B.Tech I Year

Regular Course Handbook

Subject Name: Engineering Physics (Unit-3)

BAS101 / BAS201: ENGINEERING PHYSICS

Content	Contact Hours
Unit-1: Quantum Mechanics	9
Inadequacy of classical mechanics, Planck's theory of black body radiation(qualitative), Compton effect, de-Broglie concept of matter waves, Davisson and Germer Experiment, Phase velocity and group velocity, Time-dependent and time-independent Schrodinger wave equations, Physical interpretation of wave function, Particle in a one-Dimensional box.	
Unit-2: Electromagnetic Field Theory	8
Basic concept of Stoke's theorem and Divergence theorem, Basic laws of electricity and magnetism, Continuity equation for current density, Displacement current, Maxwell equations in integral and differential form, Maxwell equations in vacuum and in conducting medium, Poynting vector and Poynting theorem, Plane electromagnetic waves in vacuum and their transverse nature. Relation between electric and magnetic fields of an electromagnetic wave, Plane electromagnetic waves in conducting medium, Skin depth.	
Unit-3: Wave Optics	10
Coherent sources. Interference in uniform and wedge shaped thin films, Necessity of extended sources, Newton's Rings and its applications, Introduction to diffraction, Fraunhoffer diffraction at single slit and double slit, Absent spectra, Diffraction grating, Spectra with grating, Dispersive power, Resolving power, Rayleigh's criterion of resolution, Resolving power of grating.	
Unit-4: Fiber Optics & Laser	9
Fibre Optics: Principle and construction of optical fiber, Acceptance angle, Numerical aperture, Acceptance cone, Step index and graded index fibers, Fiber optic communication principle, Attenuation, Dispersion, Application of fiber. **Laser:** Absorption of radiation, Spontaneous and stimulated emission of radiation, Population inversion, Einstein's Coefficients, Principles of laser action, Solid state Laser (Ruby laser) and Gas Laser (He-Ne laser), Laser applications.	
Unit-5: Superconductors and Nano-Materials:	8
Superconductors: Temperature dependence of resistivity in superconducting materials, Meissner effect, Temperature dependence of critical field, Persistent current, Type I and Type II superconductors, High temperature superconductors, Properties and Applications of Super-conductors. **Nano-Materials:** Introduction and properties of nano materials, Basics concept of Quantum Dots, Quantum wires and Quantum well, Fabrication of nano materials -Top-Down approach (CVD) and Bottom-Up approach (Sol Gel), Properties and Application of nano materials.	

Course Outcomes:

On completion of course the students are able :		
CO	CO Statement	Bloom's Level
CO1	To explain the distribution of energy in black body radiation and to understand the difference in particle and wave nature with explanation of Compton effect and Schrodinger wave equation.	Understanding, Apply
CO2	To understand the concept of displacement current and consistency of Ampere's law and also the properties of electromagnetic waves in different medium with the use of Maxwell's equations.	Understanding, Analyze
CO3	To understand the behavior of waves through various examples/applications of interference and diffraction phenomenon and the concept of grating and resolving power.	Apply
CO4	To know the functioning of optical fiber and its properties and applications. To understand the concept, properties and applications of Laser.	Understanding, Apply
CO5	To know the properties and applications of superconducting materials and nano materials.	Understanding

Reference Books:

1. Concepts of Modern Physics - Aurthur Beiser (Mc-Graw Hill)
2. Optics - Brijlal & Subramanian (S. Chand)
3. Engineering Physics: Theory and Practical- Katiyar and Pandey (Wiley India)
4. Applied Physics for Engineers- Neeraj Mehta (PHI Learning, New)
5. Engineering Physics-Malik HK and Singh AK (Mc Graw Hill)

B.Tech First Year: Regular Course Lecture Plan Session 2022-23

Subject Name	Engineering Physics (BAS101)

Unit No.	Unit Name	Syllabus Topics	Lecture No
1	Quantum Mechanics	Inadequacy of classical mechanics, Black body radiation, Stefan's law, Wien's law, Rayleigh-Jeans law	1
		Planck's theory of black body radiation (qualitative), Compton Effect	2
		de-Broglie concept of matter waves, Davisson and Germer Experiment	3
		Phase velocity and group velocity	4
		Time-dependent and time-independent Schrodinger wave equations	5
		Physical interpretation of wave function, Particle in a one Dimensional box	6
		Numerical problems related to Wien's law, Stefan's law, Compton effect	7
		Numerical problems related to de Broglie matter wave, wave function&one dimensional box	8
2	Electromagnetic Field Theory	Basic concept of Stoke's theorem and Divergence theorem, Basic laws of electricity and magnetism	9
		Continuity equation for current density, Displacement current	10
		Maxwell's Equations in differential & integral form	11
		Maxwell equations in vacuum and conducting medium	12
		Poynting vector and Poynting theorem	13
		Plane electromagnetic wave in vacuum &Transverse nature	14
		Relation between electric and magnetic field, Plane electromagnetic waves in conducting medium, Skin depth	15
		Numerical problems related to Maxwell's equation, Poynting vector, skin depth	16
3	Wave Optics	Coherent sources, Interference in uniform thin films	17
		Wedge shaped thin films,Necessity of extended sources	18
		Newton's rings and its application	19
		Numerical problems related to thin film, wedge shaped film and Newton's Ring	20
		Basic of Diffraction, Fraunhoffer diffraction at single slit	21
		Fraunhoffer diffraction at double slit	22
		Absent spectra, Diffraction grating	23
		Spectra with grating, Dispersive power, Resolving power	24
		Rayleigh's criterion ofresolution, Resolving power of grating	25
		Numerical problems related Single slit, Grating, Resolving power & dispersive power	26

B.Tech First Year: Regular Course Lecture Plan Session 2022-23

Subject Name	Engineering Physics (BAS101)

Unit No.	Unit Name	Syllabus Topics	Lecture No
4	Fiber Optics & Laser	Principle and construction of optical fiber, Acceptance angle, Numerical aperture, Acceptance cone	27
		Step index and graded index fibers, Fiber optic communication principle	28
		Attenuation, Dispersion, Application of fiber.	29
		Numerical problems related Acceptance angle, Numerical aperture	30
		Absorption of radiation, Spontaneous and stimulated emission of radiation, Population inversion, Einstein's Coefficients	31
		Principles of laser action, Solid state Laser(Ruby laser)	32
		Gas Laser (He-Ne laser), Laser applications & numerical	33
5	Superconductors and Nano-Materials	Temperature dependence of resistivity in superconducting materials, Meissner effect	34
		Temperature dependence of critical field, Persistent current, Type I and Type II superconductors	35
		High temperature superconductors, Properties and Applications of Super-conductors	36
		Introduction and properties of nano materials, Basics concept of Quantum Dots, Quantum wires and Quantum well	37
		Fabrication of nano materials-Top-Down approach (CVD) and Bottom-Up approach (Sol Gel)	38
		Properties and Application of nano materials.	39
		Numerical related to superconductor and nano materials	40

Signature	
Name of Subject Head	Dr. Ramesh Chand

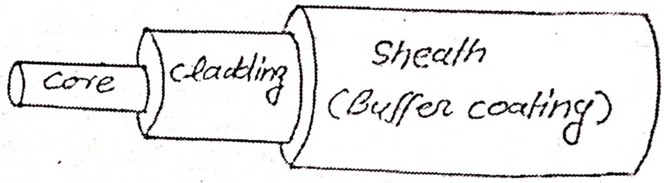
Unit 4 - FIBRE OPTICS AND LASER

Fibre optics:— Fibre optics is the technology used to transmit information as pulses of light through strands of fibre made of glass or plastic over long distances.

Q. With the help of well labeled diagram, name the components of an optical fibre. [2020-2021] [2015-2016]

Ans. Structure: It consists of three parts.

(a) Core:



It is inner most part of the fibre surrounded by a second layer (cladding). Its refractive index slightly more than cladding.

(b) Cladding: Optical properties different from the core.

(c) Sheath: It is outer most layer of the fibre cable which protect the fibre from crashing, contaminations and moisture.

Q. What is the principle of operation of an optical fibre? [2018-2019] V.Imp

Ans. The optical fibre is based on the principle of total internal reflection (TIR).

Q. What do you mean by total internal reflection?

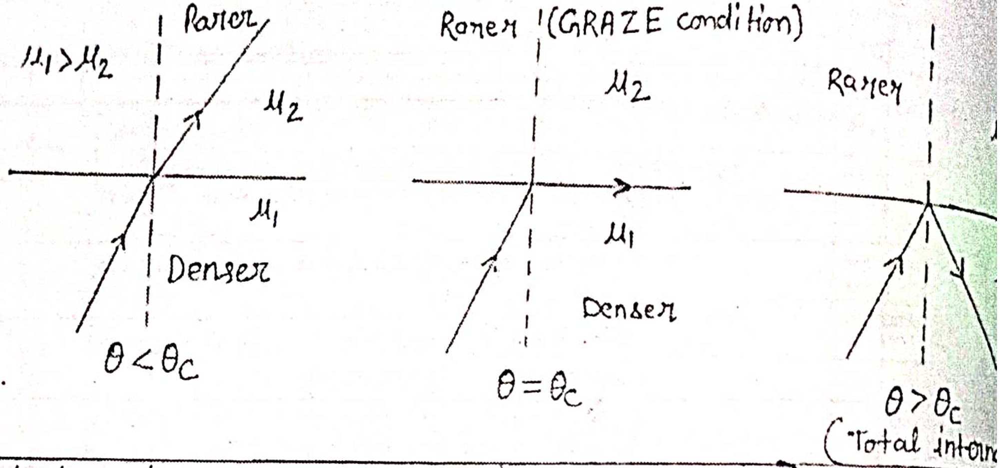
Ans. The total internal reflection at the fibre will occur when:

1. The refractive index of the core material (μ_1) must be slightly (in the fibre cable)

higher than that of cladding material (μ_2).

2. At the core-cladding interface the angle of incide[nce] must be greater than critical angle θ_c.

$$\boxed{\sin\theta_c = \frac{\mu_{cladd}}{\mu_{core}}}$$



Q. What do you understand by an optical fibre [and] discuss its classifications. [2018-2019] & [2015-201…

or

Q. Discuss the structure of an optical fibre. What [are] various types of optical fibres? Explain their adv[ant]ages and disadvantages. [2015-2016, 2018-2019]

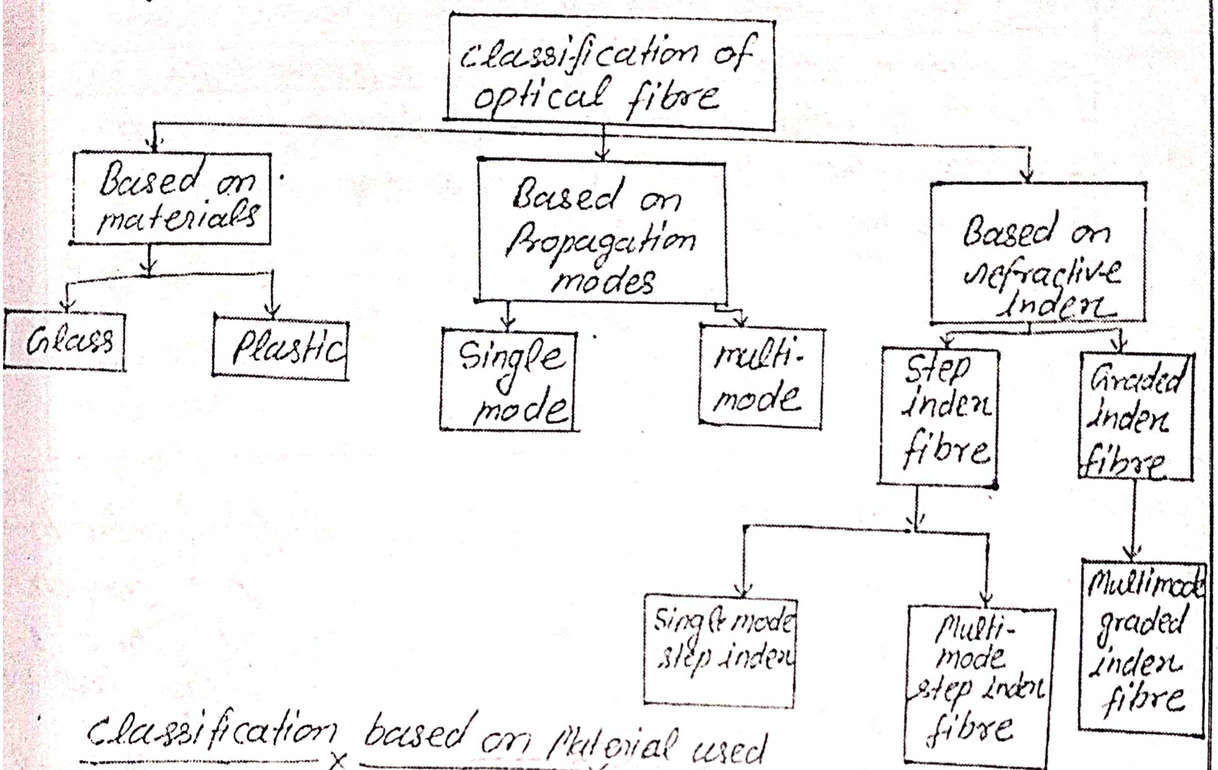
Ans. Optical fibre is very thin and flexible medi[um] having a cylindrical shape. Optical fibre is u[sed] for transportation of optical energy (Light ene[rgy]) from one point to another. It is made up of glass or plastic (generally an insulating mat[erial]).

Types of optical fibre:

The optical fibres are classified into thre[e] major types based on

(a) Material (b) Number of Modes (c) Refracti[ve] index profile

A general classification is given below:



Classification based on Material used

1. Glass fibre: When the optical fibre is made up of mixture of metal oxides and silica glasses, then it is called glass fibre.

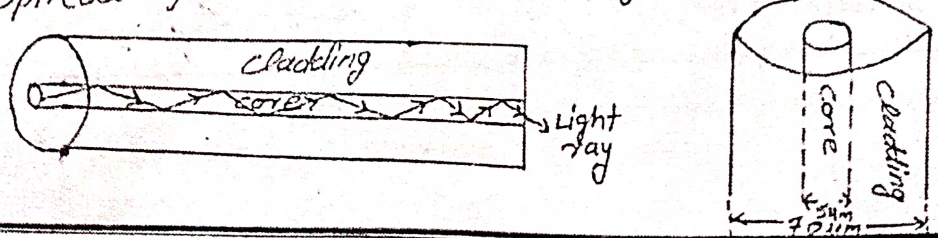
2. Plastic fibre: When the fibres are made up of plastics, then it is called as plastic fibre.

**Q. What do you understand by the mode of an optical fibre?

Ans. Classification based on number of modes: V.Imp

1. Single mode fibre (SMF): It has smaller core diameter (5µm–10µm) and high cladding diameter (70µm–100µm). The difference between the refractive indices of the core and the cladding is very small.

* When only a single mode is transmitted through an optical fibre it is called single mode fibre.



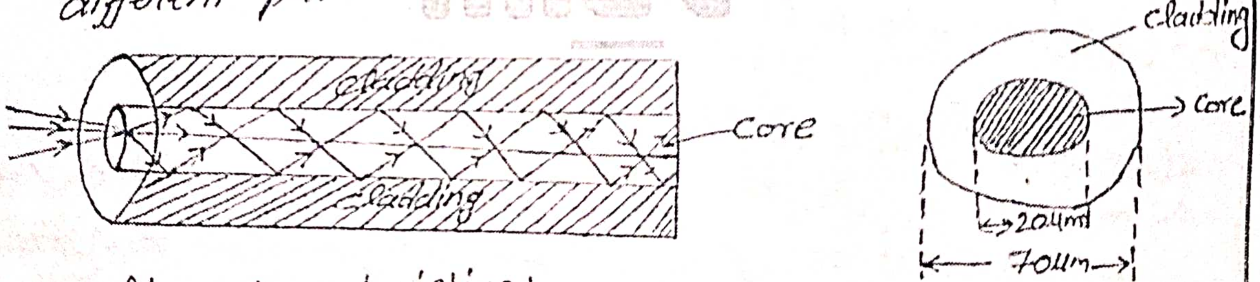
Single mode fibre characteristics:

(a) The single mode fibre can support only one mode of propagation.
(b) Suitable for long distance communication such as telephone lines.
(c) The light is passed through laser diodes.
(d) The fabrication is very difficult and costly.

Multi-mode fibre:

It has larger core diameter than single mode fibre. The core diameter is 20-100 um and that of cladding is 70-125 um. The relative refractive index difference is also larger than single mode fibre. Multimode fibre allows a large number of modes for the light rays travelling through it.

* When more than one mode is transmitted through an optical fibre is called multi-mode fibre.
* In this fibre the light can travel through many different paths within core.



Multimode fibre characteristics:-

(a) The multimode can support a number of modes.
(b) Propagation of light is easy.
(c) Light ray enters into the fibre using LED source.
(d) The fabrication is less difficult than single mode fibre.
(e) The fibre is not costly.
(f) Not suitable for long distances communication.

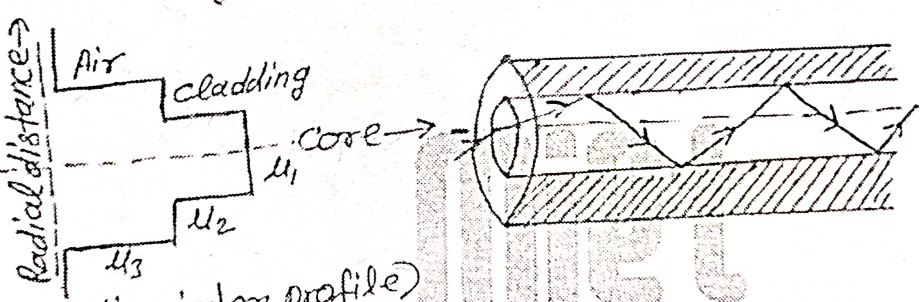
Classification of fibre based on Refractive index:

1. Step index optical fibre: In step index fibre, the refractive index is uniform through core and cladding while core refractive index is always greater than cladding refractive index.

There are two parts of step index fibre on the basis of mode.

(a) Step index single mode fibre:

A typical step-index single mode fibre has a core diameter of 5 to 10 μm and an external diameter of cladding of 50 to 125 μm.

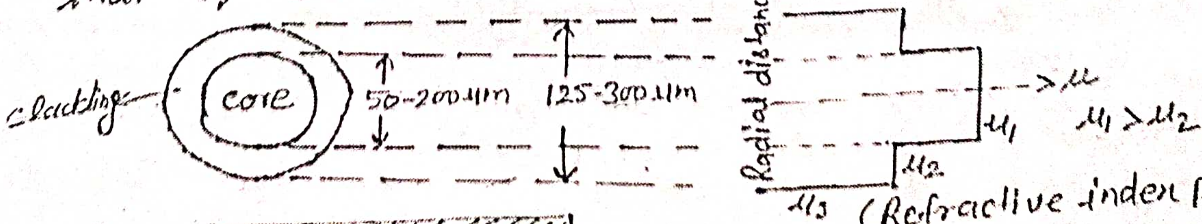


(Refractive index profile)

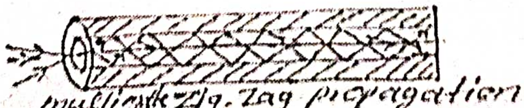
* Refractive index of core is constant.
* Refractive index of cladding is constant.

(b) Step index multimode fibre:

A typical step-index multimode fibre has a core diameter of 50 to 200 μm and an external diameter of cladding 125 to 300 μm. It has a core material with uniform refractive index and a cladding material of lesser refractive index than that of core.



(Refractive index profile)



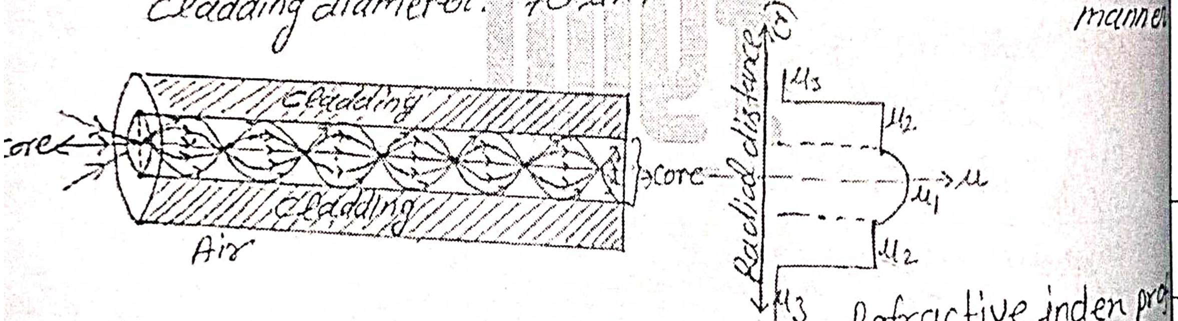
multimode zig-zag propagation

Step index multimode fibre	
Advantages	**Disadvantages**
1. Relatively easy to manufacture. 2. Cheaper than other types. 3. Larger layer NA (numerical aperture). 4. They have longer life times than laser diodes.	1. Lower bandwidth. 2. High dispersion. 3. Smearing of signal pulse.

Graded index optical fibre:

If the core has a non-uniform refracting index that gradually decreases from the center towards the core-cladding interface, the fibre is called a graded-index fibre. The cladding has uniform refractive index.

core diameter: 50 μm, Signal propagation: helical or skew manner
cladding diameter: 70 μm



Refractive index pro[file]

Graded index optical fibre	
Advantages	**Disadvantages**
1. Dispersion is low 2. Bandwidth is greater than step index multimode fibre. 3. Easy to couple with optical source.	1. Expensive 2. Very difficult to manufacture.

Q. Discuss the merits and demerits of single (mono) mode fibre over multimode counterpart. [2018-2019]

Ans. 1. No dispersion in single mode fibre during propagation while more dispersion in multimode fibre.
2. It propagates the signal for long distances while multimode is used for shorter distance.
3. There is less attenuation in single mode fibre compare to multimode fibre.

Q. What are the differences between single mode fibre and multimode fibre?

Ans.

S.No.	Single mode fibre	Multimode fibre
1.	Only one mode can propagate.	* Large number of modes can propagate.
2.	The core has smaller diameter and difference in refractive index of core and cladding is very small.	* Larger core diameter and refractive index difference is also larger than SMF between core and cladding.
3.	There is no dispersion.	* There is more dispersion.
4.	Fabrication is difficult and costly.	* Fabrication is less difficult and not costly.
5.	The fibre can carry signal to longer distances.	* It is used for shorter distances.

Q. What is the condition for number of modes in single and multimode optical fibre? [2019-2020]

Ans. The conditions for number of modes in single and multimode fibre are designed by V-number (cut-off parameter)

$$V = \frac{2\pi a}{\lambda_0}\sqrt{\mu_1^2 - \mu_2^2} = \frac{2\pi a}{\lambda_0}(NA)$$

(NA ↳ Numerical Aperture)

where a: radius of core, λ_0 = operating wavelength

μ_1 = Refractive index of core

μ_2 = Refractive index of cladding

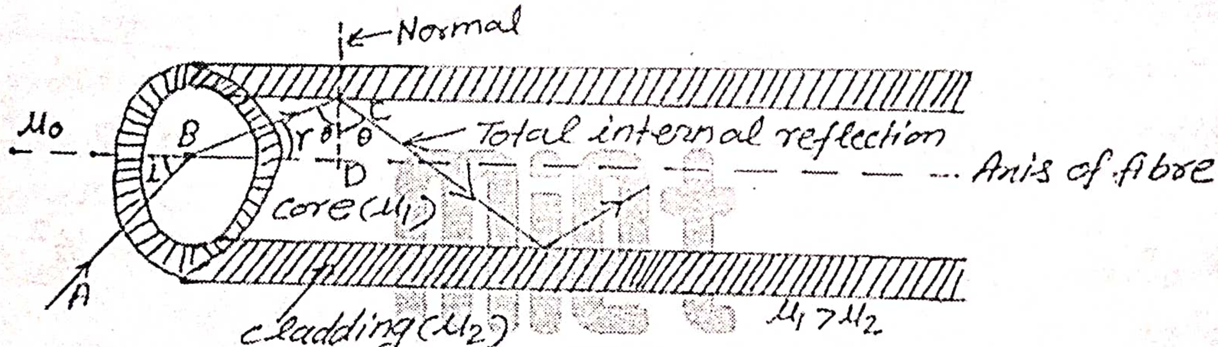
* If $V \leq 2.405 \rightarrow$ Single mode fibre
* If $V > 2.405 \rightarrow$ Multimode fibre
* V-number increases with numerical aperture and diameter of the core.

Q. What do you mean by critical angle, acceptance angle, acceptance cone and numerical aperture? Derive expression for them. [2015-2016] Imp

Ans. Critical angle: Critical angle is a particular incident angle for which refraction angle will be 90° in an optical denser medium.

Acceptance angle:-

Acceptance angle is defined as the maximum angle, that the incident light ray can make with the fibre axis, so that light ray will propagate through the fibre by total internal reflection within the core.



consider a cylindrical fibre cable which consists of an inner core of refractive index μ_1 and an outer cladding of refractive index μ_2 where $\mu_1 > \mu_2$. Let μ_0 be the refractive index of the medium from which the light ray enters the fibre.

Let a light ray AB enter the fibre at an angle i to the axis of fibre as shown in above figure. The ray refracts at an angle 'r' and strikes the core-cladding interface at an angle θ.

* when angle 'i' increases, r will increases and θ will be decreased.
* when θ angle is greater than critical angle θ_c, then light ray will stay within the core of fibre.

Applying Snell's law of refraction at the point of entry of the ray AB into the core,

we have $\mu_0 \sin i = \mu_1 \sin r$ ——— (1)

from ΔBCD → $r = 180 - (90+\theta) = 90-\theta$

or $\sin r = \sin(90-\theta) = \cos\theta$ ——— (2)

Now from equations (1) & (2)

$\mu_0 \sin i = \mu_1 \cos\theta$ ——— (3)

For maintaining $\theta \geq \theta_c$ (critical angle) for TIR then angle of incident i will be i_{max}. Applying this condition in eq. (3), we get

$\sin i_{max} = \frac{\mu_1}{\mu_0} \cos\theta_c$ ——— (4)

we know that, $\sin\theta_c = \frac{\mu_2}{\mu_1}$ (by critical angle)

$\cos\theta_c = \sqrt{1-\sin^2\theta_c} = \sqrt{1-\frac{\mu_2^2}{\mu_1^2}}$

or $\cos\theta_c = \sqrt{\frac{\mu_1^2-\mu_2^2}{\mu_1^2}} = \frac{\sqrt{\mu_1^2-\mu_2^2}}{\mu_1}$ ——— (5)

Now from eq. (4) and (5)

$\sin i_{max} = \frac{\mu_1}{\mu_0} \frac{\sqrt{\mu_1^2-\mu_2^2}}{\mu_1} = \frac{\sqrt{\mu_1^2-\mu_2^2}}{\mu_0}$ ——— (6)

$i_{max} = \sin^{-1}\left(\frac{\sqrt{\mu_1^2-\mu_2^2}}{\mu_0}\right)$ ——— (7)

For air medium $\mu_0 = 1$

The acceptance angle $i_{max} = \sin^{-1}\left(\sqrt{\mu_1^2-\mu_2^2}\right)$ → (8)

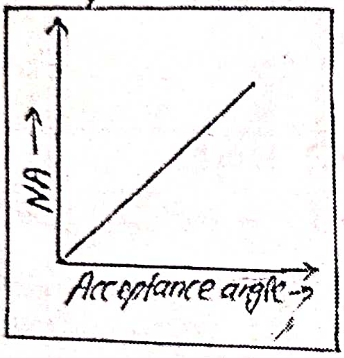
Acceptance cone:—

If all possible direction of acceptance angle are considered at same time we get a cone corresponding to surface known as acceptance cone.

Acceptance cone = $2 i_{max}$

Numerical Aperture:-

Numerical aperture determines the light gathering ability of the fibre. This is also cal[led] the merit of the optical fibre. So, it is a measure of amount of light that can be accep[ted] by the fibre. This is also defined as the sine [of] acceptance angle.



$$NA = \sin i_{max}$$

$$NA = \sqrt{\mu_1^2 - \mu_2^2} \quad \text{——— (1)}$$

The numerical aperture (NA) may a[lso] be evaluated in terms of relative refractive index difference Δ defi[ned] as

$$\Delta = \frac{\text{Refractive I. difference between core [\&] c[ladding]}}{\text{Refractive I. of core of optical fibre}}$$

$$\Delta = \frac{\mu_1 - \mu_2}{\mu_1} = 1 - \frac{\mu_2}{\mu_1}$$

$$\frac{\mu_2}{\mu_1} = 1 - \Delta \quad \text{——— (2)}$$

$$NA = \sqrt{\mu_1^2 - \mu_2^2} = \mu_1 \sqrt{1 - \frac{\mu_2^2}{\mu_1^2}} \quad \text{——— (3)}$$

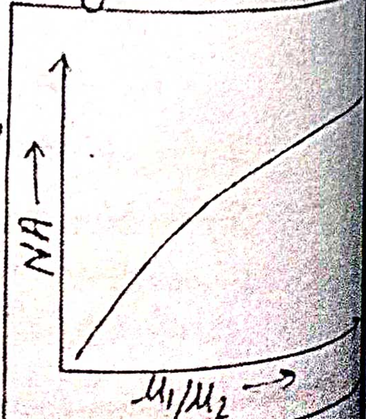
Now from eq. (2) and (3), we get

$$NA = \mu_1 \sqrt{[1 - (1-\Delta)^2]} = \mu_1 \sqrt{[2\Delta - \Delta^2]}$$

The core-cladding refractive index difference is very small due to which Δ^2 is very small hence:

$$\boxed{NA = \mu_1 \sqrt{2\Delta}}$$

** Numerical aperture increases when the ratio $\left(\frac{\mu_1}{\mu_2}\right)$ increases.



Q. What do you understand by attenuation in an optical fibre? [2015-2016, 2020-2021, 2016-2017]

Ans. Attenuation of optical signal in fibre:

When signals guided through an optical fibre, the reduction in amplitude or intensity of light signal is called attenuation or total loss. The losses are measured in (dB) and attenuation is measured in dB/Km. Attenuation in fibre is expressed in terms of optical power of signal.

If P_i and P_o are the power of optical signal at input and output end of fibre cable having length L, then we have

The loss per km is given by

$$P_o = P_i e^{-\alpha L}$$

or

$$\alpha = \frac{-10}{L} \log_{10}\left(\frac{P_o}{P_i}\right) \text{ dB/Km}$$

where α is known as attenuation coefficient. here length L is expressed in kilometers.

** Attenuation is caused by absorption, scattering and bending losses.

Q. Discuss various types of losses in optical fibre. [2016-2017]

Ans. There are three main losses which responsible for attenuation in signal. Imp

(1) Absorption loss (2) Scattering loss

(3) waveguide loss

(1). Absorption loss: Absorption is a major cause of signal loss in an optical fibre during the propagation of signals. The absorption in optical fibre is due to following reasons.

(a) Imperfections in the atomic structure of the fibre material:

Imperfections in the atomic structure

induce absorption by the presence of missing molecules or oxygen defects. It is also induced by the diffusion of hydrogen molecules into the glass fibre.

(b) Intrinsic absorption:

Intrinsic absorption is caused by basic fibre-material properties. If an optical fibre were absolutely pure, with no imperfections or impurities, then all absorption would be extrinsic.

(c) Extrinsic absorption:

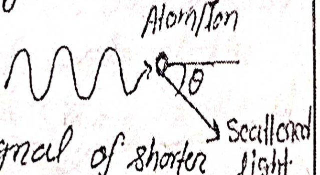
This type of absorption is caused by impurities introduced into the fibre material. Trace metal impurities, such as iron, nickel and chromium are introduced into the fibre during fabrication. Extrinsic absorption is caused by the electronic transition of these metal ions from one energy level to another.

(2) Scattering loss:

This is second main reason of signal attenuation in fibre. In order to change the refractive index of the core of fibre, chemical impurities are added. Moreover, unwanted chemical impurities remain present in fibre during fabrication process. These chemical impurities act as scattering centers for light wave and responsible for signal loss.

It has been observed that Rayleigh scattering loss is inversely proportional to the fourth power of the wavelength of incident light.

$$\text{Scattering loss} \propto \frac{1}{\lambda^4}$$



** It is obious that an optical signal of shorter wavelength suffers more scattering loss than light of longer wavelength. Hence communication is avoided in shorter wavelengths region such as UV and Visible range.

(3) Waveguide loss:- These are called extrinsic losses and can be minimized by taking care during fibre designing and fabrication.

(a) Macro bending loss and Micro bending - cause local stresses in core.

(b) Presence of unwanted chemical impurities - cause variation in local density.

(c) Non uniform core radius - causes unwanted guided modes of light.

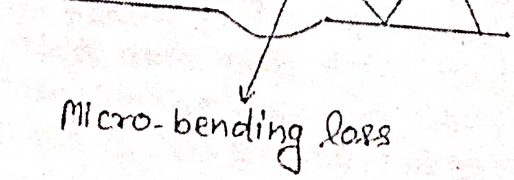
(d) Connecting issues in fibres - cause leakage of optical signal.

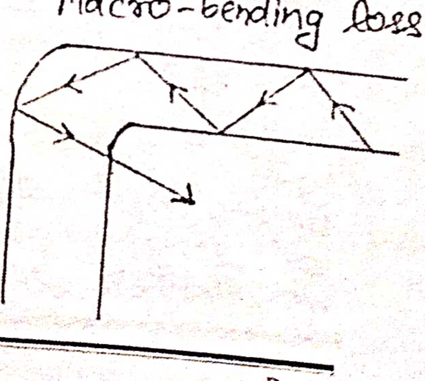
(e) Axial distortion - Cause imperfection at core cladding interface.

Bending loss: Bending the fibre also causes attenuation. There are two types of bending losses.

(a) Macro-bending loss:-
The curvature of the bend is much larger than fibre diameter. As the radius of curvature decreases the loss increases exponentially until it it reaches at a certain critical radius.

(b) Micro-bending loss:- Micro-bending loss is a loss due to small bending. In which either the core or cladding undergoes slight bends at its surface. It is also occurs due to manufacturing defects in the core.



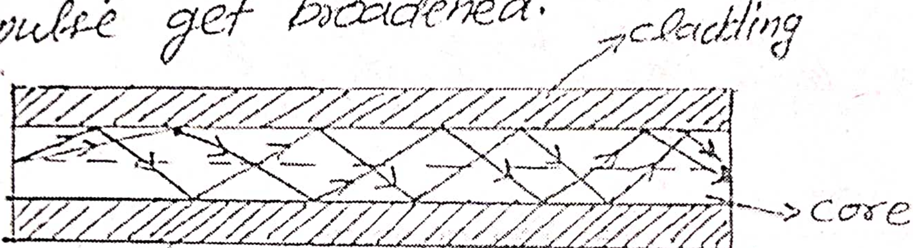


Q. What do you understand by dispersion in an optical fibre? [2017-2018]

Ans. There are three main mechanisms responsible for dispersion in fibre.

1. Intermodal Dispersion or Multi-mode dispersion:

This kind of dispersion arises because different guided modes of light travel with different velocities in fibre. In other words, light of different wavelengths follow different paths and hence different... It means these modes do not reach at the end (output) of the fibre at the same time and therefore pulse get broadened.



2. Intramodal dispersion or material dispersion:

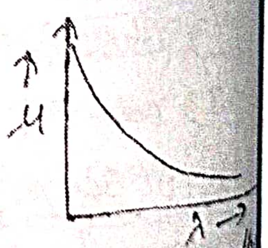
This type of dispersion arises due to material of fibre. The refractive index of core material varies with wavelengths of light waves. It means, same fibre material offers different refractive index to light waves of different wavelengths. Hence light of different wavelengths travel with different velocities.

we know that

$$\mu = \frac{B}{\lambda} + \frac{C}{\lambda^2} + \frac{D}{\lambda^4} \approx \frac{B}{\lambda}$$

&

$$V = \frac{c}{\mu}$$



* The shorter wavelength wave travel slower than the longer wavelength wave. Consequently, a pulse containing different light waves gets broadened as it travels along the core of fibre.

(3). Waveguide dispersion:- It arises due to fibre dimensions like core of radius etc. This dispersion limits the band width of optical signal. The designing parameters of a fibre are related with its V number as:

$$V = \frac{2\pi a}{\lambda_0}\sqrt{\mu_1^2 - \mu_2^2} = \frac{2\pi a}{\lambda_0}(NA)$$

$a \rightarrow$ Radius of the core; $\lambda_0 \rightarrow$ Operating wavelength of light wave

$\mu_1 \rightarrow$ Refractive index of core, $\mu_2 \rightarrow$ Refractive index of cladding.

* If $V \leq 2.405 \rightarrow$ It supports single mode fibre
* If $V > 2.405 \rightarrow$ It supports multimode fibre.
* It is obvious that, higher the value of NA and larger the diameter give rise undesired modes of light. However, single mode fibres are dispersion less due to smaller diameter of core and minimum value of NA of the fibre.
* Number of guided waves or modes in multimode fibres are given below

$$M = \frac{V^2}{2} \rightarrow \text{(Step index multimode fibre)}$$

$$M = \frac{V^2}{4} \rightarrow \text{(Graded index multimode fibre)}$$

Q. A step index fibre has core refractive index 1.468, cladding refractive index 1.462. Compute the maximum radius allowed for a fibre, if it supported only one mode at a wavelength 1300nm. [2015-16]

Solⁿ: We know that, $V = \frac{2\pi a}{\lambda_0}\sqrt{\mu_1^2-\mu_2^2}$

for single mode fibre V-number = 2.405

$$V = \frac{2\times 3.14\times a}{1300\times 10^{-9}}\sqrt{(1.468)^2-(1.462)^2}$$

$$a = \frac{2.405\times 1300\times 10^{-9}}{2\times 3.14\times\sqrt{(1.468)^2-(1.462)^2}}$$

$$a = 3.76\times 10^{-6}\,m$$

$$a = 3.76\,\mu m$$

Q. A communication system uses a 25Km long fibre having a loss of 2.5 dB/Km. The input power is 2500 μW, compute the output power. [2017-2018] V. Imp

Solⁿ: The loss per km is given by

$$dB = -\frac{10}{L}\log_{10}\left(\frac{P_o}{P_i}\right)$$

$$2.5 = \frac{-10}{25}\log_{10}\frac{P_o}{2500\times 10^{-6}}$$

$$\frac{P_o}{2500\,\mu W} = \text{Antilog}\left(-\frac{2.5\times 25}{10}\right)$$

$$P_o = 5.62\times 10^{-7}\times 2500\,\mu W$$

$$P_o = 0.0014\,\mu W$$

Q. Calculate the numerical aperture and the acceptance angle and the critical angle of the fibre from the following data: $\mu_{core} = 1.48$ and $\mu_{cladding} = 1.46$. [2018-19, 2016-17] V. Imp

Sol^n: The numerical aperture NA is given by

(I) $NA = \sqrt{\mu_1^2 - \mu_2^2}$

$= \sqrt{(1.48)^2 - (1.46)^2}$

$\boxed{NA = 0.24249}$

(II) Acceptance angle:

we know that $\sin i_{max} = NA$

$i_{max} = \sin^{-1}(NA)$

$= \sin^{-1}(0.24249)$

$\boxed{i_{max} = 14.03^\circ}$

(III) Critical angle:

we know that $\sin \theta_c = \frac{\mu_2}{\mu_1}$

$\theta_c = \sin^{-1}\left(\frac{\mu_2}{\mu_1}\right)$

$= \sin^{-1}\left(\frac{1.46}{1.48}\right)$

$\boxed{\theta_c = 80.57^\circ}$

Q. A Step Index fibre has core refractive index 1.4[illegible] cladding refractive index 1.46. If the operating wavelength of the rays is 0.85 μm, calculate [illegible] cut-off parameter and the no. of modes which t[illegible] fibre will support. The diameter of core = 50 μ[illegible]

or

A step Index fibre has core and cladding refrac[illegible] indices 1.466 and 1.460 respectively. If the wavel[illegible] of light (0.85 μm) is propagated through the f[illegible] of core diameter 50 μm. Find the normaliz[illegible] frequency and number of mode supported by the f[illegible]

Solution - we know that

Cut off parameter or Cut off number or Nor[illegible] frequency or Cut off is given by

$$V = \frac{2\pi a}{\lambda}\sqrt{\mu_1^2 - \mu_2^2}$$

Given that

radius (a) $= \frac{50}{2} = 25\,\mu m$

$\lambda = 0.85\,\mu m$, $\mu_1 = 1.466$, $\mu_2 = 1.4[illegible]$

$$V = \frac{2 \times 3.14 \times 25\,\mu m}{0.85\,\mu m}\sqrt{(1.466)^2 - (1.46)^2}$$

$$= 184.706\sqrt{2.1492 - 2.1316}$$

$$= 184.706 \times 0.13266$$

$$\boxed{V = 24.503}$$

Number of modes $N = \frac{V^2}{2} = \frac{(24.503)^2}{2} \approx 300.1[illegible]$

$N \approx 300$

LASER

Introduction:

LASER is an acronym for Light amplification by stimulated emission of radiation which describes the theory of laser operation. Albert Einstein published the theoretical basis for the laser in 1917, but it was only in 1960. The first functioning laser was constructed be T.H. Maiman in california, using a ruby crystal to produce laser light.

Q. What are the properties of Laser?

Ans. Laser light properties:

(a) Highly monochromatic: The light emitted from a laser is monochromatic, that is, it is of one wavelength (color).

(b) Highly intense: All the power or energy is concentrated with in a small area.

(c) Collimated: It is formed in an optical cavity between two parallel mirrors which constrain the light to a path perpendicular to the surfaces of the mirrors.

(d) Unidirectional: which implies laser light is of very small divergence. It seems that laser light comes from the resonant cavity and wave propagating along the optical axis only.

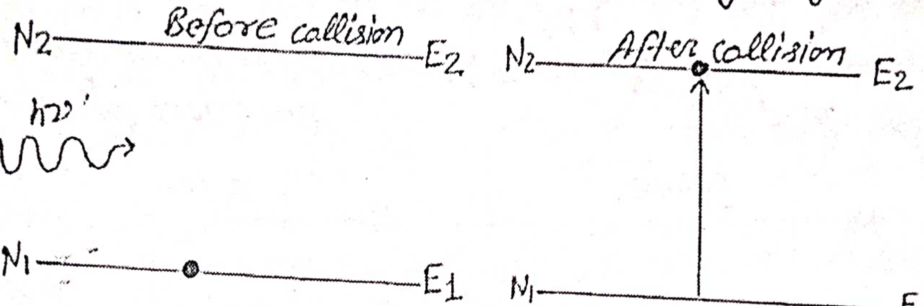
(e) Highly coherent: which means the waves of light emitted have a constant relative phase.

Q. What is the principle of laser? [2015-2016]

Ans. It is based on the principle of stimulated emission of radiation, with light amplification. For stimulated emission of radiation to take place, the population of atom in higher energy level should be greater than the lower energy level. This can be achieved by pumping.

Q. Discuss about absorption of radiation, spontaneous emission and stimulated emission of radiation. Imp

Ans. Absorption of radiation: Let us consider two energy levels 1 and 2 of an atom with energies E_1 and E_2 as shown in following figure.



* An atom residing in energy state E_1 can absorb a photon and go to excited state with energy E_2, provided the photon energy $h\nu$ equals the energy difference $(E_2 - E_1)$. Therefore

$$h\nu = E_2 - E_1$$

or $$\nu = (E_2 - E_1)/h \quad [h \rightarrow \text{Planck's Const.}]$$

This process is called stimulated absorption or simply absorption.

* The rate of absorption or rate of transition $1 \rightarrow 2$ is proportional to N_1 and also to energy density $u(\nu)$.

$$P_{12} = N_1 B_{12} u(\nu)$$

$B_{12} \rightarrow$ Einstein's coefficient of absorption.

Spontaneous emission:

Let us now consider an atom initially is in the higher state E_2 (Shown in following figure) higher energy state E_2 is not a stable state.

After a short interval of time (10^{-8} sec), the atom jumps to ground state E_1 by emitting a photon of frequency ν. This is known as spontaneous emission of radiation.

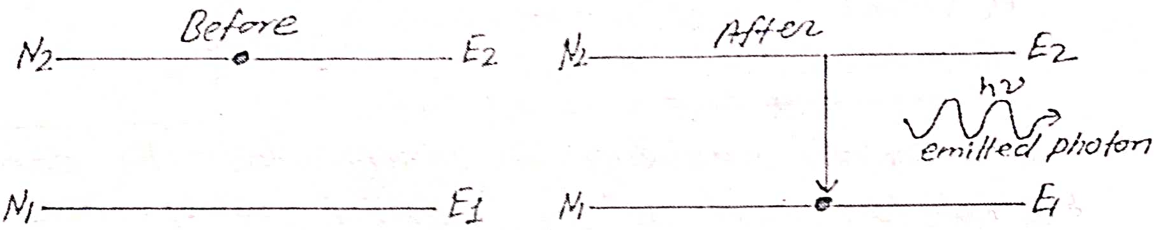
* The spontaneous emission is random in character.

Therefore spontaneous emission is incoherent.

* The probability of spontaneous emission transition 2→1 is directly proportion to number of atoms in upper energy level.

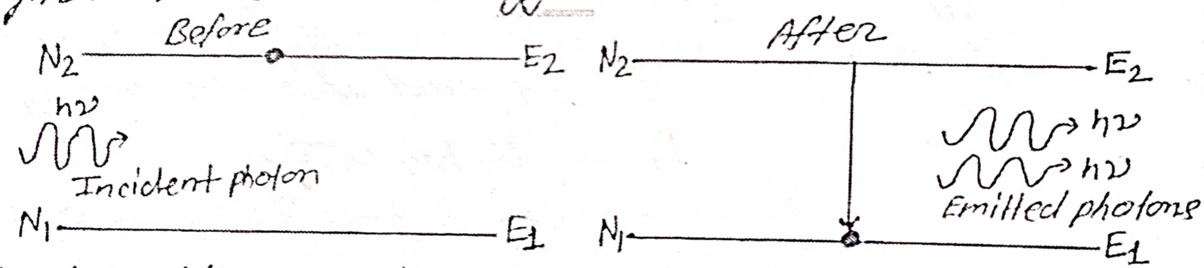
$$P_{21} = N_2 A_{21}$$

A_{21} → Einstein's coefficient of spontaneous emission of radiation.



Stimulated Emission:

According to Einstein, an atom in an excited energy state, under the influence of photon of frequency ν incident upon it, transits from higher to lower energy state.



* This transition produces a second photon which is identical to incident photon with respect to frequency, phase and propagation direction. This process is called stimulated or induced emission.
* The probability of stimulated emission transition 2→1 is directly proportional to number of atoms in upper energy level N_2 and energy density $u(\nu)$.

$$P_{21} = N_2 B_{21} u(\nu)$$

B_{21} → Einstein's coefficient for stimulation.

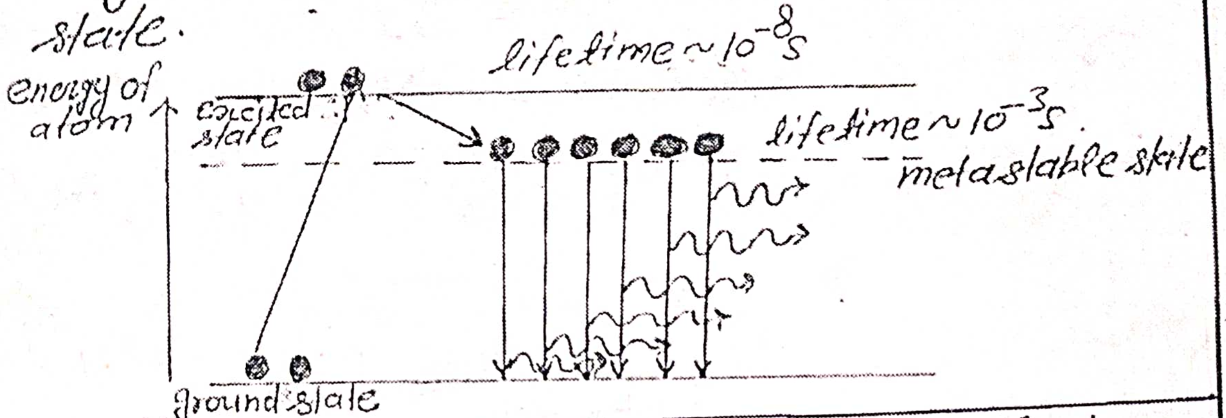
Q. Differentiate between spontaneous and stimulated emission of radiation. Which one is required for laser action? [2017-2018, 2018-2019]

Ans. Difference between spontaneous emission and stimulated emission.

S.No.	Spontaneous emission	Stimulated emission
1.	The emitted photons from various atoms have no phase relationship between them.	The emitted photons have same frequency and are in phase with incident photons.
2.	Emitted radiation are non-coherent.	Emitted radiation are coherent.
3.	Emitted photons can move in any direction.	For every incident photon, there are two outgoing photons moving in same direction.
4.	The rate of emission is proportional to number of atoms in excited state E_2.	The rate of emission is proportional to number of atoms in excited state E_2 and energy density of incident radiation.
5.**	Spontaneous emission disfavours laser action.	**Stimulated emission favours laser action.

Q. Define metastable state. [2015-2016, 2016-2017]

Ans. Metastable state:
It is also the excited state but having life time of 10^{-3} seconds. The population inversion occurs only in between the metastable state and lower state.

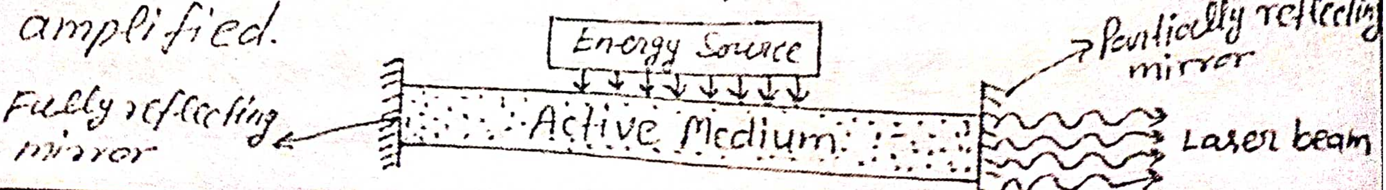


Q. What are the necessary conditions for lasing action?

Ans. 1. The rate of emission must be greater than the rate of absorption.
Due to providing external energy the number of atoms in higher energy state is made greater than that in lower energy state, the emission rate will become greater than the absorption rate.

2. The probability of spontaneous emission must be negligible in comparison to the probability of stimulated emission.
If certain atoms are excited to metastable state, the probability of spontaneous emission will be quite negligible.

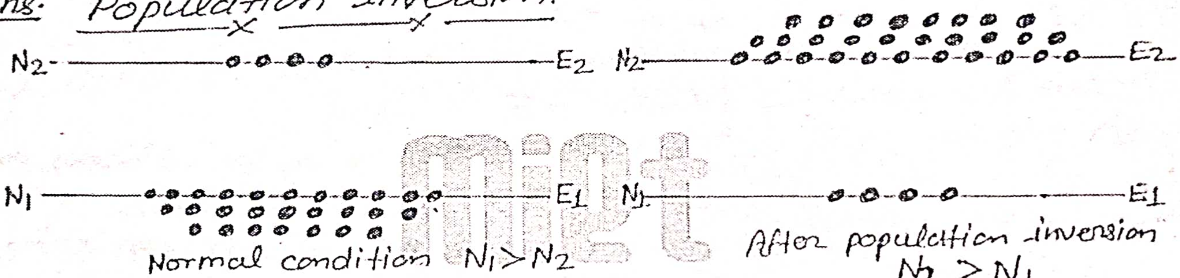
3. The coherent beam of light must be sufficiently amplified.



* The photons emitted by stimulating emission are reflected back and fourth in the laser medium by these mirrors so that they are confined within the systems long enough to allow them to stimulate further emission from other excited state. Due to frequent reflection of photons the energy of photons will be amplified. By which the intense beam of light will release through partially reflecting mirror.

Q. What do you understand by population inversion? Imp

Ans. Population inversion:



* For the laser action to take place, the higher energy levels should be more populated than the lower energy levels, i.e., $N_2 > N_1$. This condition is called population inversion.

Q. What are Einstein's coefficientes? Establish a relation between them. Also discuss the essential conditions for laser action. [2015-16, 2018-19] Imp

Ans. Einstein's coefficientes:-

Einstein's coefficientes are mathematical quantities which are a measure of the probability of absorption or emission of light by an atom or molecule. The Einstein A coefficient is related to the rate of spontaneous emission of light and the

Einstein B coefficients are related to the absorption and stimulated emission of light.

Einstein's coefficients of radiation: The rate of absorption or rate of transition 1→2 is proportional to N_1 and also to energy density $u(\nu)$.

$$P_{12} = N_1 B_{12} u(\nu)$$

where B_{12} → Einstein's coefficient of absorption

Einstein's coefficient of spontaneous emission:

The probability of spontaneous emission transition 2→1 is directly proportional to number of atoms in upper energy level

$$P_{21} = N_2 A_{21}$$

A_{21} → Einstein's coefficient of spontaneous emission

Einstein's coefficient of stimulated emission:

The probability of stimulated emission transition 2→1 is directly proportional to number of atoms in upper energy level N_2 and energy density $u(\nu)$

$$P_{21} = N_2 B_{21} u(\nu)$$

B_{21} → Einstein's coefficient of stimulated emission

Relation between Einstein's coefficients:

Let N_1 and N_2 be the number of atoms at any instant in the state 1 and 2 respectively. The probability of absorption that the number of atoms in state 1 absorbs a photon and rise to state 2 per unit time is given by

$$P_{12} = N_1 B_{12} u(\nu) \quad \text{———} (1)$$

The total probability due to emission (spontaneous and stimulation) from higher to lower state

$$P_{21} = N_2 A_{21} + N_2 B_{21} u(\nu) \quad \text{---(}$$

At the thermal equilibrium, the absorption & emission probabilities are equal, we can

$$P_{12} = P_{21}$$

$$N_1 B_{12} u(\nu) = N_2 A_{21} + N_2 B_{21} u(\nu)$$

$$u(\nu)(N_1 B_{12} - N_2 B_{21}) = N_2 A_{21}$$

or

$$u(\nu) = \frac{N_2 A_{21}}{(N_1 B_{12} - N_2 B_{21})}$$

$$u(\nu) = \frac{N_2 A_{21}}{N_2\left(\frac{N_1}{N_2} B_{12} - B_{21}\right)}$$

$$u(\nu) = \frac{A_{21}}{B_{21}\left[\left(\frac{N_1}{N_2}\right)\left(\frac{B_{12}}{B_{21}}\right) - 1\right]}$$

$$u(\nu) = \frac{A_{21}}{B_{21}}\left[\frac{1}{\left(\frac{N_1}{N_2}\frac{B_{12}}{B_{21}} - 1\right)}\right]$$

Probability of stimulated absorption is equal to probability of stimulated emission:

$$B_{12} = B_{21}$$

Then from eqn (3) $u(\nu) = \frac{A_{21}}{B_{21}}\left\{\frac{1}{\left(\frac{N_1}{N_2} - 1\right)}\right\}$

According to Maxwell Boltzmann's distribution

$$N_1 = N_0 e^{-E_1/KT}$$

$$N_2 = N_0 e^{-E_2/KT}$$

$N_0 \rightarrow$ Total number of atoms present

$K \rightarrow$ Boltzmann's constant

$$\frac{N_1}{N_2} = e^{(E_2-E_1)/KT}$$

But $E_2 - E_1 = h\nu$

then $$\frac{N_1}{N_2} = e^{(h\nu)/KT} \quad \text{———— (5)}$$

Now from eq. (4) and (5)

$$u(\nu) = \frac{A_{21}}{B_{21}} \frac{1}{(e^{(h\nu)/KT} - 1)} \quad \text{———— (6)}$$

According to Planck's law, the energy density of radiation $u(\nu)$ is given by,

$$u(\nu) = \frac{8\pi h \nu^3}{c^3} \left(\frac{1}{(e^{(h\nu)/KT} - 1)} \right) \quad \text{———— (7)}$$

on comparing equation (6) and (7), we get

$$\boxed{\frac{A_{21}}{B_{21}} = \frac{8\pi h \nu^3}{c^3}} \quad \text{———— (8)}$$

** From above equation it is clear the ratio between spontaneous emission coefficient and stimulated emission coefficient is proportional to ν^3. It means probability of spontaneous emission increases rapidly with the increasing energy difference between two states.

** This shows that probability of spontaneous emission is very large compared to stimulated emission.

Imp.

Q. What are the main components of LASER?

Ans. There are three main components of basic laser system:

(a) Active medium (b) Energy source or pumping
(c) Optical resonator or resonant cavity

(a) Active medium:

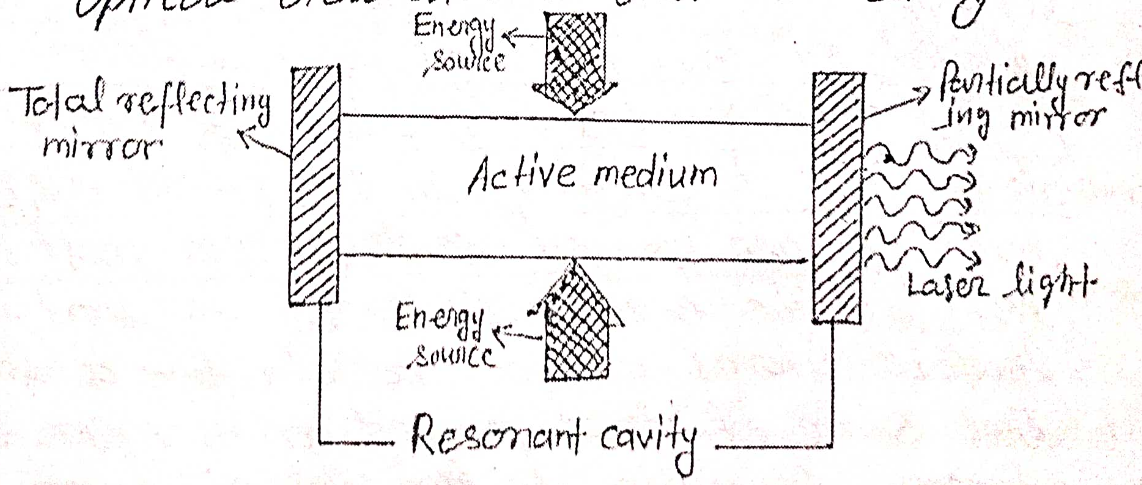
This is the basic material in which atomic transition take place. When the active medium is excited, it achieve population inversion. Active medium decide the types of laser; solid, liquid and gaseous state laser. It also determine the shape, size and output of laser.

(b) Energy source or pumping:

The excitation mechanism raises the atoms, molecules or ions into their excited state. The energy source or pumping is required for lasing action.

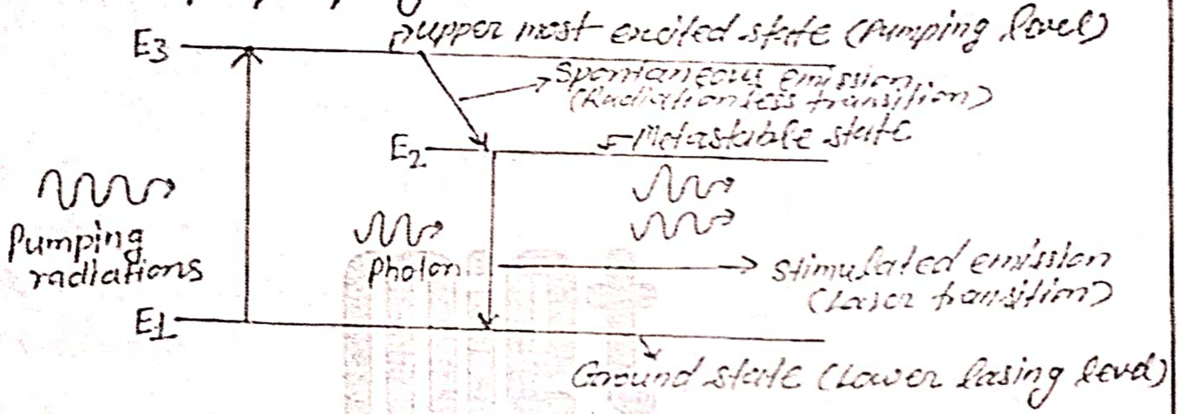
(c) Optical resonator or resonant cavity:

The optical resonator consists of two reflecting mirrors R_1 and R_2. The mirror R_1 is fully reflecting while the other mirror R_2 is partially reflecting. The active medium is placed between them. These mirrors act as an optical resonator or resonant cavity.



Q. What do you understand by three and four level lasers? What is the advantage of the four level laser over three level laser? [2016-17, 2018-19]

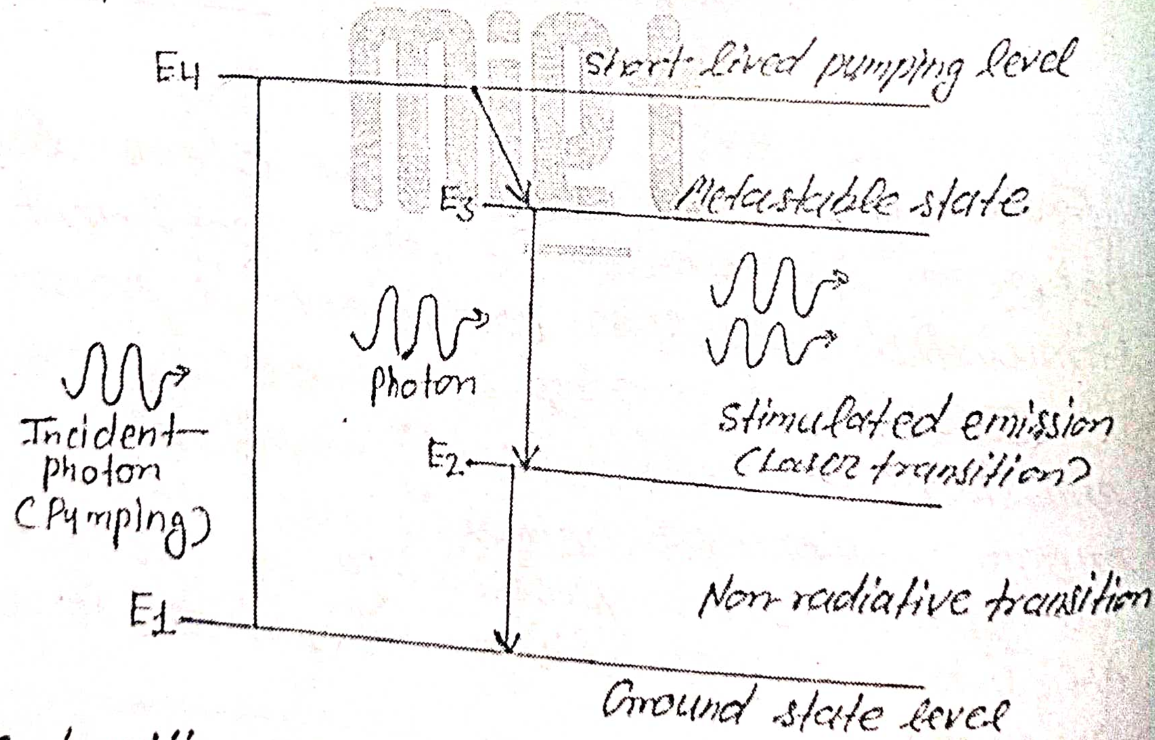
Ans: In this laser system, upper energy level E_3 is known as pumping level and ground energy level E_1 is known as lower lasing level. The intermediate excited state is called upper lasing level and its lifetime 10^{-3} sec which is greater than the lifetime of pumping level E_3 (10^{-8} sec).



Initially the atomic population of ground state E_1 is maximum. When the atoms in ground state are subjected to an intense (pumping) radiation of pumping frequency $(E_3-E_1)/h$, a large number of atoms that is originally in the ground energy level E_1 are pumped to the upper most energy level E_3. The excited state E_3 is short lived, therefore atoms cannot remain for a longer time. Some of these pumped atoms make spontaneous transition to the lowest energy level E_1 but most of them decay rapidly into an intermediate metastable state E_2. The transition between E_3 to E_2 is radiation less or non radiative. In this transition energy is converted to the system as heat. As the energy level E_2 is long lived, the atomic population metastable state E_2 goes on increasing grad while the atomic population of ground level E_1 goes on decreasing. Due to contineous pumping the population inversion is achieved between E_2 E_1 levels. Then photon ($E_2 - E_1 = h\nu$) will initi the stimulation emission which cause the formation of laser light.

Concept of four level Laser:-

In this laser system pumping excites some the atoms from the ground level E_1 to a lived upper most level E_4.



The transition E_4 to E_3 as well as E_2 to E_1 are radiation less transition and much faster compa to E_3 to E_2. As the lower lasing level E_2 not the ground state, but very much above ground level E_1, it is virtually vacant o from any atoms. Due to contineous pumping, inversion is achieved between the levels E_3 and E_2. Then photon of energy $h\nu = (E_3 - E_2)$ start a chain of stimulated emission, atom come down to state E_2 from state E_3, laser beam is produced.

Advantage of four level laser over three level laser system:

1. Pumping needed for the excitation of atoms is much lower than the three level laser.
2. The efficiency of four level lasers is much better than that of a three level laser.
3. Contineous operation is possible.

Q. Describe the principle and working of Ruby laser system. Compare it with He-Ne laser. [2015-16, 2016-17, 2020-21] V. Imp

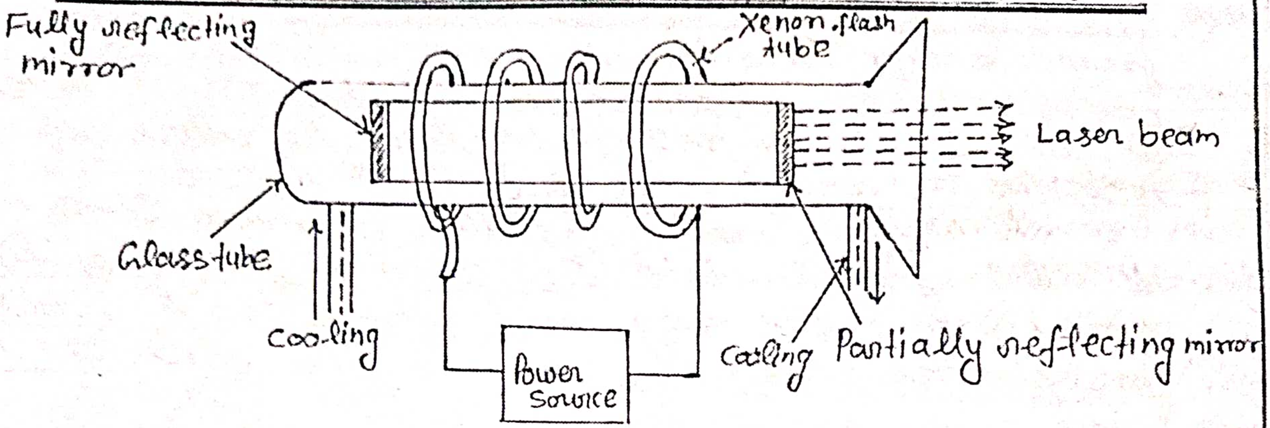
Ans. Ruby Laser:-

History and construction:

This is the first laser developed by T.H. Maiman in 1960 and is the solid laser. A solid laser can be made by introducing impurity atoms into a crystal (by doping method).

It consists of a pink ruby cylindrical rod whose ends are optically flat and parallel. One end is fully silvered and the other is only partially silvered. The partially reflecting end can be used as a window for laser output. This work as Resonant cavity.

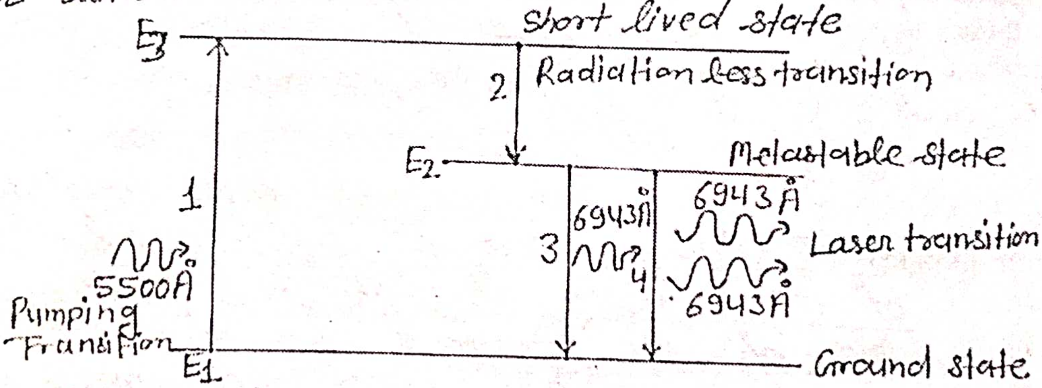
Ruby rod is surrounded by a helical xenon flash tube, which provides light to raise chromium ions to upper energy levels.



Ruby rod is surrounded by a helical xenon flash tube, which provides light to raise chromium ions to upper energy levels.

Principle: It is based on the principle of 3-level laser system.

Working:– The ruby rod is a crystal of aluminium oxide (Al_2O_3) doped with 0.05% chromium oxide (Cr_2O_3), so that some of the Al^{+++} ions are replaced by Cr^{+++} ions. These "impurity" chromium ions give pink colours to the ruby and give rise to laser action.



The crystal is in the form of cylindrical rod which is 2 to 20 cm in length and nearly 0.1 to 2.0 cm in diameter.

The energy level diagram consists of an upper short-lived energy level E_3 above its ground energy level E_1, the energy difference E_3-E_1 corresponds to a wavelength of about 5500Å. There is an intermediate excited-state level E_2 which is metastable having a life time of 10^{-3} sec.

Normally, most of the chromium ions are in the ground state E_1. When a flash of light falls upon the ruby rod, the 5500 Å radiation photons are absorbed by the chromium ions which are pumped to the excited state E_3. The excited ions give up, by collision, part of their energy to the crystal lattice and decay to the metastable state E_2. The transition 2 is a radiation less transition. E_2 is the metastable state in which population is increased. When an excited ion passes from the metastable state to the ground state, it emits a photon of wavelength 6943 Å. This photon is the cause of further stimulation of fresh photon which is in same phase with stimulating photon. Now the transition 4 is the laser transition. The process is repeated again and again because the photons repeatedly move along the crystal, being reflected from its ends.

The photons thus multiply. When the photon beam becomes sufficiently intense, part of it emerges through the partially silvered end of the crystal.

Drawbacks of Ruby laser over He-Ne laser:—

1. Ruby laser produces a pulsed laser beam, while He-Ne laser produces a contineous laser beam.
2. Ruby laser is a three level laser and He-Ne laser is a four level laser.

3. In Ruby laser, optical pumping is used while in He-Ne laser, electric discharge method is used.
4. Cooling arrangement is required in Ruby laser and there is no cooling arrangement in He-Ne laser.
5. Ruby laser light has wavelength of 6943 Å while He-Ne laser has 6328 Å.

V. Imp

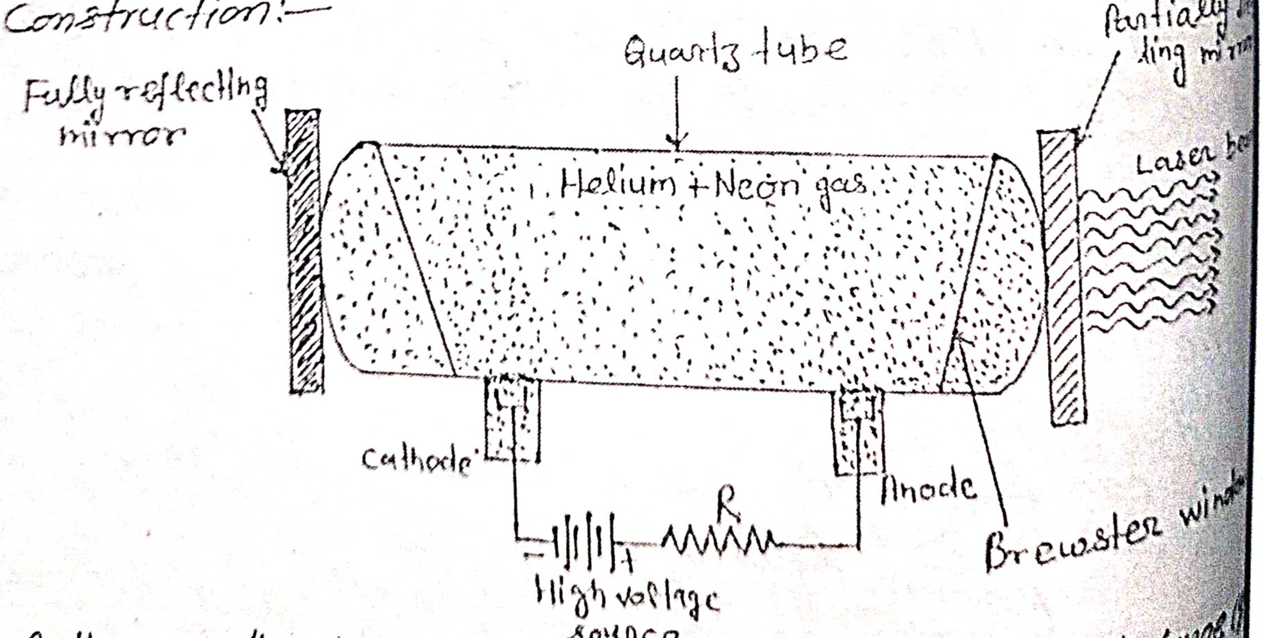
Q. Illustrate the construction and working of He-Ne laser. Discuss important applications of laser.

[2015-16, 2016-17, 2...

Ans. Helium Neon Gas Laser (four level transition ...)

Introduction: Ali Jawan invented He-Ne gas laser in 1960. It is the first gas laser which was operated successfully. To get continuous and intense beam of laser, gas lasers are used. The spectral lines in a gas laser are narrow and well defined as compared to solid in which absorption bands are broad.

Construction:—



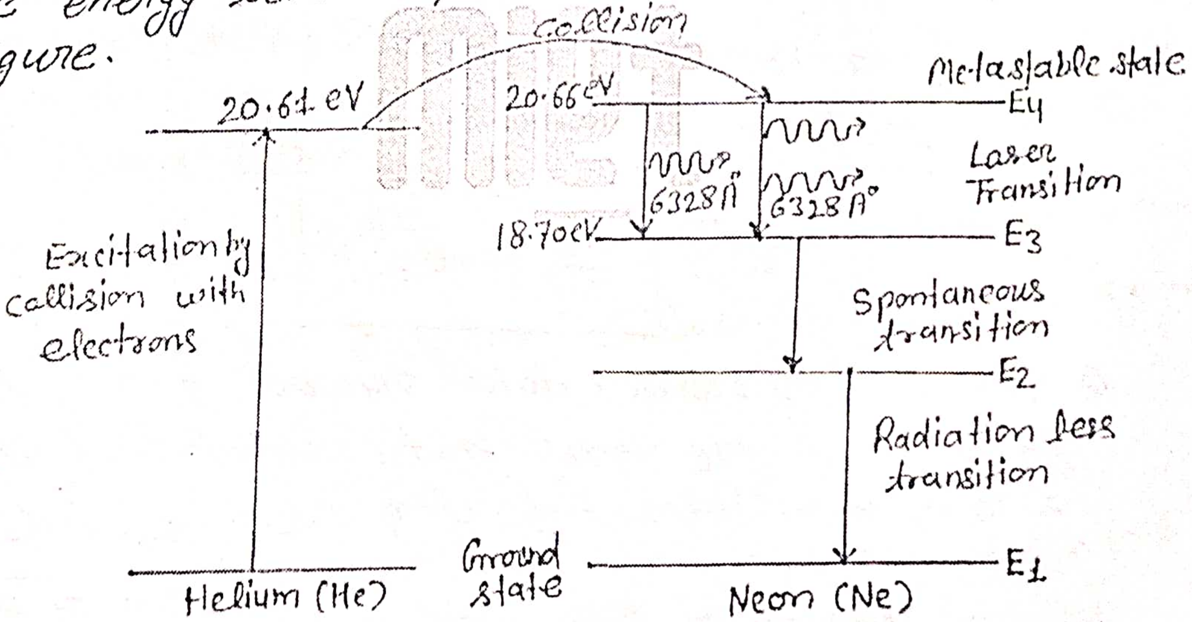
Active medium:— He-Ne laser consists of a discharge tube containing the Helium and Neon in the ratio 7:1 at a total pressure of about 1 torr (1 mm ...

Resonant cavity:- Active medium enclosed between set of mirror one is fully reflective and other is partially reflective this forms the plane parallel resonant cavity. The end faces of discharge tube are inclined at the polarizing angle so that the laser light is plane polarized. Such an arrangement is known as Brewster window.

Pumping mechanism:

A powerfull generator (R.F. Generator) is used to produce a discharge in the gas. Actual lasing atoms are neon atoms while Helium is used just for selective pumping of the upper laser level of Neon.

Working:- He-Ne gas laser is a four level laser. The energy levels of He&Ne atoms are shown in figure.



when an electric discharge passes through gas, the electrons in discharge tube collide with He and Ne atoms as He atoms are lighter than the Ne atoms they are easily excite to metastable state 20.61 eV and Ne atom to 20.66 eV respectively above the ground state. Some of excited He atoms transfer their energy to unexcited Ne atoms by collisions. Thus lighter He-atoms help in achieving population inversion in heavier Ne atoms.

When an excited Ne atoms drop down spontaneously from metastable state at 20.66 eV to lower energy state at 18.70 eV, it emits a photon (6328 Å) in visible region. This photon travels through mixture of gas and if it is moving parallel to axis of tube, is reflected back and fourth motion by reflector ends until it stimulates an excited Ne-atom and causes it to emit a fresh 6328 Å photon in phase with stimulating photon.

The photon emitted spontaneously which do not move parallel to axis of tube escape through sides of tube. The stimulated transition from 20.66 eV level to 18.70 eV level is the laser transition. The photons will knock out two more photons and the process is repeated again and again then photon multiplies. when gain is achieved, a portion of it escapes through partially silvered end.

The Ne-atoms drop down from 18.70 eV to lower metastable state through spontaneous emission emitting incoherent light. From level E_2, Neon atoms are brought to ground state through collision with walls of tube. Hence final transition is radiation less.

Applications of He-Ne laser:-

(1). It is used in laboratory experiments to produce interference and diffraction patterns.

(2). It is used in optical communications without fibre for moderate distance.

Some important applications of LASER:

Industrial:- In industries and thechnical fields the laser beam is used for drilling fine holes in diamonds, teeth, paper clips, hard sheets and even in human hairs.

* Laser cutting technology is widely used in the fabrication of space craft.
* Laser welding used to weld in the metal industry for neat and clean weld. It has been observed that finger prints can be detected under laser light where the normal method of obtaining finger prints through dusting powder is ineffective.

In medical:

* LASIK (laser in-sity (study at same place) keratomileusis) is eye surgery that permanently changes the shape of the cornea is done to improve vision and reduce a person's need for glasses or contact lenses.
* In treatment of skin related problems like unwanted hair removal, tattoo removal etc.
* Micro-surgery (laparoscopic surgery) has become possible due to narrow angular spread of the laser beam.

In optical communication:-

* Laser has an important application in optical communication. Optical communication is a method of transmitting information from one place to another by sending highly intense laser light through an optical fibre.

In Atmospheric Studies:

* Laser remote sensing is frequently used for precise measurement of ozone in the atmosphere. Atmospheric optics uses lasers for the detection of traces of pollutant gases, temperature, water vapour concentration.

Holography and LIDAR:

* We can get 3-D photography using laser.
* LIDAR (Light Detection and Ranging) is a method of measuring distances by illuminating the target with laser light.

Q. Calculate the population ratio of two states in laser that produces light of wavelength 6000 Å at 300 K. [2018-2019]

Solution: We know that population of two states at temperature T K is given by

$$\frac{N_2}{N_1} = e^{-(E_2-E_1)/KT} \quad [K\text{- Boltzmann constant}]$$

$$E_2-E_1 = h\nu = \frac{hc}{\lambda}$$

$$E_2-E_1 = \frac{6.62\times10^{-34}\times3\times10^{8}}{6\times10^{-7}} \text{ J}$$

$$= 3.31\times10^{-19} \text{ J}$$

or $$E_2-E_1 = \frac{3.31\times10^{-19}}{1.6\times10^{-19}} \text{ eV} = 2.07 \text{ eV}$$

Here $K = 8.6\times10^{-5}$ eV/K, and $T = 300$ K

at 300K $$\frac{N_2}{N_1} = e^{-(E_2-E_1)/KT}$$

$$= e^{-\left(\frac{2.07}{8.6\times10^{-5}\times300}\right)}$$

$$\boxed{\frac{N_2}{N_1} = e^{-80}}$$

Q. In a Ruby Laser, total number of Cr^{+3} ions 2.8 × 10^{19}. If the laser emits radiation of wavelength 7000 Å, then calculate the energy of the laser pulse.

Solution: Energy of laser pulse E = total no. of ions × energy of one photon

$$E = nh\nu = \frac{nhc}{\lambda}$$

Here, $h = 6.6\times10^{-34}$ J.sec, $c = 3\times10^{8}$ m/s, $\lambda = 7000$ Å = 7 × 10^{-7} m
and $n = 2.8\times10^{19}$

$$E = 2.8\times10^{19}\times\frac{(6.6\times10^{-34}\times3\times10^{8})}{7\times10^{-7}} \text{ J}$$

$$\boxed{E = 7.94 \text{ J}}$$

Question: Calculate the Energy and momentum of a photon of a laser beam of wavelength 6328 A°.

Solution: The Energy of photon

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

Given $\lambda = 6328\,A° = 6328 \times 10^{-10}\,m$

we know $h = 6.62 \times 10^{-34}$ J-sec $c = 3 \times 10^{8}$ m/sec

$$E = \frac{6.62 \times 10^{-34} \times 3 \times 10^{8}}{6328 \times 10^{-10}}$$

$$E = 3.14 \times 10^{-19}\,J$$

$$\text{or } E = \frac{3.14 \times 10^{-19}}{1.6 \times 10^{-19}}\,eV = 1.962\,eV$$

momentum of photon $p = \frac{h}{\lambda} = \frac{6.62 \times 10^{-34}}{6328 \times 10^{-10}}$

$$= 1.05 \times 10^{-27}\ \text{Kg m/sec}$$

Question: In a CO_2 laser, the Energy difference between two levels is 0.121 eV, Calculate the frequency of radiation.

Solution: We know $E_1 - E_2 = h\nu = \Delta E$

$$\nu = \frac{\Delta E}{h} = \frac{0.121\,eV}{6.62 \times 10^{-34}} = \frac{0.121 \times 1.6 \times 10^{-19}}{6.62 \times 10^{-34}}$$

$$= 0.029 \times 10^{15}\,s^{-1}$$

5 Year's

University Paper Questions

(AKTU Question Bank)

5 Years AKTU University Examination Questions		Unit-4	
S. No	Questions	Session	Lecture No
1	What is the principle of operation of an optical fibre?	2018-2019	17-26
2	With the help of well labeled diagram, name the components of an optical fiber.	2020-2021	17-26
3	What do you understand by an optical fibre and discuss its classifications.	2018-2019	17-26
4	Discuss the structure of an optical fibre. What are various types of optical fibres? Explain their advantages and disadvantages.	2015-2016, 2018-2019	17-26
5	What do you understand by the mode of an optical fibre? Discuss the merits and demerit of single (mono) mode fibre over multimode counterpart.	2018-2019	17-26
6	What is the condition for number of modes in single and multimode optical fibre?	2015-2016	17-26
7.	Why model dispersion is negligible in single mode fiber?	2019-2020	17-26
8	What do you mean by critical angle, acceptance angle, acceptance cone and numerical aperture? Derive expression for them.	2015-2016	17-26
9	What do you understand by attenuation in an optical fiber?	2015-2016 2020-2021	17-26
10	What do you understand by dispersion in an optical fiber?	2017-2018	17-26
11	A step index fibre has core refractive index 1.468, cladding refractive index 1.462. Compute the maximum radius allowed for a fibre, if it supported only one mode at a wavelength 1300 nm.	2015-2016	17-26
12	A communication system uses a 25 km long fiber having a loss of 2.5dB/km. The input power is 2500μW, Compute the output power.	2017-2018	17-26
13	What is the principle of laser?	2015-2016	17-26
14	Differentiate between spontaneous and stimulated emission of radiation. Which one is required for laser action?	2017-2018, 2018-2019	17-26
15	Define metastable state.	2015-2016, 2016-2017	17-26
16	What are Einstein's coefficients? Establish a relation between them. Obtain a relation between them. Also discuss the essential conditions for laser action.	2015-2016, 2016-2017	17-26
17	What do you understand by three and four level lasers? What is the advantage of three level laser over four level laser?	2016-2017, 2018-2019	17-26
18	Describe the principle and working of Ruby laser system. Compare it with He-Ne laser.	2015-2016 2019-2020	17-26
19	Illustrate the construction and working of He-Ne laser? Discuss important applications of laser.	2015-2016 2016-2017 2020-2021	17-26
20	Calculate the population ratio of two states in He-Ne laser that producers light of wavelength 6000A at 300K.	2018-2019	17-26
21	In a Ruby Laser, total number of Cr+3 ions is 2.8×10^{19}. If the laser emits radiation of wavelength 7000 A^0, then calculate the energy of the laser pulse.	2015-2016	17-26