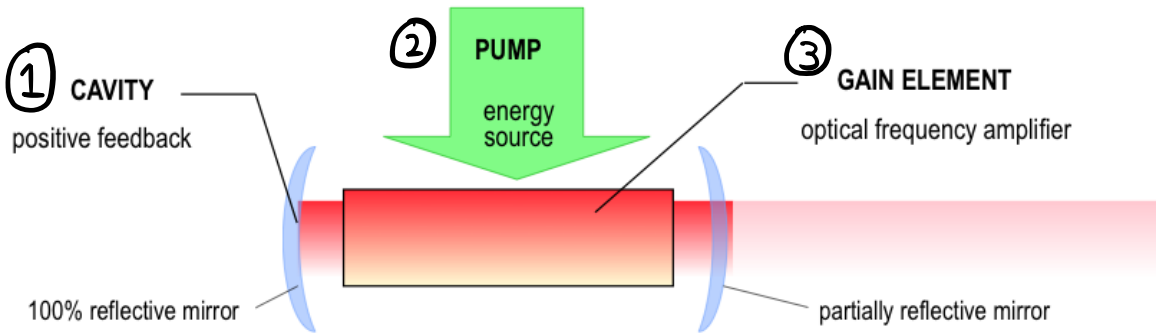
LASER

- Light Amplification by Stimulated Emission of Radiation
- It's an Oscillator

Core Design

- Lasers are constructed using three essential elements:



- Laser is "monochromatic" (one colour). ie: No spectrum of light

VCSEL:

- Vertical Cavity Laser

Electrons → Have mass, Repel (Fermion)

Photons → No mass, Pass through each other (Bosons)

- Both have Wave properties. Electron Wavelength is very small
- Both have momentum

Photon

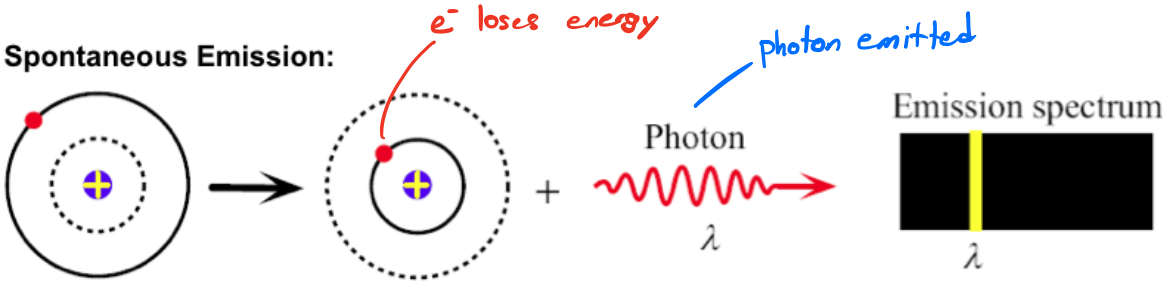
$E = hv$, $v = \frac{c}{\lambda}$

Electron

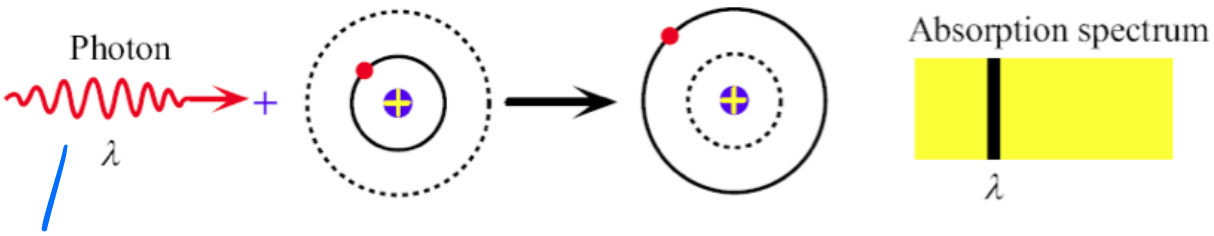
$E = mc^2$

Electron Transitions

Spontaneous Emission:



Stimulated Absorption:

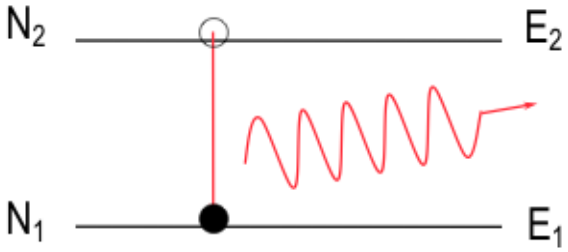


Shine a light on an electron

Spontaneous Emission

N_2 = population density of energy level 2.

(i.e. # of electrons per cm^3)

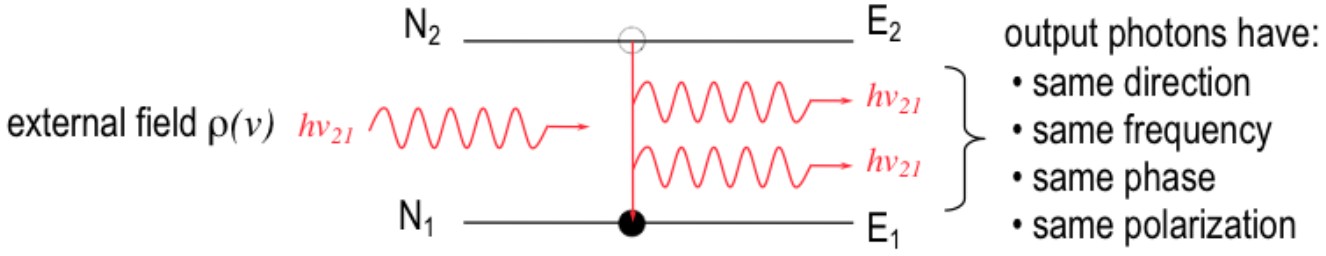


$$\nu_{photon} = \frac{E_2 - E_1}{h} = \frac{c}{\lambda_{photon}}$$

($h = 6.626 \times 10^{-34}$ J.s)

- Some probability that e⁻'s in the excited state will launch a photon and return to the ground state
- Eventually, all emissions occur

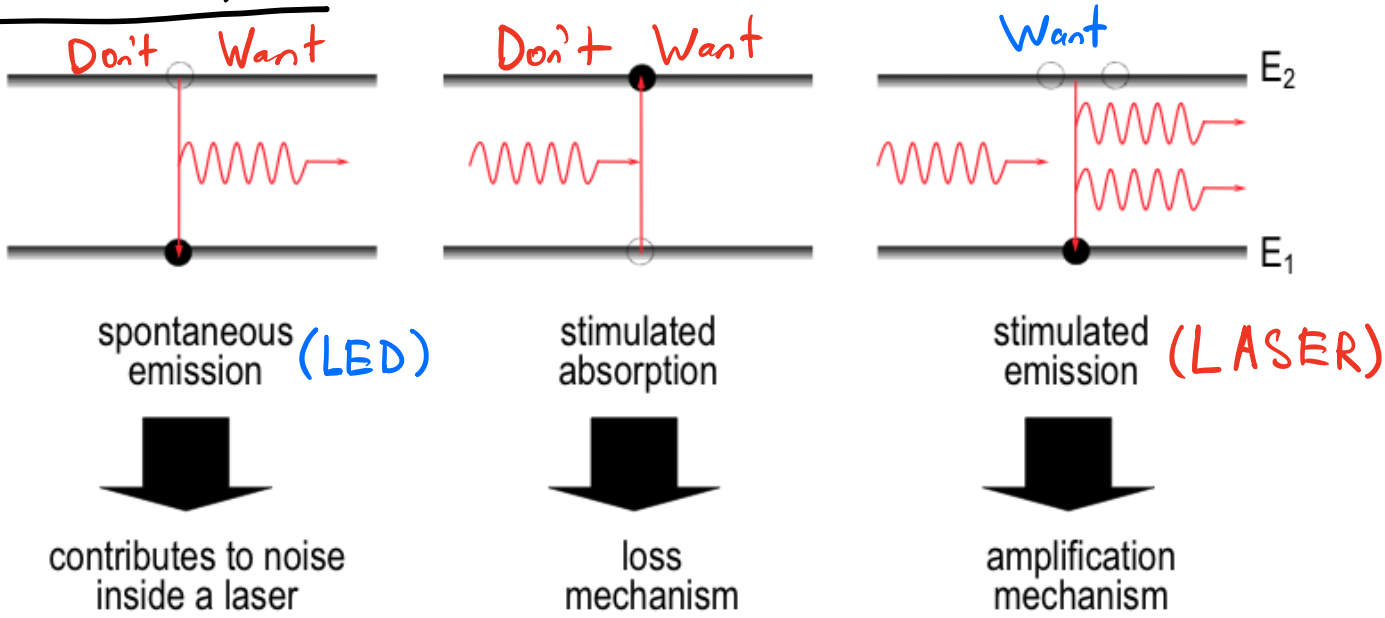
Stimulated Emission



- $\rho(\nu)$ = energy density of the applied radiation field at frequency ν. (energy per unit volume per unit frequency interval: $J.m^{-3}.Hz^{-1}$).

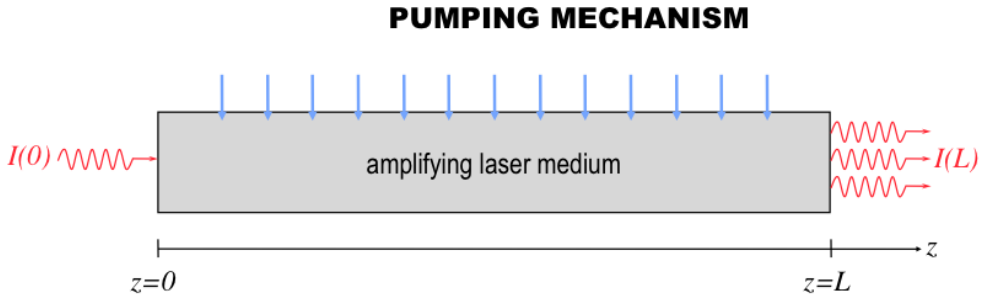
- You hit an electon in the excited state with a photon, it emitts a photon with the same Characteristics as the one you hit it with (Phase, direction, ...)
- It and the original photon continue travelling in the same direction
- e^- returns to the ground state

Summary



- All three processes occur simultaneously inside a laser.
- What about LEDs? Detectors? Optical Amplifiers?

Optical Amplification



Condition for Lazing:

Gain = Loss

- condition for self-sustaining oscillator

① if Gain < Loss → Nothing

② if Gain > Loss → Blows up

③ if Gain = Loss → Lazing

Change this gap to change laser colour