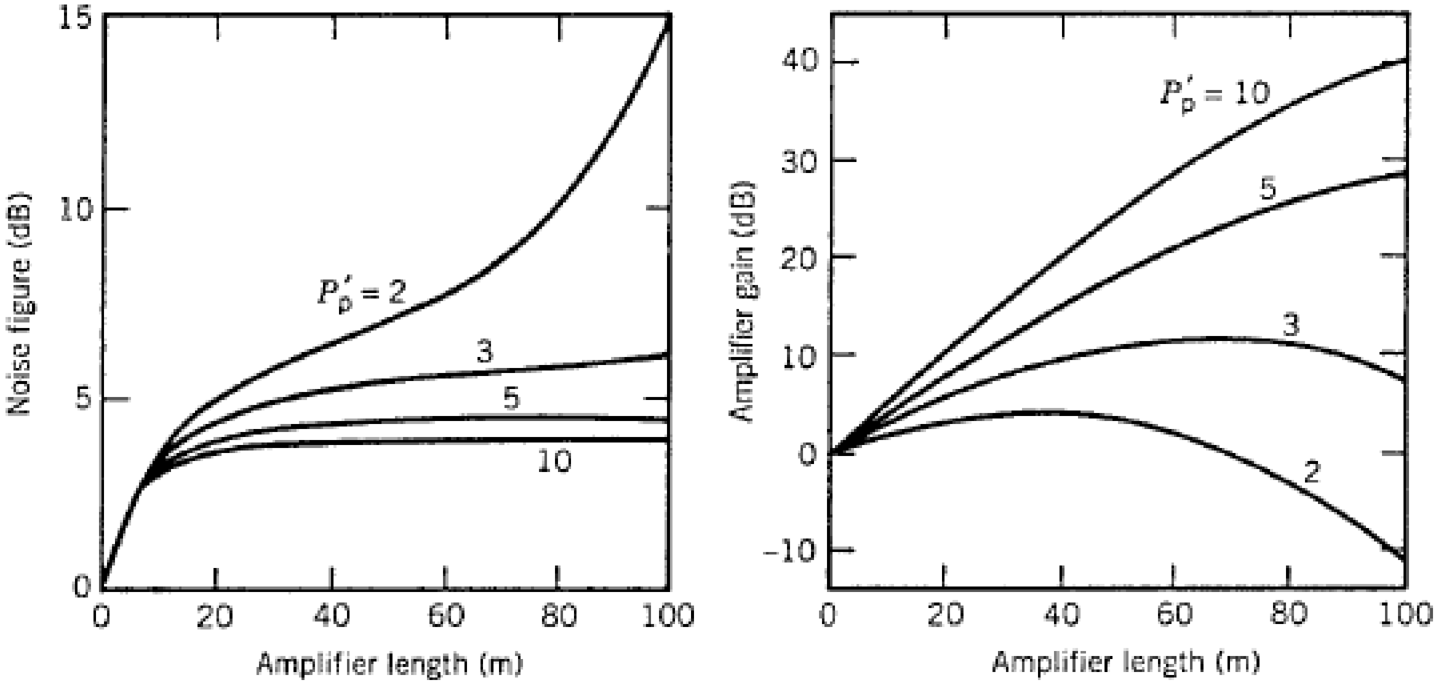




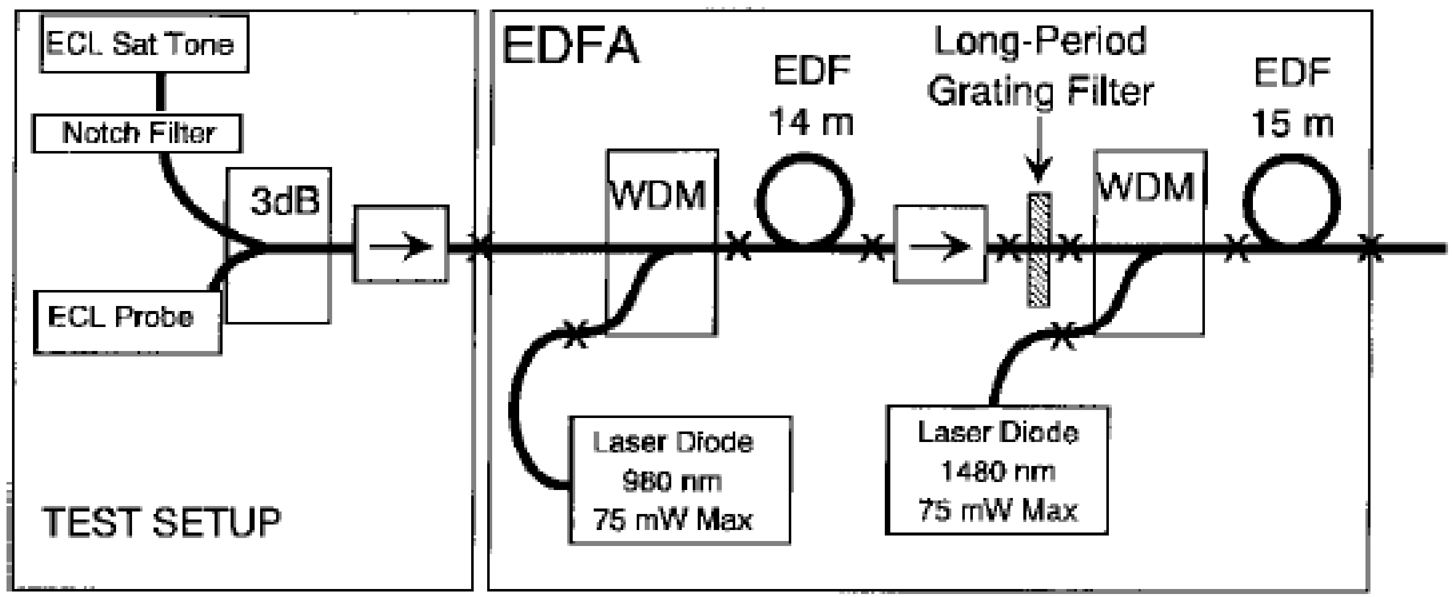
Erbium-Doped Fiber Amplifiers



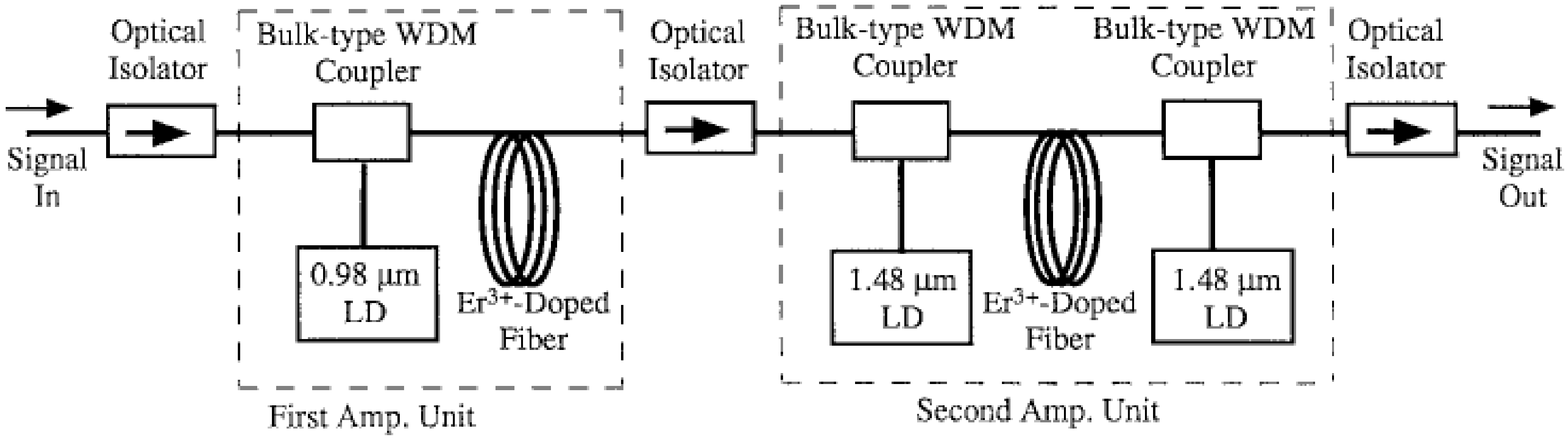
Erbium-Doped Fiber Amplifiers



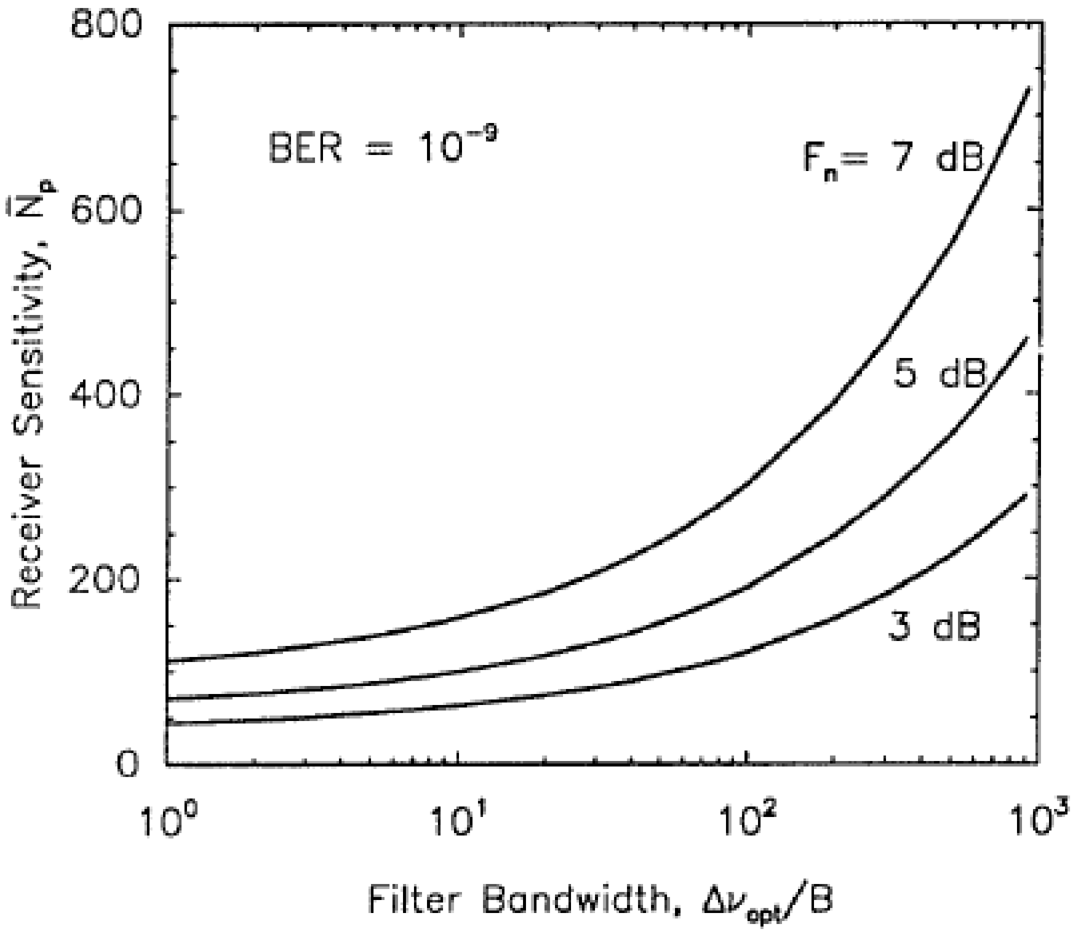
Erbium-Doped Fiber Amplifier



Erbium-Doped Fiber Amplifier



Receiver Sensitivity



Accumulated Dispersion & Nonlinearity

- Must solve NL Schrodinger equation:

$$\frac{\partial A}{\partial z} + \frac{i\beta_2}{2}\frac{\partial^2 A}{\partial t^2} = i\gamma|A|^2 A - \frac{\alpha}{2}A$$

- Noise added according to:

$$A_{\mathrm{out}}(t) = \sqrt{G}A_{\mathrm{in}}(t) + a_n(t)$$