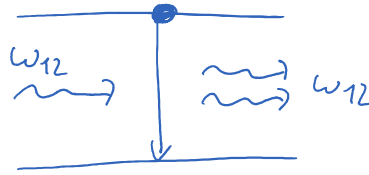


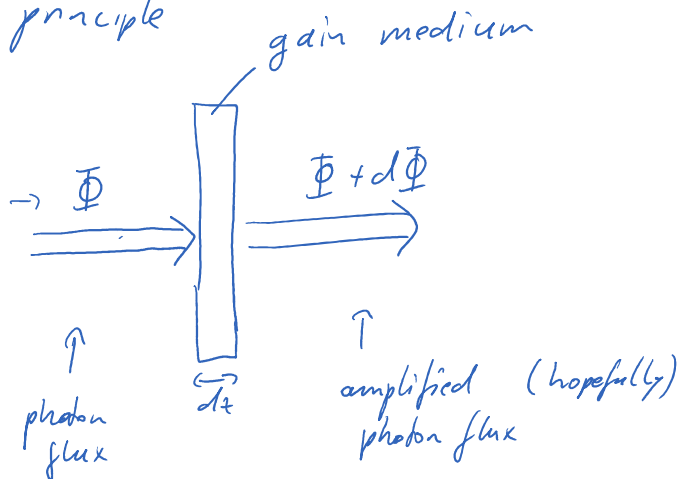
L A S E R

Donnerstag, 2. Dezember 2021 12:55

Light
Amplification by
Stimulated
Emission of
Radiation



Laser principle



$$d\Phi = G_{21} \Phi (N_2 - N_1) dz$$

difference between stimulated emission (gain)
and absorption (loss)

amplification: $d\Phi > 0$

$$\hookrightarrow \underline{N_2 > N_1}$$

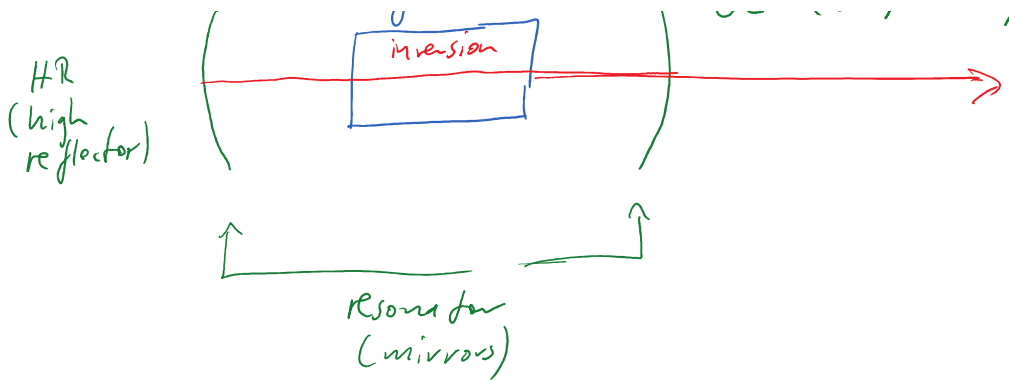


lasing (usually) needs inversion

$\hookrightarrow$ amplification

Laser (usually) needs feedback





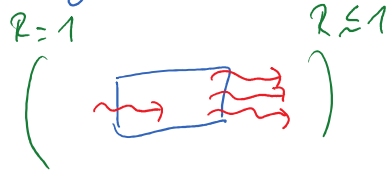
Lasing:

$t=0$: inversion ($N_2 > N_1$)

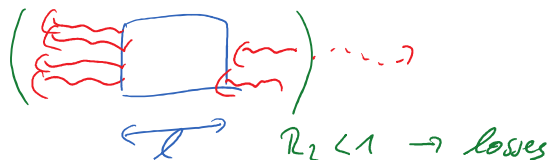
but $g(\omega_2) = 0 \Rightarrow$ only A_{21} spont. emission happens



$t > 0$ $g(\omega_2) > 0$



gain by stimulated emission

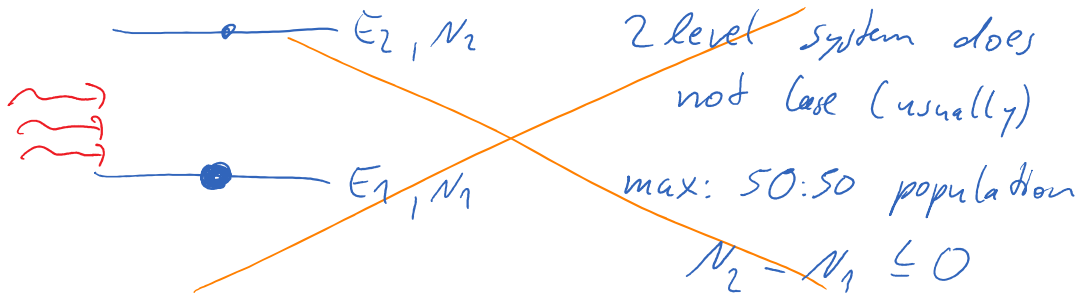


laser threshold :

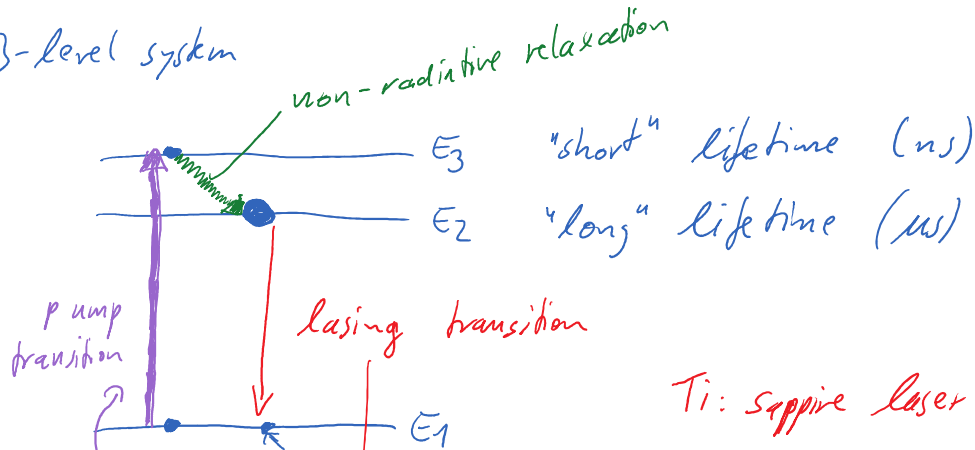
$$R_1 R_2 \cdot \exp[2 \sigma_{21} (N_2 - N_1) L] = 1$$

$> 1 \rightarrow \text{lasing}$

inversion



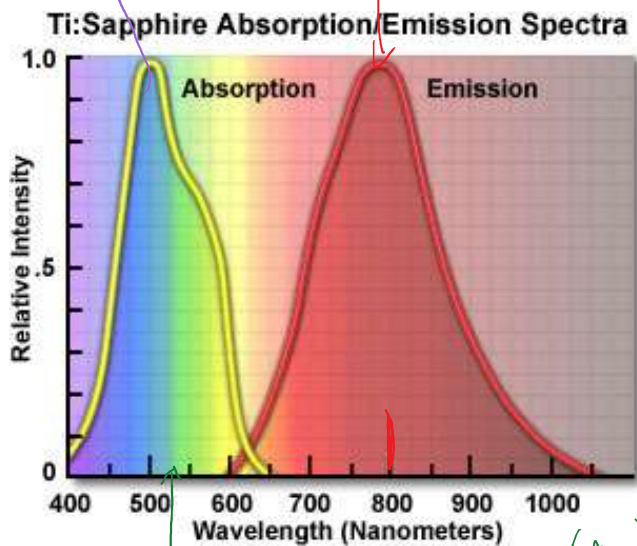
3-level system



Ti: sapphire laser

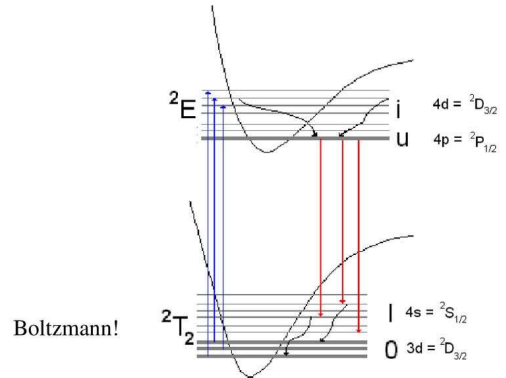
Ti^{3+} ions inside

Al_2O_3 (sapphire) matrix

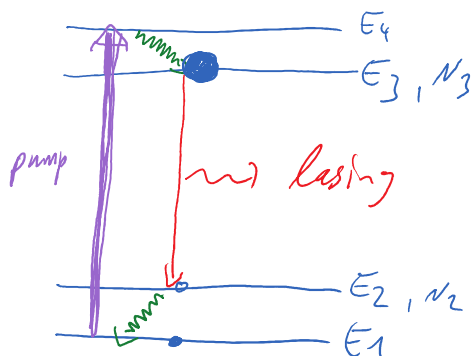


532nm pump light (1064)

Energy level scheme



4-level system:



inversion: $N_3 - N_2$

$N_2 \approx 0$

$$E = \frac{hc}{\lambda}$$

ϵ_1

Nd:YAG : 1064 nm

$$E = \frac{hc}{\lambda}$$

$E \text{ cm}^{-1} = \text{"wave numbers"}$

Nd³⁺ ions

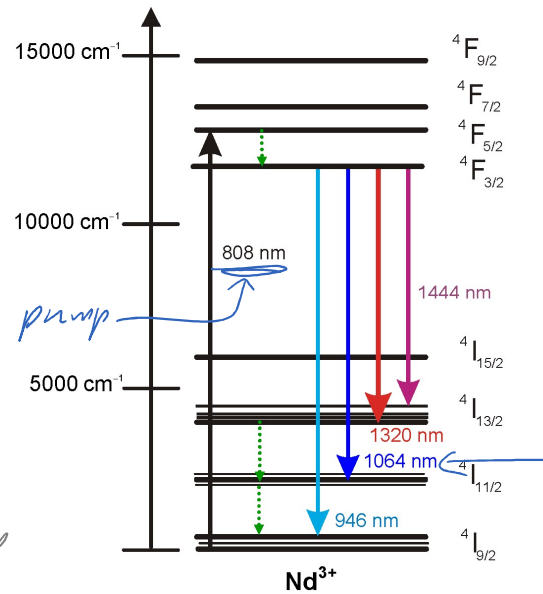
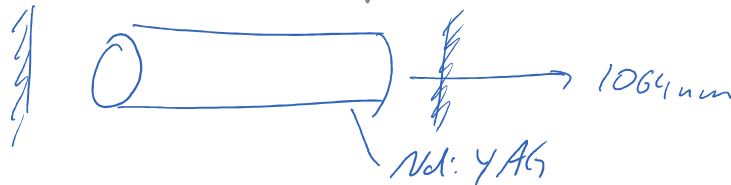
in

Yttrium

Al

Garnet

e.g. flash lamp



Non linear optics

IR
↓

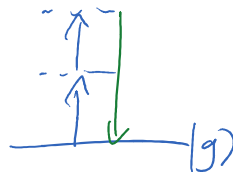
vis
↓

2 photons @ 1064 nm → 1 green photon @ 532 nm



Second harmonic
generation
(SHG)

frequency doubling



Diode Lasers

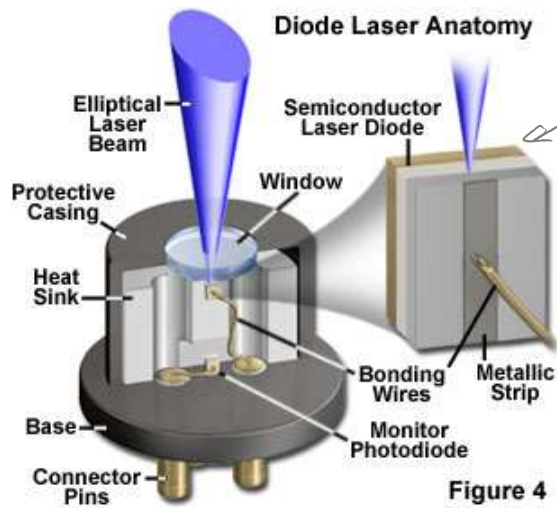


Figure 4

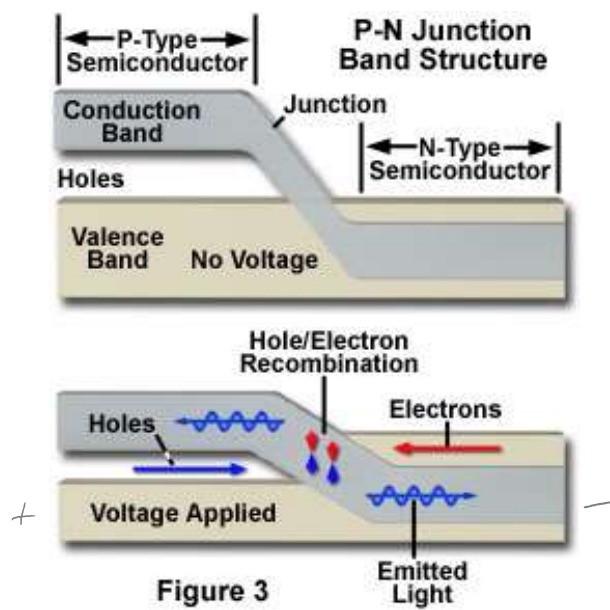
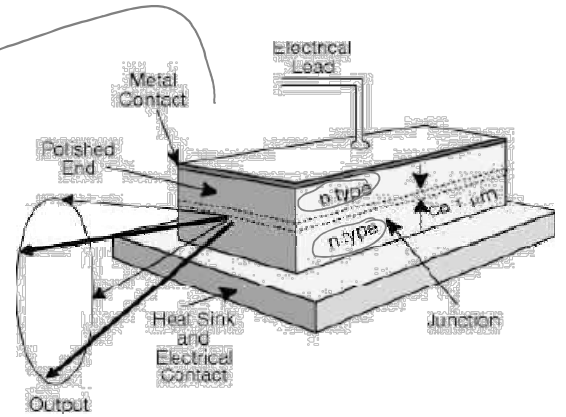
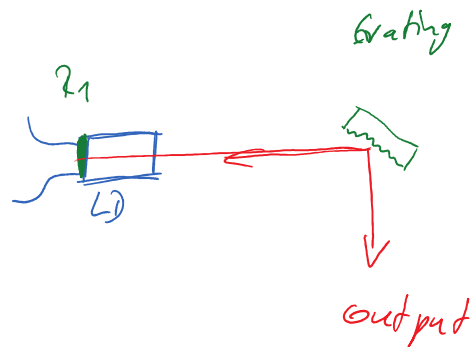


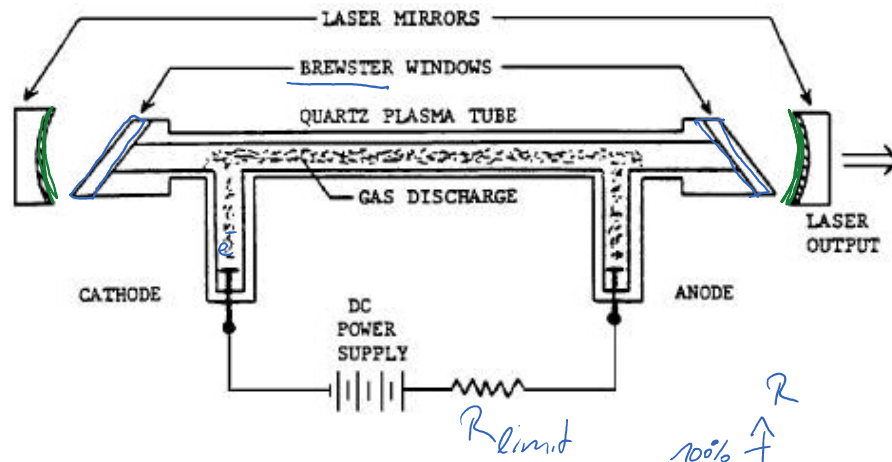
Figure 3

ECDL

Extended
Cavity
Diode
Laser



He Ne - Laser



He Ne

