Lecture 1: Overview

Light Amplification by Stimulated Emission of Radiation

$\}$ = 10^{14} to 10^{15} Hz

$c = 3 \times 10^{8}$ m/s

λ = 10 μm to 300 nm

Space: $\lambda \sim$ 1 μm

Time: cycle $T \sim 1$ fs = 10^{-15} s

Frequency: 1 Hz

Assume:

$E \sim 1mJ$ | $\sim 10\ fs = 10_{\square 14} s$ $a \sim 10 \propto m$

then:

$$P = \frac{E}{|}$$

$$P \sim \frac{1mJ}{10\ fs} = 10_{11} W = 100GW$$

$$I = \frac{P}{\square a_2}$$

$$I \sim \frac{10_{11} W}{\square (10_{\square 3})_2 cm_2} \sim 10_{16} \frac{W}{cm_2} \sim 10PW / cm_2$$

Directionality:

Diffraction Limit:

$$\theta \sim \frac{\lambda}{a} = \frac{1 \propto m}{1mm} \sim 10_{-3} rad$$

- Communication

  If 1% is used for the information band,→10^2 to 10^3 more capacity than in existence

  telephone conversation ~ 4 KHz

  TV program ~ 5 MHz

- Optical Computing

- Surgery, Phototherapy – noninvasive

- Fusion - High Power
  - Tight Focus

- Laser spectroscopy, metrology

Types of Lasers

1. Pulsed: $fs\ (10_{-15}s)$, $ps\ (10_{-12}s)$, $ns\ (10_{-9}s)$

   Continuous Wave (CW)

2. Single-mode & Multi-mode

Pumps

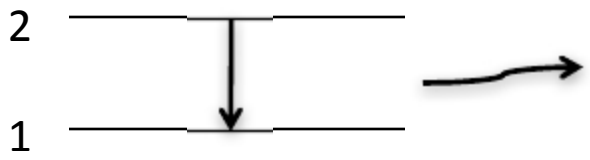
i) Optical pumping (flash lamp)
ii) Electrical discharge
iii) Current (semiconductor)
iv) Chemical Reactions

Historical

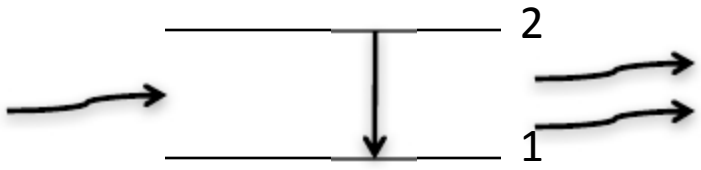
- Einstein in 1917

i) absorption

ii) spontaneous emission



iii) stimulated emission



Shawlow, Townes (1958) – “Infrared and Optical Masers”; *Physical Review* + 2 patents

Basov, Prokhorov (1955) 3-level system & optical pumping

- NH3 (ammonia) Maser (first proposed by Townes in 1951; patent filed in 1955)

Basov, Prokhorov and Townes shared *Nobel Prize in 1964*

Bloembersen (1956) 3-level system

Ted Maiman (1960; Hughes) - Ruby Laser – first demonstrated laser (published in *Nature*)

Other names: Robert Dicke, Gordon Gould, Joseph

Physicists & Engineers

R - Power Reflectivity
L - Loss per pass through the windows
G - Power gain through the tube per pass

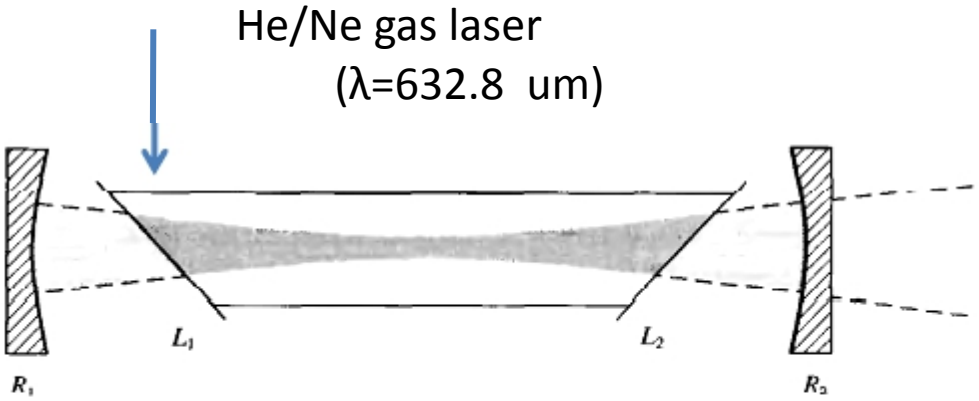


FIGURE 0.1. Schematic of a simple laser.

$$G(1- L_2)R_2(1- L_2)G(1- L_1)R_1(1- L_1) \geq 1$$

-Condition for laser oscillations

Lasers

Solid	Liquid	Gas
Ruby	dye	CO_2 ~ 10µm
Nd: YAG	.	Ar^+
Nd: glass	.	Kr^+
Diode	.	He-Ne
Ti: Sapphire	.	N_2
.	.	.