Unit-2 Lasers and applications

PHY109 – ENGINEERING PHYSICS

Prepared by: Dr. Dipal B. Patel

Brief introduction to the course

- **L: 3 T:1 P:0 Credits:4**
- **Unit 1: Electromagnetic theory [7 lectures]**
- **Unit 2: Lasers and applications [6 lectures]**
- **Unit 3: Fiber optics [5 lectures]**
- **Unit 4: Quantum mechanics [7 lectures]**
- **Unit 5: Waves [5 lectures]**
- **Unit 6: Solid state physics [6 lectures]**

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Unit-2 Lasers and applications

Contents:

- Fundamentals of laser
- Energy levels in atoms
- Radiation matter interaction
- Absorption of light
- Spontaneous emission of light
- Stimulated emission of light
- Metastable state
- Population inversion
- Lasing action

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Unit-2 Lasers and applications

Contents:

- Properties of laser
- Population of energy levels
- Einstein A and B coefficients,
- Resonant cavity
- Excitation mechanisms
- Nd - YAG, He-Ne Laser, Semiconductor Laser,
- Applications of laser in engineering, holography.

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LASER

- Light Amplification by Stimulated Emission of Radiation

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Energy levels in atoms

- An atom can be excited by supplying energy with an amount equal to the difference of its any two energy levels.
- Then after a very short duration of time the atom shall radiate energy when it comes down to its lower energy state
- An electron undergoes a transition between two energy states E_1 and E_2 if the atom emits/absorbs a photon of appropriate energy,

$$E_2 - E_1 = h\nu$$

- Where, h =Planck's constant & ν = frequency of radiation

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Radiation matter interaction

UV-visible interaction with matter

- The absorption of a photon occurs only when the energy of the photon precisely matches the energy gap between the initial and final states.

- In such interaction of radiation with matter, if there is no pair of energy state that the photon energy can elevate the system from the lower to upper state, then the matter is said to be transparent to that radiation.

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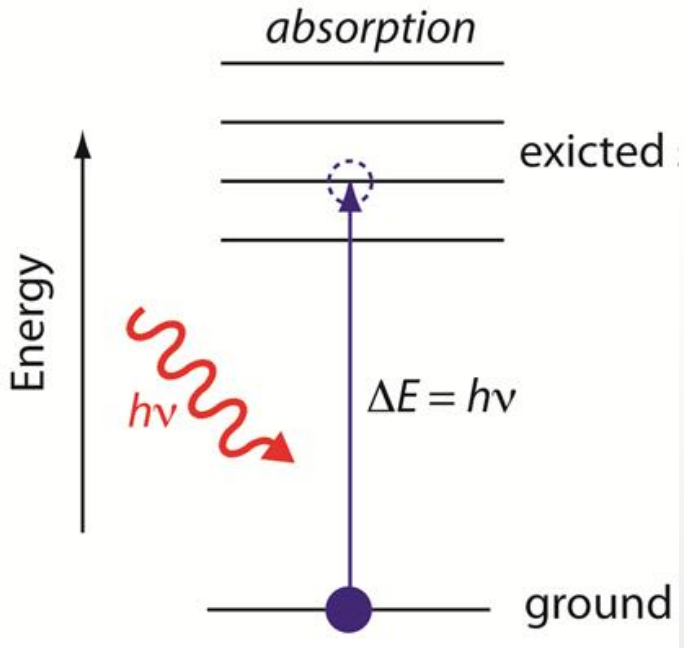
Absorption of light

- At low temperatures, most of the atoms stay in lower energy states.
- If an atom is initially in the *lower energy state* E1, it can be raised to the *higher energy state* E2 by the absorption of a photon of energy hν,



Absorption of light

- The *probability of occurrence* of this absorption from state 1 to state 2 is proportional to the *energy density* $u(\nu)$ of the radiation,

$$P_{12} = B_{12}\, u(\nu)$$

B12 = Einstein's coefficient of absorption of radiation

Spontaneous emission

- If an atom is initially in the upper state E2, it can come down to lower state E1 by emitting a photon of energy $E=h\nu$ …*spontaneous emission.*

- It is a natural radiation decay process that is inherent in all excited states of all materials.

- However, such emission is not always the dominant decay process !