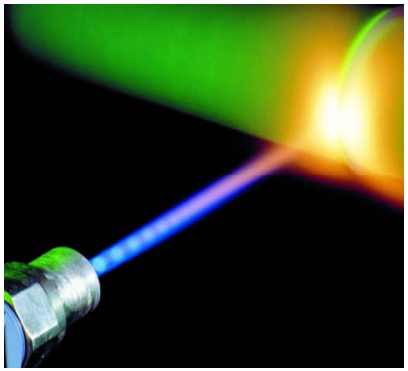
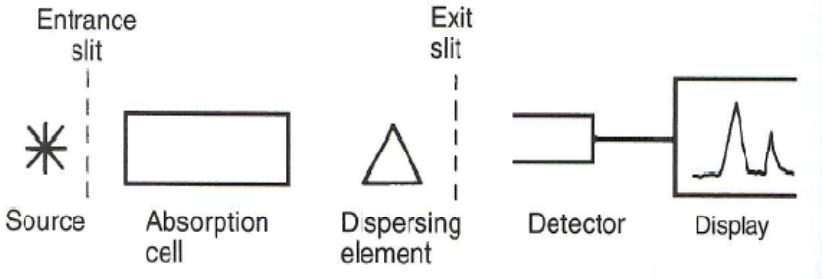
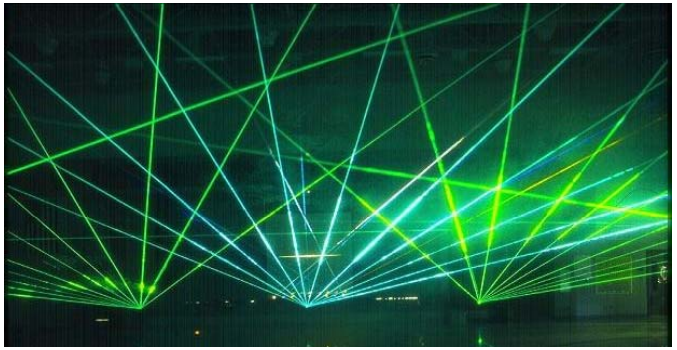
UV and Laser Light sources







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CHEM 5161

UV light sources

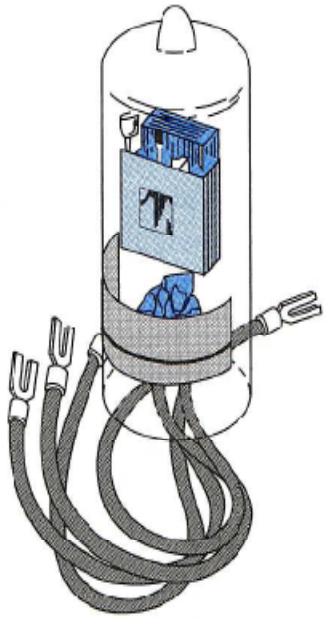
- Deuterium and Hydrogen Lamp
- LED
- Tungsten filament (see above)
- Xe-arc lamps (see above)

Deuterium lamp

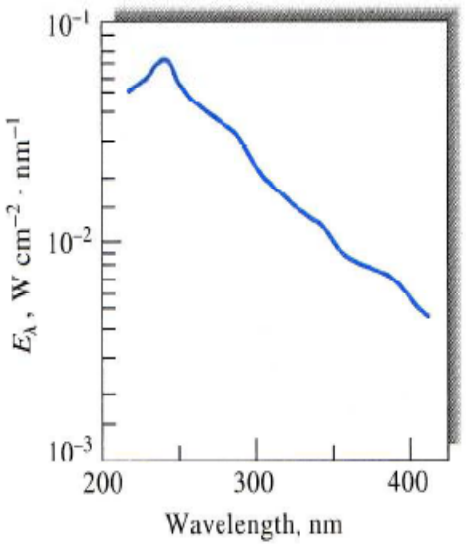
- Maximum intensity occurs at 225 nm
- What temperature is this equivalent to ?

- How can this be acchieved ?
  - formation of an excited molecular species
  - followed by dissociation to give two atomar species and a UV photon
  - UV photon of variable wavelength, due to kinetic energy distribution of the atoms

- Output region: 160 – 800 nm
- Continuum output: 160 – 400 nm

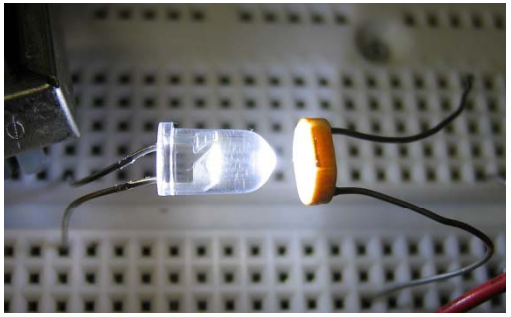


(a)



(b)

Light Emitting Diodes (LED)



- Semiconductor: pn-junction device (forward biased)
- Gallium Aluminum Arsenide (900nm)
- Gallium Aresenic Phosphide (650nm)
- Gallium Nitride (465 nm)
- Indium Gallium Nitride (450nm)
- Spectral region: 375 – 1000nm (mixtures)
- FWHM: 20 – 50 nm
- White LED: blue LED strikes phosphor (400-800nm)

- Long lifetimes
- Small environmental impact

Next time: Laser light sources

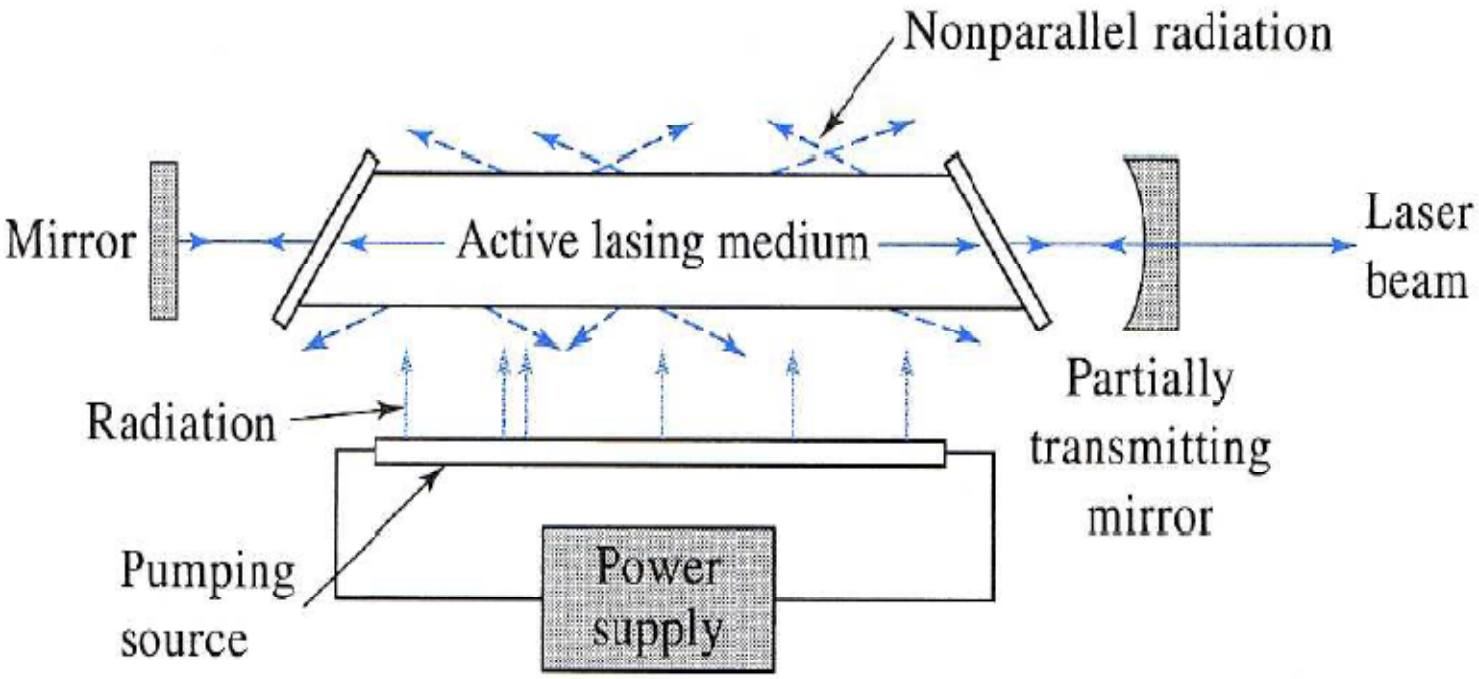
- Much smaller spectral width
  - Typically on the order of fractions of cm^{-1}
- Pulsed lasers are subject to broadening of their emission line width
- What is the bandwidth of a femtosecond laser? 1fs = 10^{-15} s

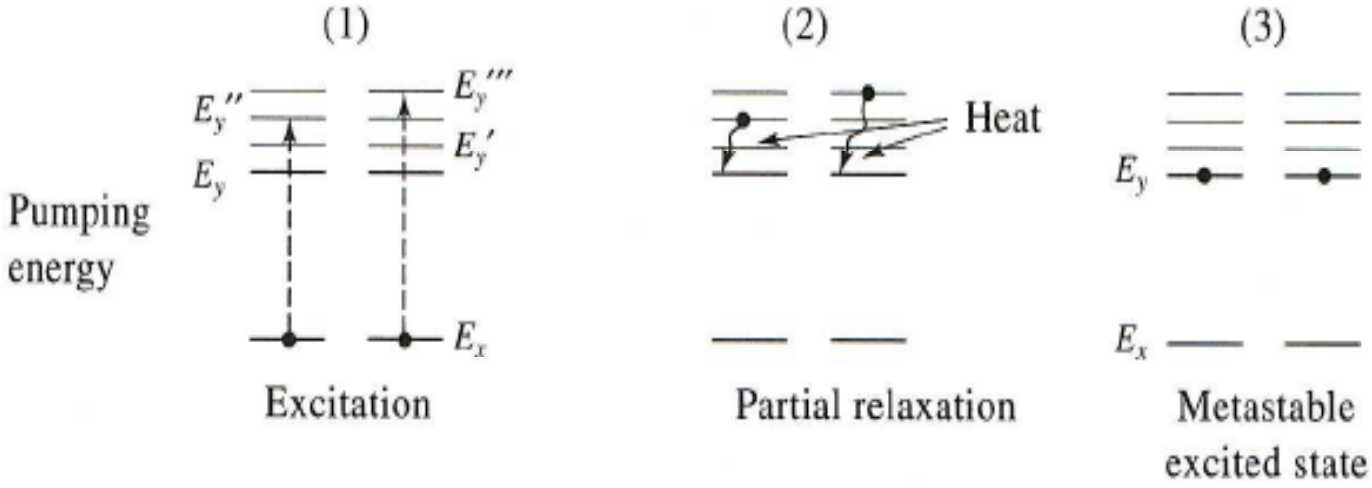
$$\Delta E \Delta t \geq \hbar \qquad \text{or} \qquad \Delta \nu \Delta t \geq \frac{1}{2\pi}$$

Light Amplification by Stimulated Emission of Radiation (LASER)

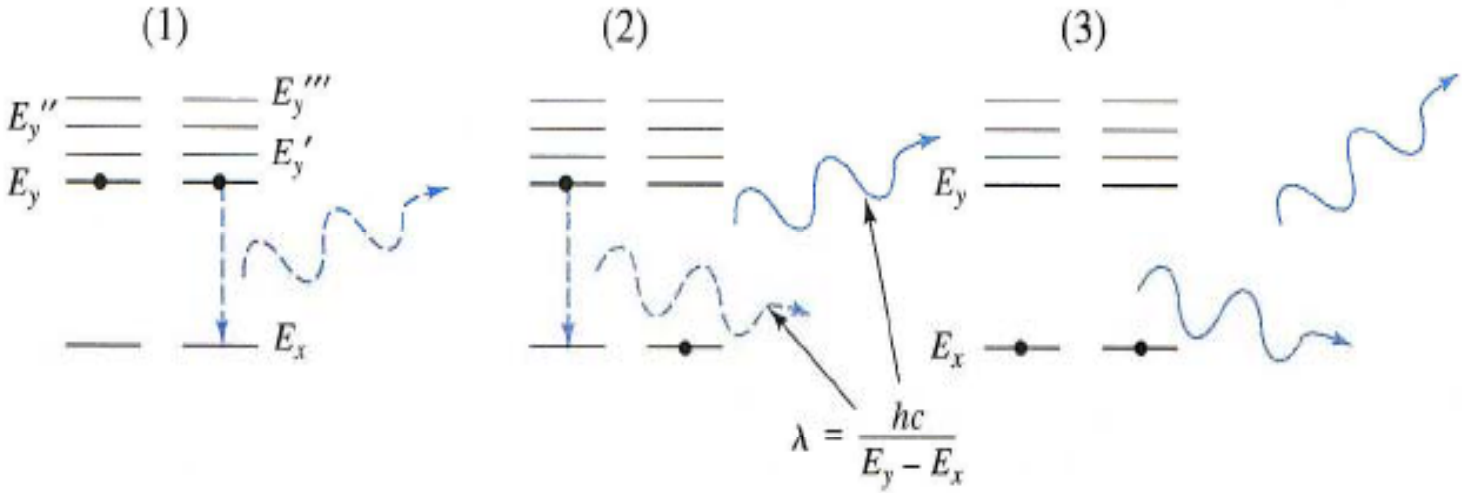
- Components:
  - Lasing medium
  - Pumping light source
  - Resonator
- Keywords:
  - Narrow bandwidth: 10^{-4} cm^{-1} < FWHM < 1000 cm^{-1}
  - Population Inversion (CW vs pulsed lasers)
  - Competition of pumping, spontaneous emission, stimulated emission, absorption
  - Coherence
  - Brightness
  - Directionality
  - (Q-switching)
  - (Mode locking)

Schematic representation of a typical laser source

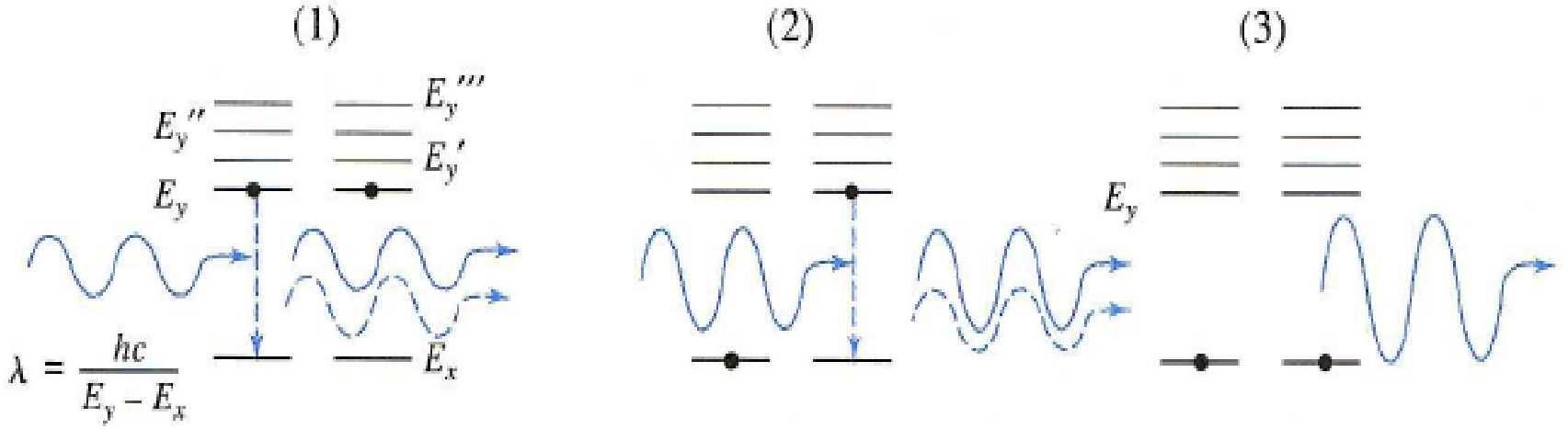




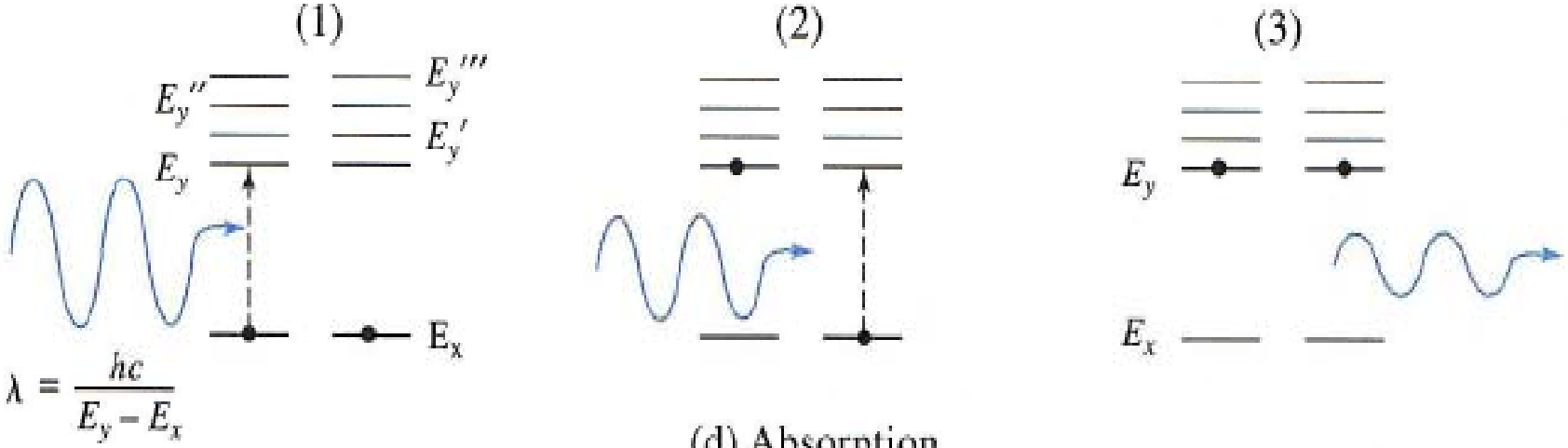
(a) Pumping (excitation by electrical, radiant, or chemical energy)



(b) Spontaneous emission

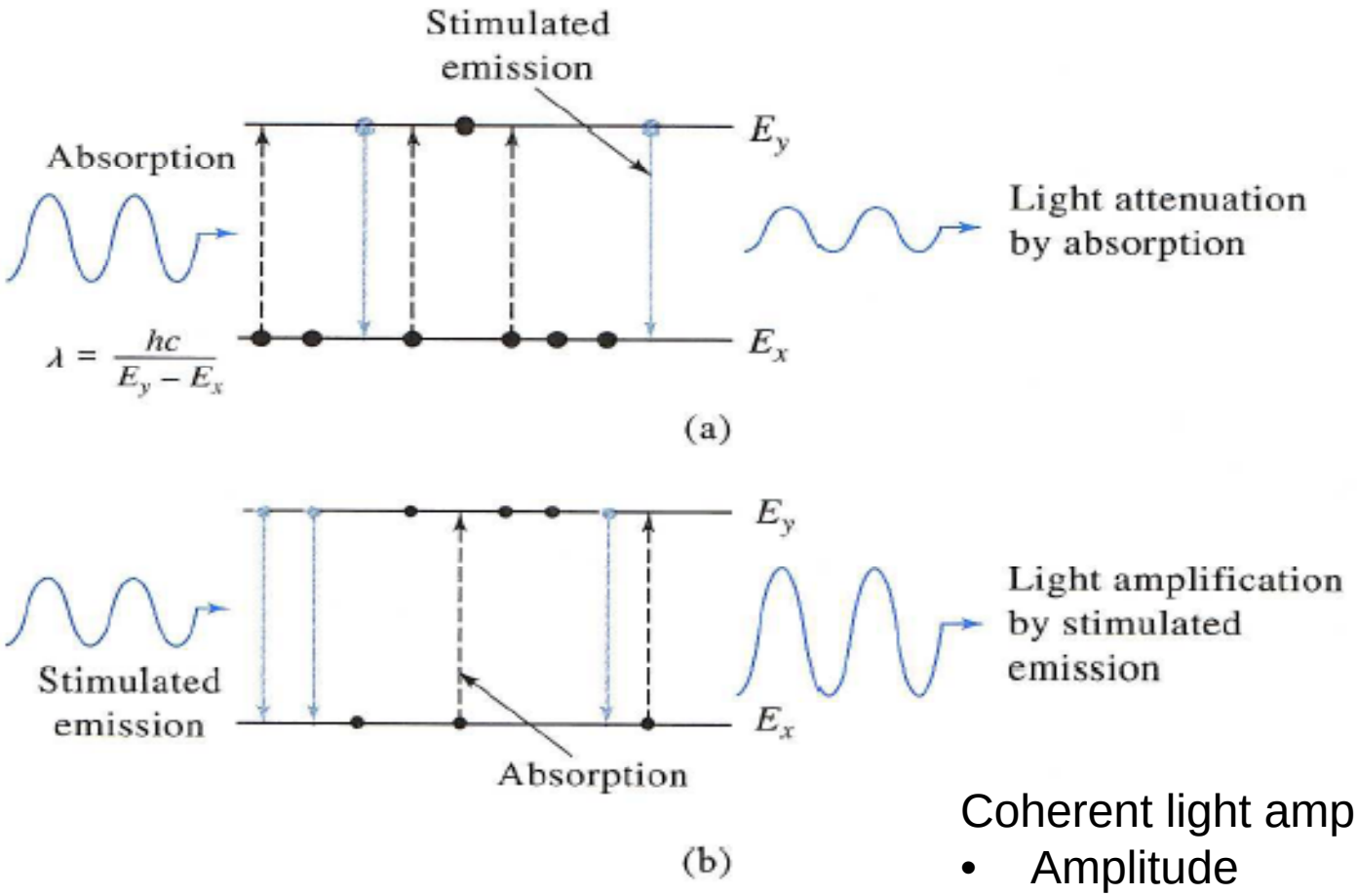


(c) Stimulated emission



(d) Absorption

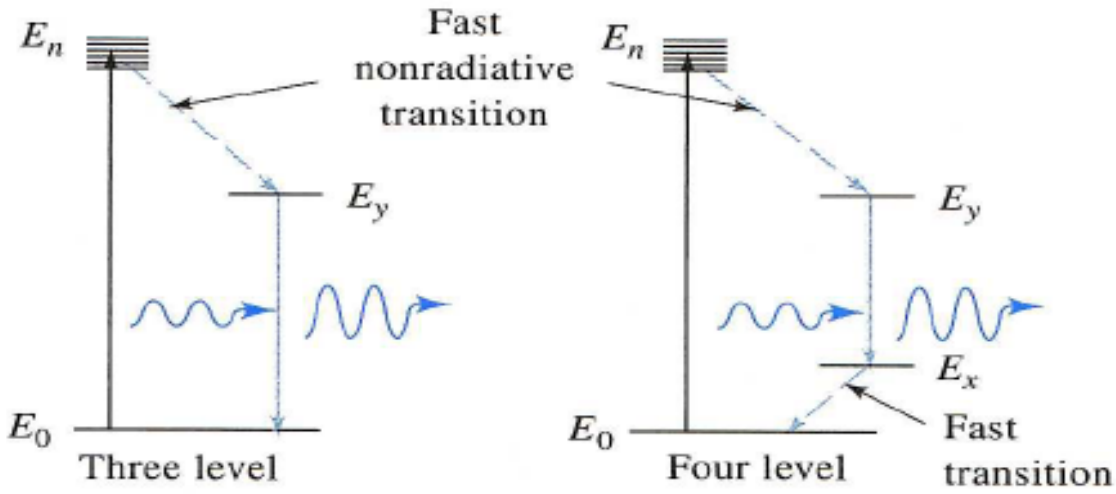
Passage of light through (a) a non inverted population and (b) an inverted population



Coherent light amplification:

- Amplitude
- Phase
- Polarization

Population inversion in three and four level systems



Resonator Quality and Cavity modes

- Resonator quality factor: $Q = \nu / \Delta\nu$
- Transverse vs longitudinal cavity modes
- The axial mode seperation is set by geometry:

$$\Delta\nu = \frac{c}{2d}$$

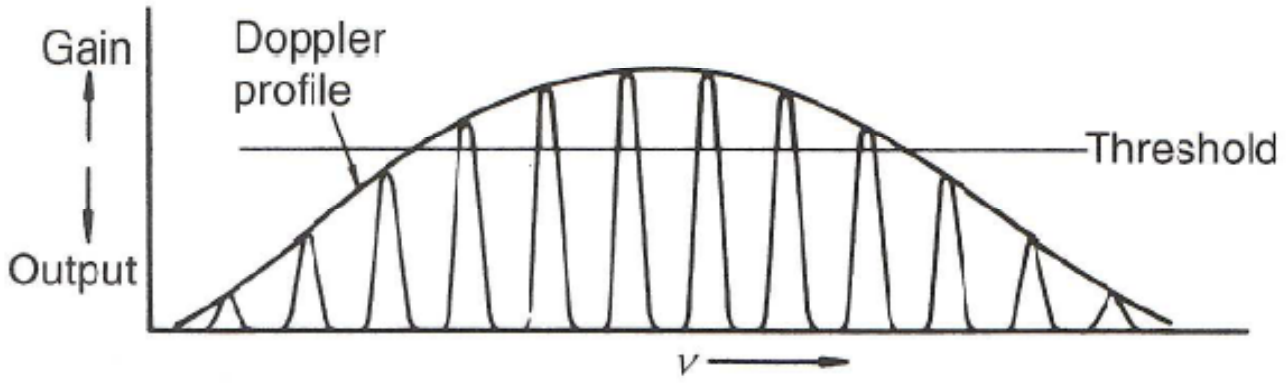


Figure 9.3 Doppler limited laser line with twelve axial modes within the line width

- Single mode vs multimode operation

Questions

- Calculate the axial mode separation for a 50cm long cavity.

$$\Delta v = \frac{c}{2d}$$

A: 100 MHz

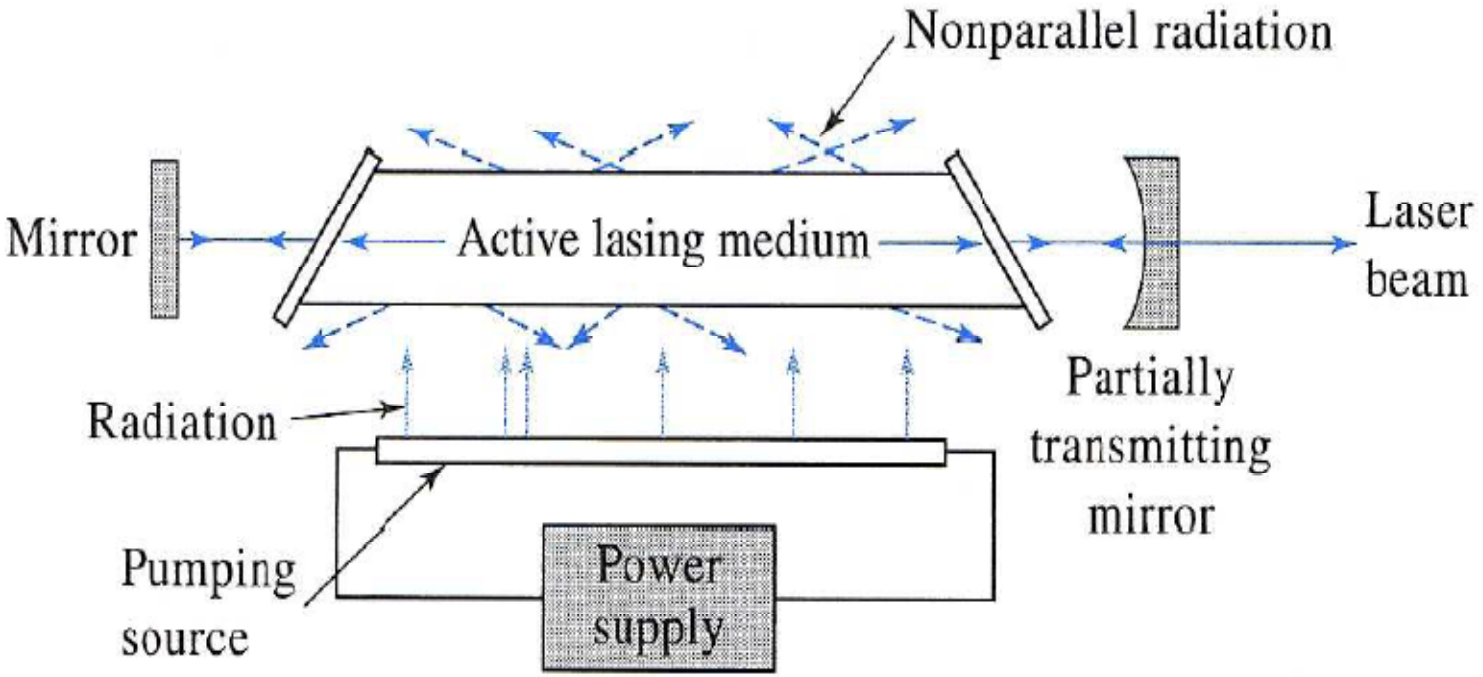
B: 200 MHz

C: 300 MHz

D: 400 MHz

E: 500 MHz

Q-switching and mode locking



$$Q = \frac{2\pi\nu E_c t}{E_t} \qquad P_p = \frac{E_p}{\Delta t}$$

Q-switching produces shortened pulses (10-200ns)
Mode locking is required to produce shorter pulses (10^{-12} – 10^{-15} s)