Ministry of Higher Education and Scientific Research
Al-Mustaqbal University
College of Medical and Health Technologies
Aesthetic and Laser techniques Department

Laser Physics

Laser level systems

First stage

Lecture4

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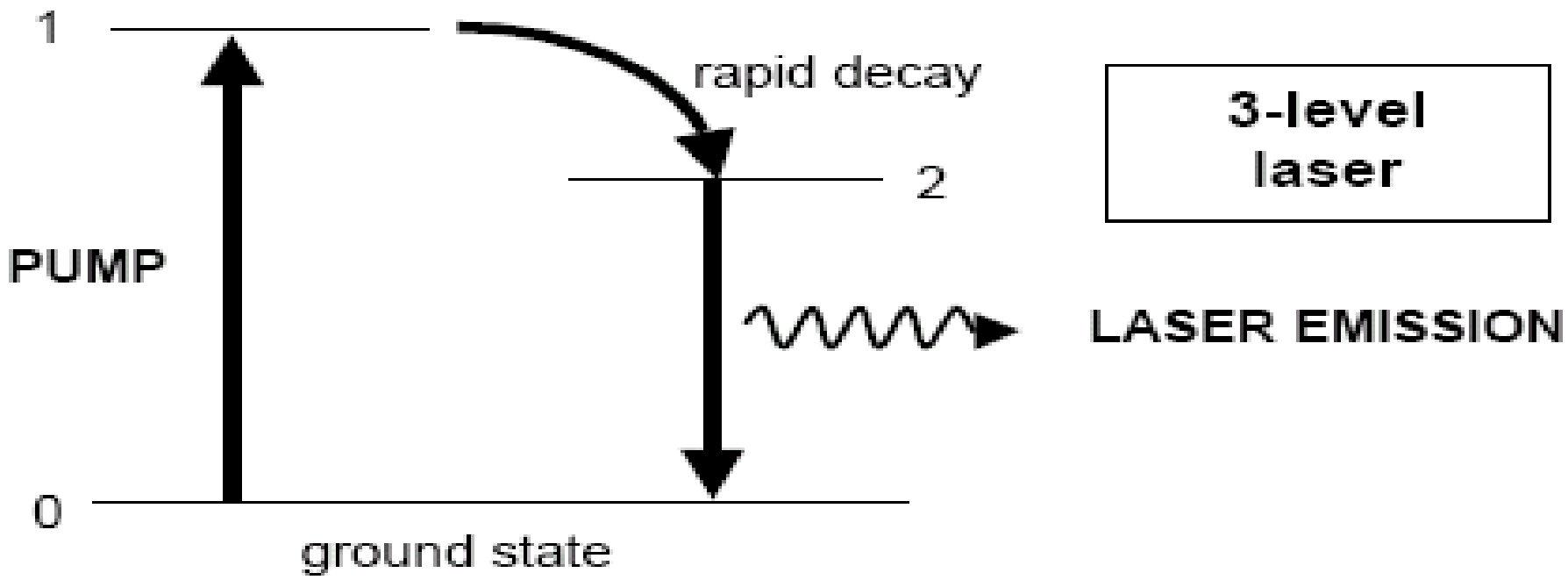
Laser level systems

Triple-Level System:

It consists of three energy levels: the ground level, which represents the **l**ower **l**aser **l**evel (LLL), the excited level, which represents the **u**pper **l**aser **l**evel (ULL), and the metastable or intermediate level (**ULL**).



The ground level is the same as the lower laser level . Half the number of atoms or molecules from the ground level must be pumped to the upper level to achieve the inverted distribution, so a very high pumping energy is required . The metastable level is not chosen for the inverted distribution process because it cannot store as many excited atoms or molecules as the upper laser level , which is very wide

The laser output power (PL) is calculated as follows:

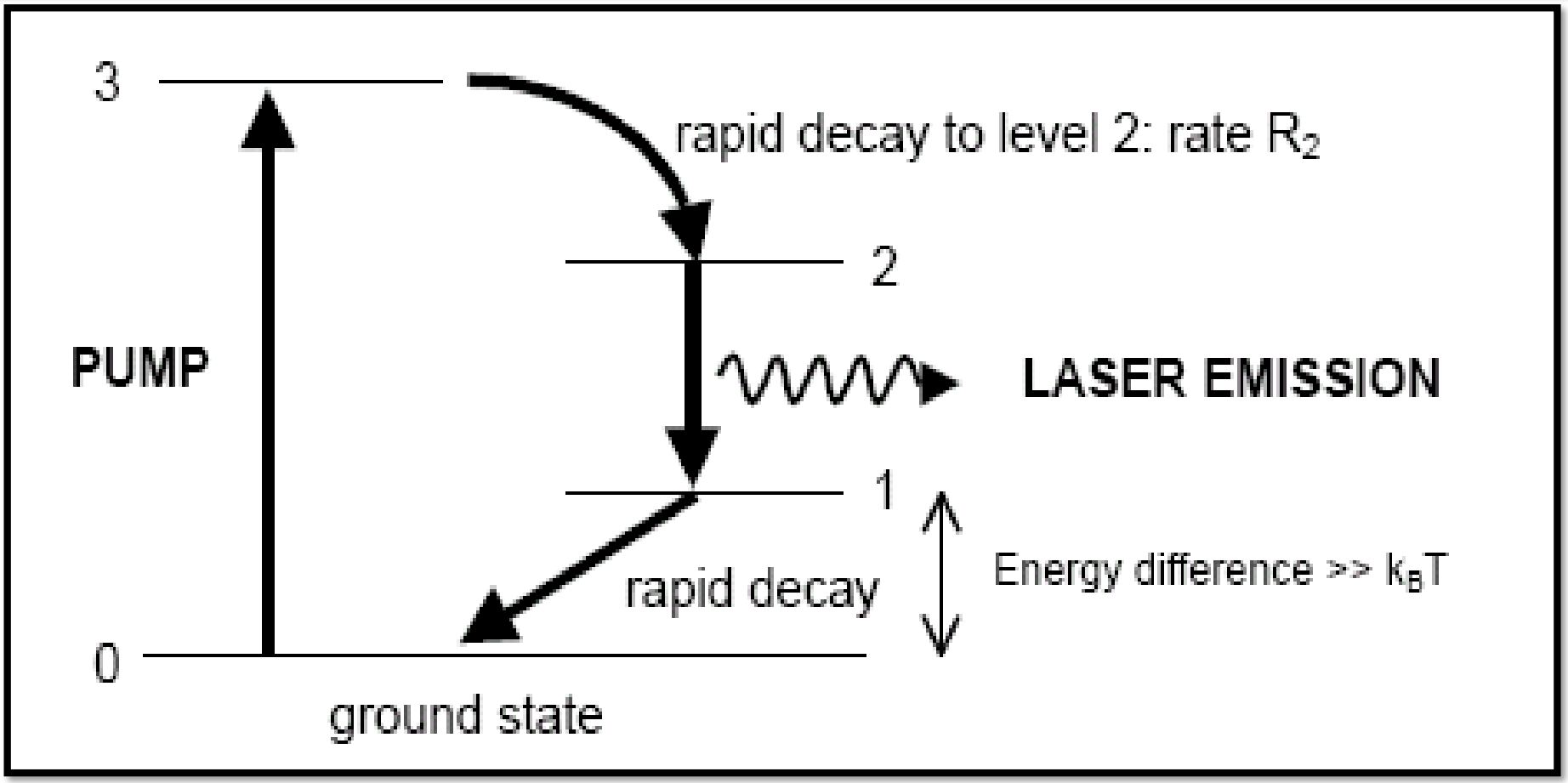
$$P_L = h\nu(w_p \beta N_1 - A_{21} N_2)$$

Where **$h\upsilon$** is the energy of the emitted photon (laser), **w_p** is the pumping rate of atoms or molecules to the upper level, **β** is the **efficiency** of the N2 level, and **A_{21}** is the spontaneous emission rate from the metastable level to the ground level.

Four-Level System:

It consists of four energy levels:

the ground level, the lower laser level (LLL), the excited level, and the upper laser level (ULL)



The ground level is not the same as the lower laser level , so we don't need a very powerful pumping source to achieve the inverted distribution. Most materials used for laser generation are four-level systems.

The laser output power (PL) is calculated as follows:

$$P_L = h\nu\Delta N_c w_L = h\nu\Delta N_c \left(\frac{P_2'}{\Delta N_c} - w_{21}\right)$$

Where $h\upsilon$ is the energy of the emitted photon (laser), ΔN_c is the value of the inverse distribution, w_L is the pumping or descent rate of atoms or molecules from the upper laser level to the lower laser level, and P_2 is the effective pumping power, calculated as follows:

$$P_2' = P_2[1-(\frac{w_2}{w_{10}})(1+\frac{P_1}{P_2})]$$

If the number of atoms or molecules N2 is greater than N1 by one, this means that the inverse distribution between levels E2 and E1 has occurred.

Conclusion

Three-level system

1-It consists of three levels

2-It requires pumping half the number of atoms from the ground state to the excited state to obtain the inverted distribution

3-The ground plane is the same as the lower laser plane

4-Laser action occurs between E2 and E1

5-Requires a high pumping power source.

6-The lifespan of the E3 level is very small.

7- E2 level has a long lifespan

8-Rapid transition occurs between E3 and E2

9-Less efficient than the four-level system

10-The power of the laser depends on:

1-The frequency of the laser beam (υ)

2. The probability of stimulated transition (w_p)

3. The level efficiency (β) E2

4. The probability of spontaneous emission A21

5. The number of atoms in the N1 and N2 levels

11-Under thermal equilibrium, **N2** is very small and can be neglected

12-There is no transition between **E2** and the **ground** plane.

Conclusion

Four-level system

1-It consists of four levels.

2-It requires pumping a few atoms from the ground plane to the excited plane to obtain the inverted distribution

3-The ground plane is not the lower laser plane

4-Laser action occurs between E3 and E2.

5-No high pumping power source required

6-The lifespan of the E3 level is very small

7-The lifetime of the E2 level is relatively long.

8-Rapid transition occurs between E3 and E2

9-Higher efficiency than the three-level system

10-The laser power depends on:

1-The frequency of the laser beam (υ)

2. The probability of the stimulated transition (w_p)

3. The effective pumping rate (**P'2**)

4. The difference in the number of atoms in the **N1** and **N2** levels (ΔN_c)

11-Under thermal equilibrium, **N1** and **N2** are so small that they can be neglected

12-There is a transition between level **A1** and the ground level


Thanks for
listening.