Amplifier gain:

small-signal gain:

$$I_{out} = I_{in} e^{gl}$$

$$g = \frac{2\pi^2}{3\pi\varepsilon_0 c\hbar} (N_2 - N_1)|\mu|^2 g(\nu - \nu_0)$$

in terms of lifetime:

$$g = \sigma (N_2 - N_1)$$

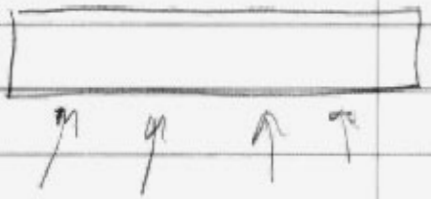
$$\sigma = \frac{\lambda_0^2}{8\pi n^2} \frac{g(\nu-\nu_0)}{\tau_{sp}}$$

use peak $\sigma = \sigma_0$

$$\Gamma_s = \frac{h\nu}{\sigma_0}$$

so $$gl = \frac{h\nu(N_2 - N_1)l}{\Gamma_s} = \frac{\Gamma_{stored}}{\Gamma_s}$$

Γ_{stor} = stored energy fluence



$$= \frac{\text{absorbed energy}}{\text{area}}$$

available energy:

$$\Gamma_{stor} \cdot \pi r_{beam}^2$$

ASE : amplified spontaneous emission.

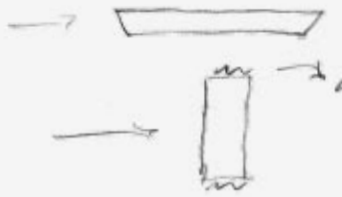
fluorescence emitted → 4π sr (spont. emission)
- then amplified on the way out

$G_0 = 10$: 1 spont. photon → 10 out.

single-pass amp:

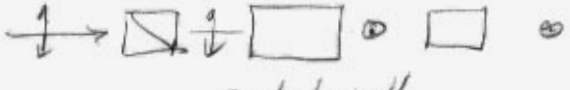
ASE limits max gain in one stage
- effective storage time is reduced.
- limits gain seen by pulse.

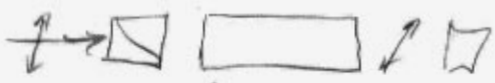
methods:
- short-pulse pumping
- eliminate sources of parasitic lasing.



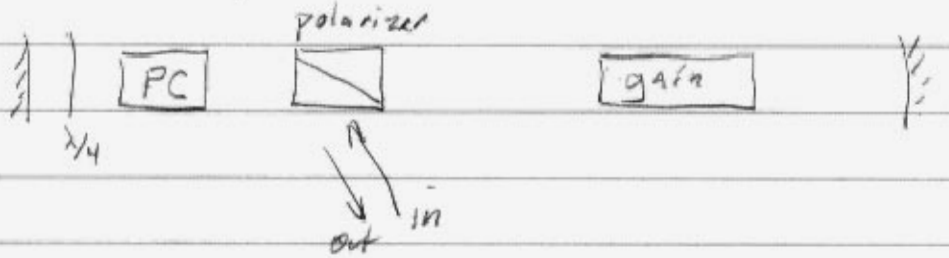
multistage:
- separate stages:

-





Regenerative amplifier:



sequence:

1) seed pulse in
2) seed passes PC, turn on PC to λ/4
3) seed trapped in amp. N_{passes}
4) energy depleted, switch out. PC to 0

Gain model: assume no saturation w/in pulse.

1st pass $\quad \Gamma_1 = \Gamma_0 \exp\left[\Gamma_{st}^{(0)} / \Gamma_s\right]$

$\Gamma_{st}^{(1)} = \Gamma_{st}^{(0)} - \Gamma_1$ remove extracted energy, ∴ less gain

2nd $\quad \Gamma_2 = \Gamma_1 \exp\left[\Gamma_{st}^{(1)} / \Gamma_s\right]$

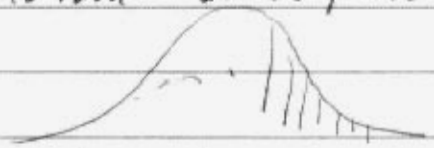
$\Gamma_{st}^{(2)} = \Gamma_{st}^{(1)} - \Gamma_2$

etc.

small signal: $G_{tot} = e^{N g_0 l}$ $\quad N$ = no. passes.

Saturation w/in pulse:

Same idea: divide pulse into time slices



pulse thru slice-by-slice.

leading edge sees more gain

for high gain, high saturation → pulse distortion.