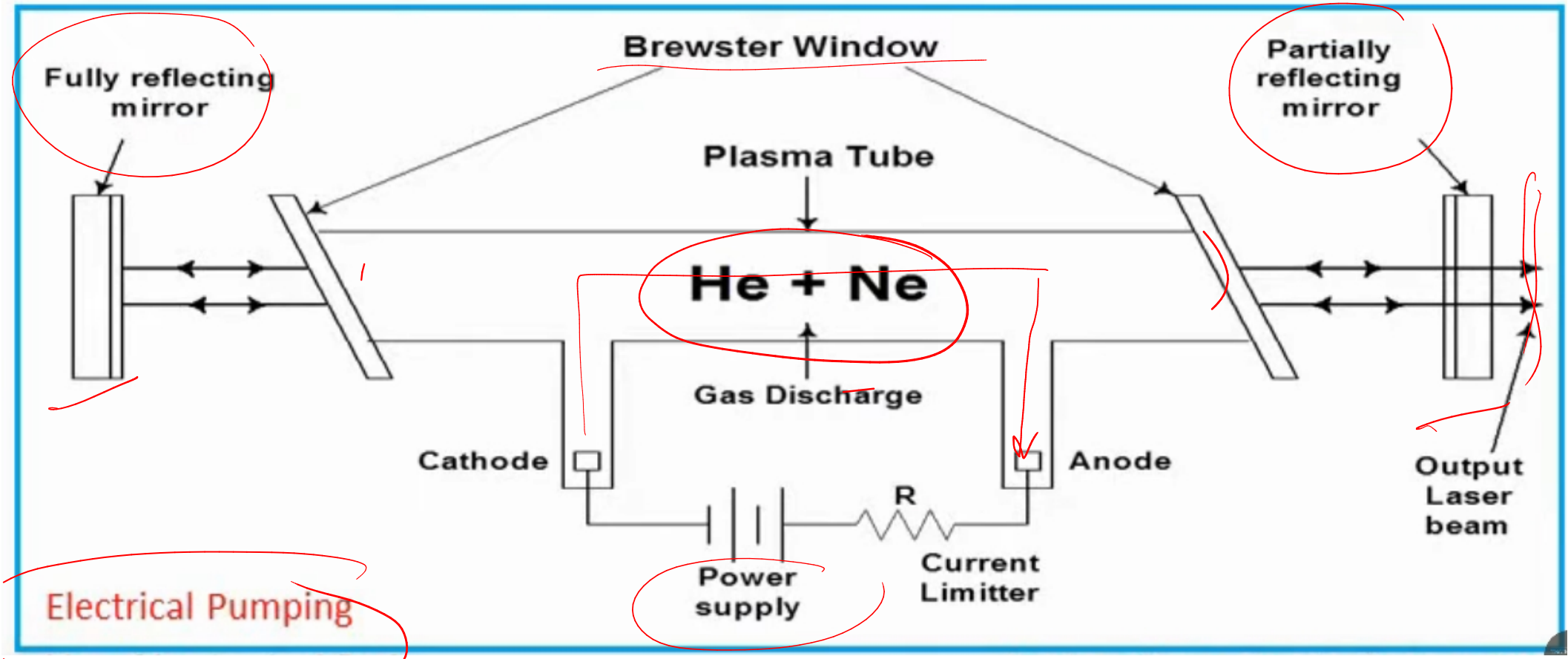
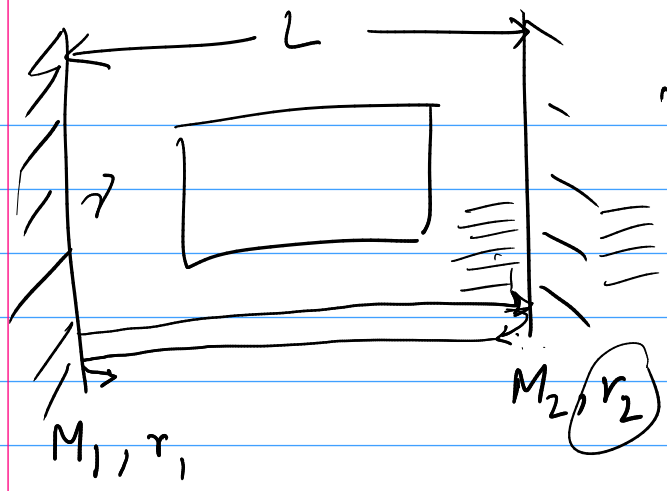
1. Why He?

2. He : Ne = 10 : 1





$$I = I_0 e^{(\gamma-\alpha)L}$$

$$I(L) = r_2 I_0 e^{(\gamma-\alpha)L}$$

$$I(2L) = r_1 r_2 I_0 e^{2(\gamma-\alpha)L}$$

$$\text{Gain} = \frac{I(2L)}{I_0} \geq 1$$

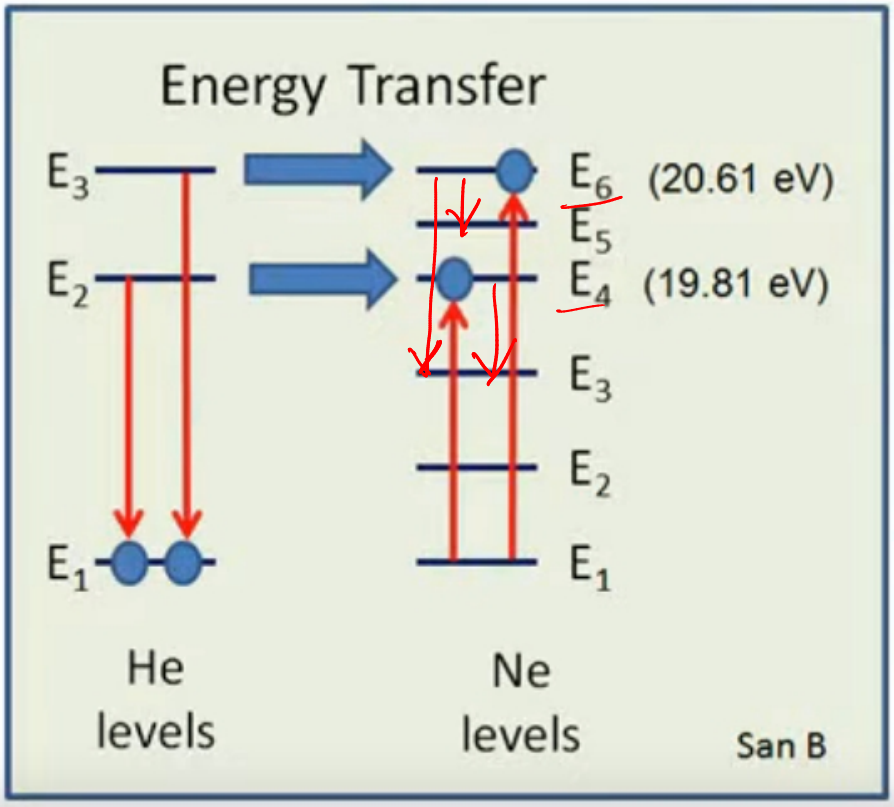
$$e^{2(\gamma-\alpha)L} \geq \frac{1}{r_1 r_2}$$

$$2(\gamma-\alpha)L \geq -\ln(r_1 r_2)$$

$$\gamma - \alpha \geq -\frac{1}{2L}\ln(r_1 r_2)$$

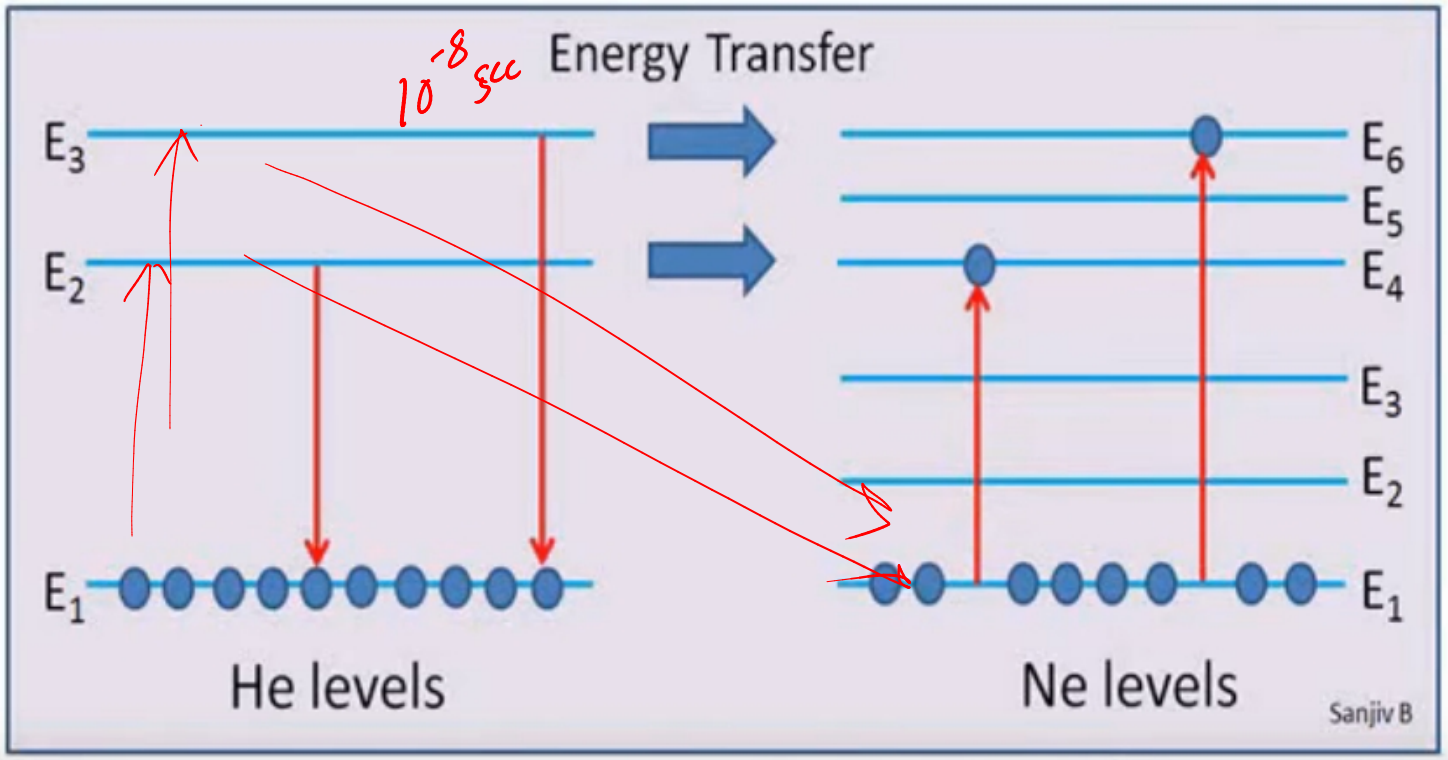
$$\boxed{\gamma \geq \alpha - \frac{1}{2L}\ln(r_1 r_2)}$$

Role of Helium in He Ne LASER

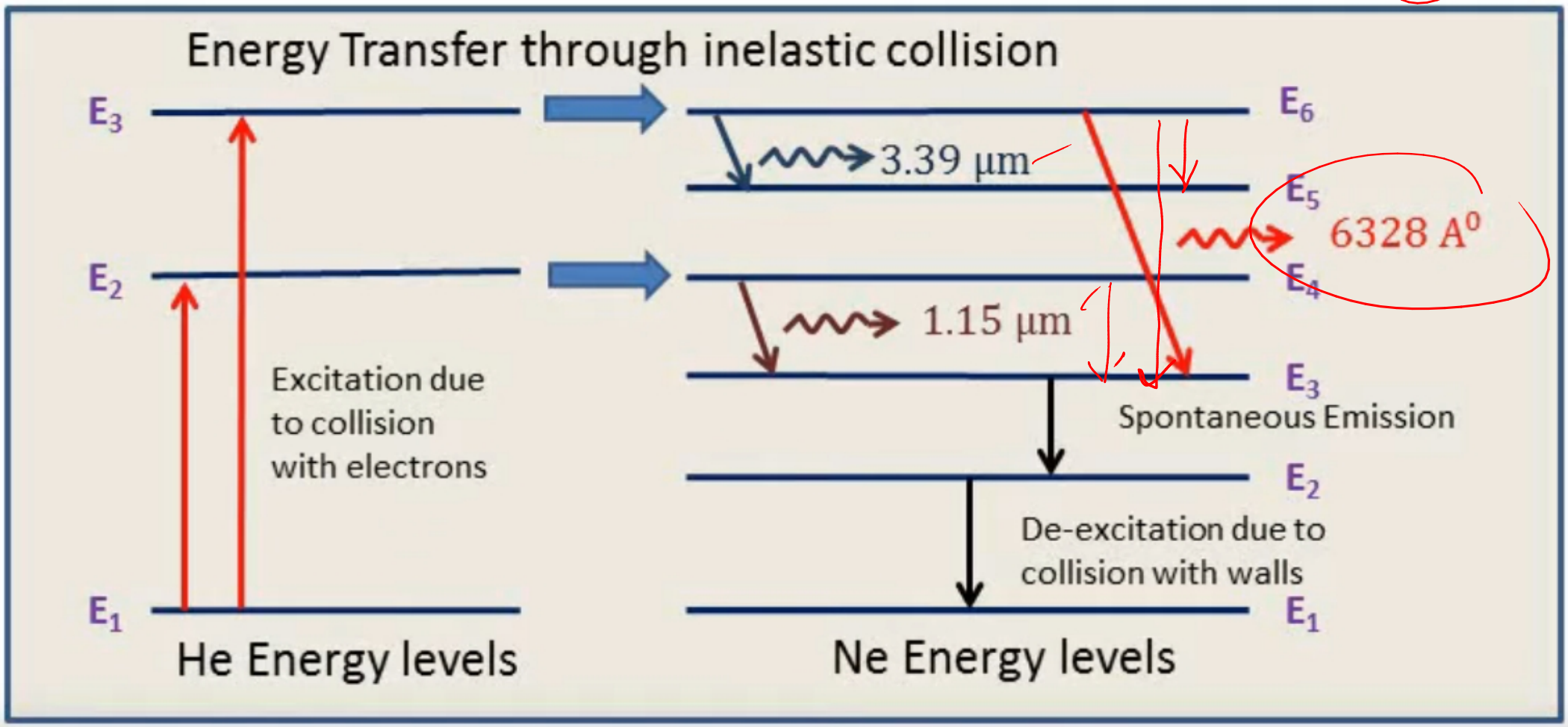


- The helium atoms are lighter. So more readily excitable than neon atoms.
- Helium atoms in excited energy levels E_2 and E_3 collide with the Neon atoms in the ground level. Neon atoms are excited to energy levels E_4 and E_6 and Helium atoms come back to the ground state.
- **The neon atoms are much heavier and could not be pumped efficiently without Helium atoms.**
- **The role of Helium atoms is to excite Neon atoms and cause population inversion.**

Why the proportion of He : Ne is 10:1 ?



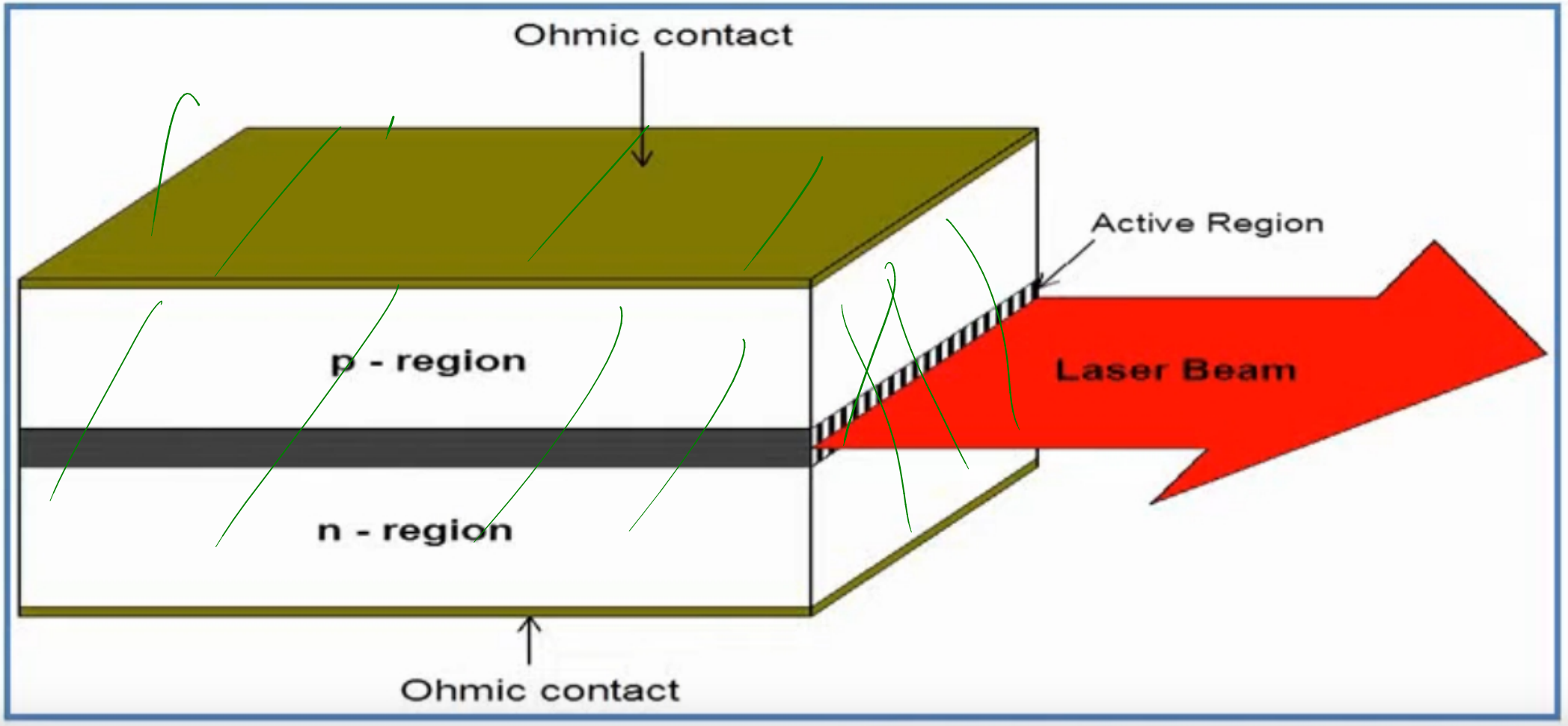
- Many He atoms excited to higher energy levels E2 and E3 will fall down due to spontaneous emission and wont be able to transfer their energy to Ne atoms.
- The probability of energy transfer from Helium atoms to Neon atoms is more as there are 10 Helium atoms per 1 Neon atom in a gas mixture.

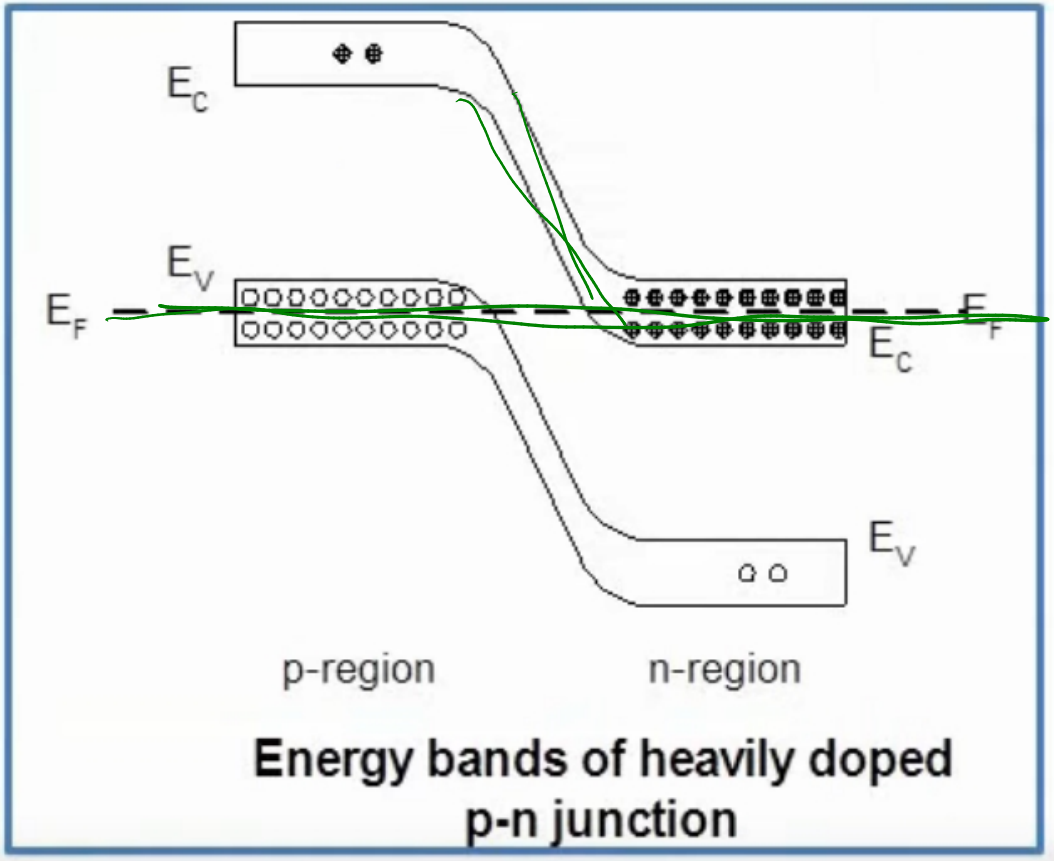

Energy Transfer through inelastic collision
E3
E2
E1
Excitation due
to collision
with electrons
He Energy levels
E6
E5
E4
E3
E2
E1
3.39 μm
1.15 μm
6328 A0
Spontaneous Emission
De-excitation due to
collision with walls
Ne Energy levels

$E_6 \rightarrow E_5$ transition	Generates a laser beam of wavelength 33900 A^0 (3.39 μm)
$E_6 \rightarrow E_3$ transition	Generates a laser beam of wavelength 6328 A^0
$E_4 \rightarrow E_3$ transition	Generates a laser beam of wavelength 11500 A^0 (1.15 μm)

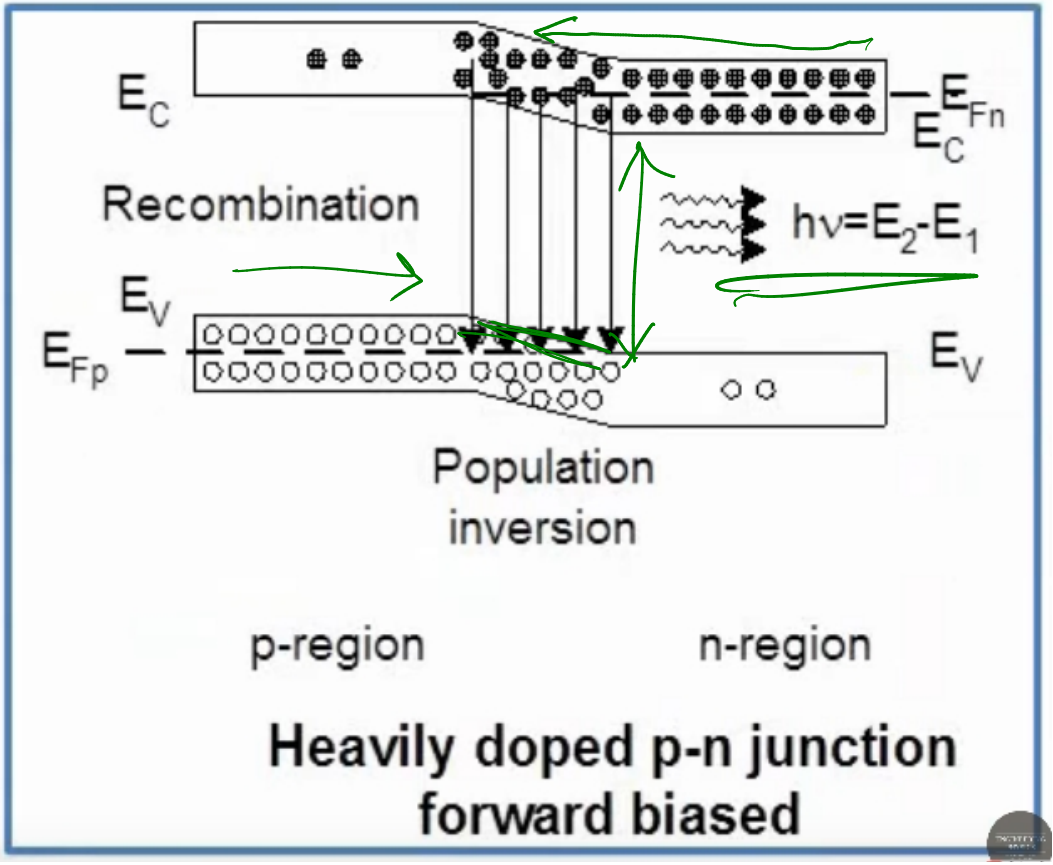
Merits and Demerits :

- Operates in a continuous wave mode
- Widely used as a monochromatic source in interferometer, laser printing, bar code reading etc.
- Used as a reference beam in surveying, for alignment in pipes etc.
- He-Ne laser is highly stable. No separate cooling is needed.
- But the output power is very low.


Ohmic contact
Active Region
p - region
Laser Beam
n - region
Ohmic contact



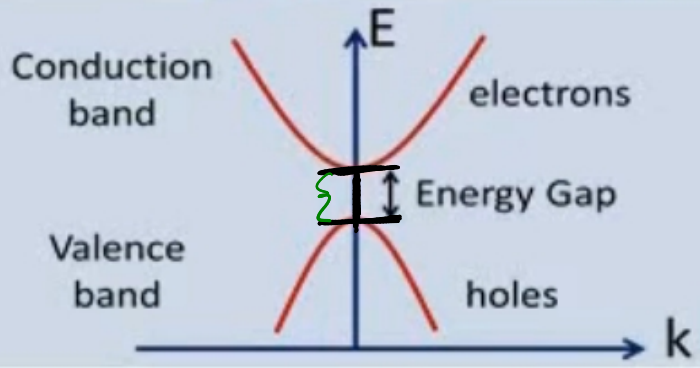
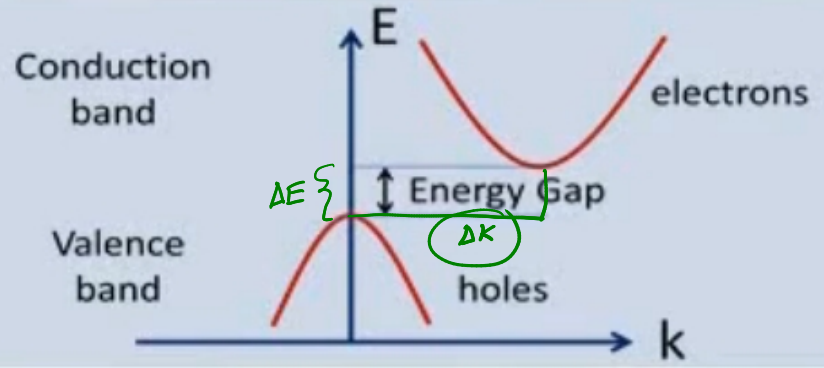
Energy bands of heavily doped p-n junction



Heavily doped p-n junction forward biased

$p = \hbar k$

$E = \frac{p^2}{2m} = \frac{\hbar^2 k^2}{2m}$

Direct bandgap Semiconductors	Indirect bandgap Semiconductors
	
Maximum of valence band and minimum of conduction band occur at same momentum values	Maximum of valence band and minimum of conduction band occur at two different momentum values.
Electron making a transition from valence band to conduction band need not undergo any change in its momentum.	In order to make a transition from maximum point in valence band to minimum point in conduction band, the electron requires energy for the change in momentum in addition to the energy gap E_g
The compound semiconductors such as GaAs, are direct gap semiconductors	All elemental semiconductors such as Si, Ge, are indirect gap semiconductors
These direct gap semiconductors are used in LED and Semiconductor Lasers.	Not useful for LEDs and Semiconductor Lasers

Advantages:

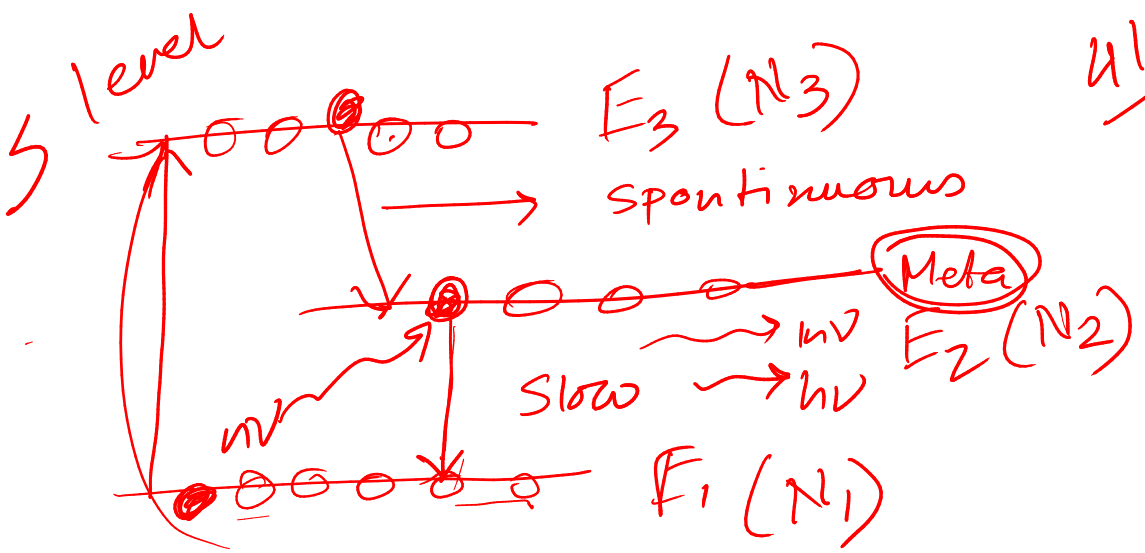
1. The construction of CO_2 laser is simple
2. The output of this laser is continuous.
3. It has high efficiency
4. It has very high output power.
5. The output power can be increased by extending the length of the gas tube.

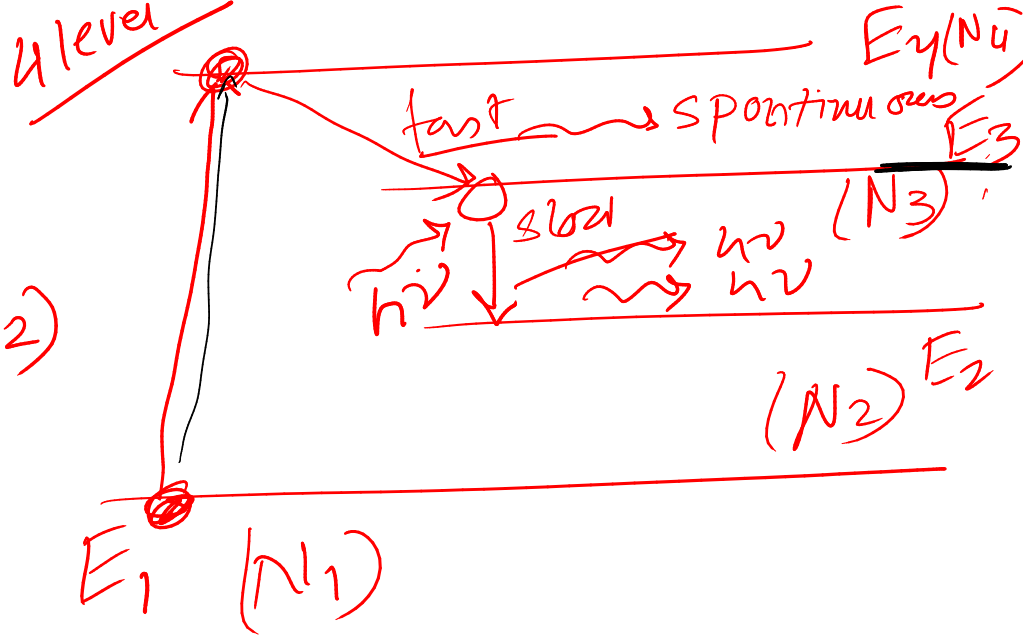
Disadvantages:

1. The contamination of oxygen by carbon monoxide will have some effect on laser action
2. The operating temperature plays an important role in determining the output power of laser.
3. The corrosion may occur at the reflecting plates.
4. Accidental exposure may damage our eyes, since it is invisible (infra red region) to our eyes.

Applications:

1. High power CO_2 laser finds applications in material processing, welding, drilling, cutting soldering etc.
2. The low atmospheric attenuation (10.6μm makes CO_2 laser suitable for open air communication.
3. It is used for remote sensing
4. It is used for treatment of liver and lung diseases.
5. It is mostly used in neuro surgery and general surgery.
6. It is used to perform microsurgery and bloodless operations.

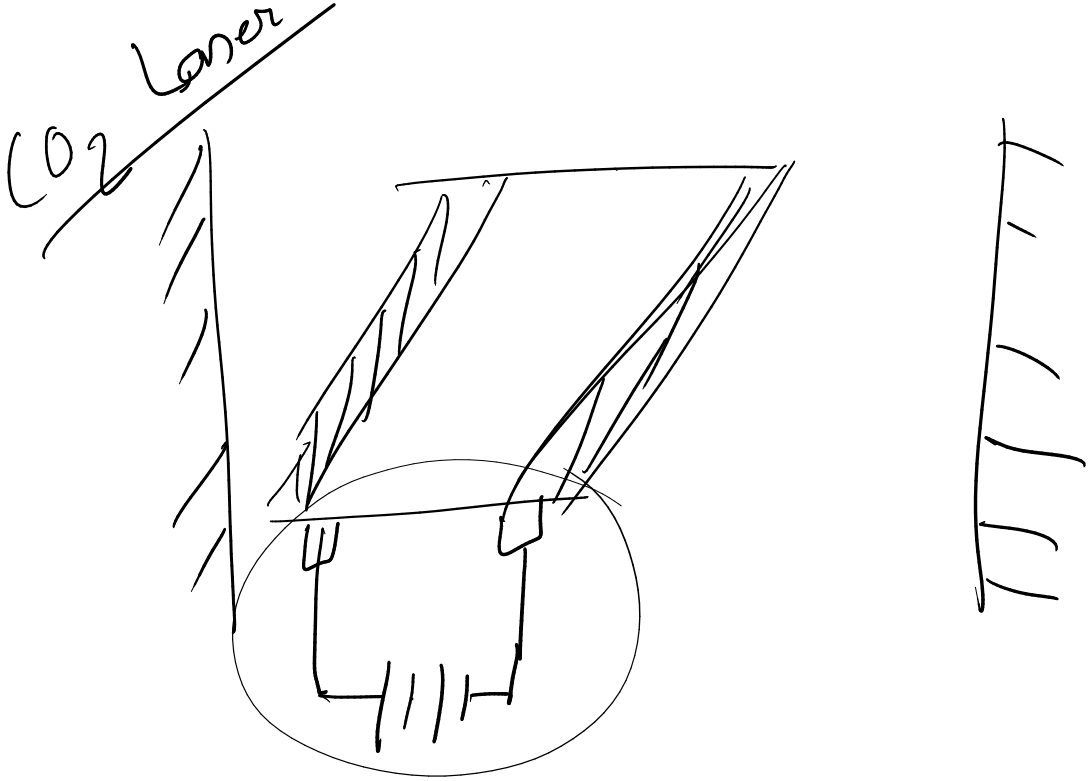


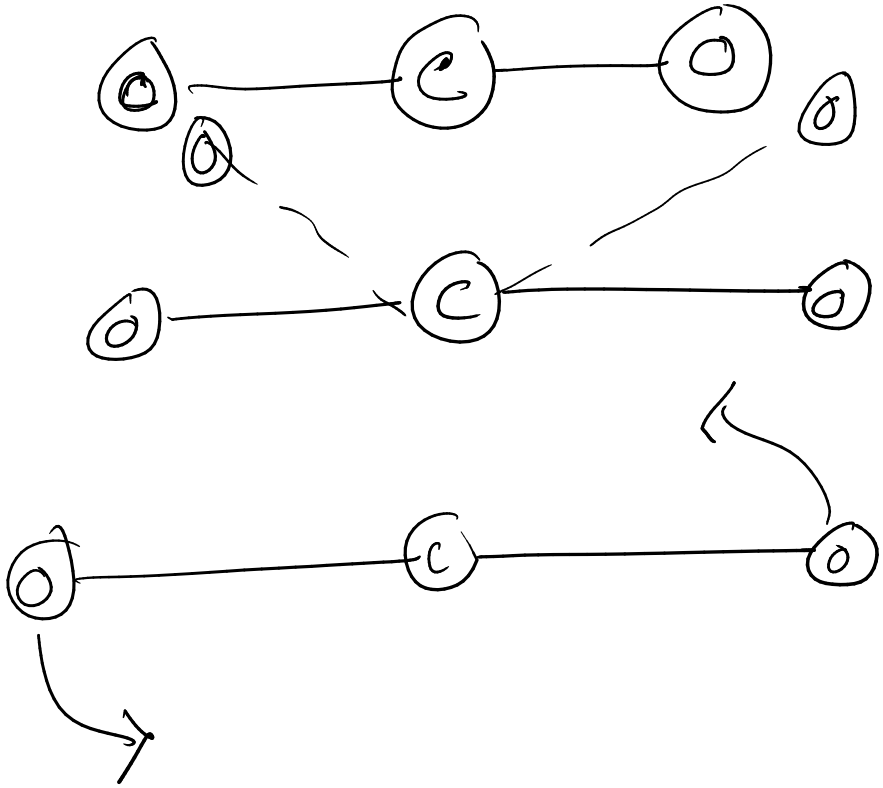


$N_2 > N_3 > N_1$ laser

Pulsed beam

Continuous





CO_2

N_2

He

1:2:3

+ water vapour

Streteching (m)

Bending (n)

Rotation (q)

(m n q)

$N_2 + e^- \longrightarrow N_2^*$

$N_2^* + CO_2 \longrightarrow CO_2^*$