Chapter 14

Tunable Dye Lasers

Presented by

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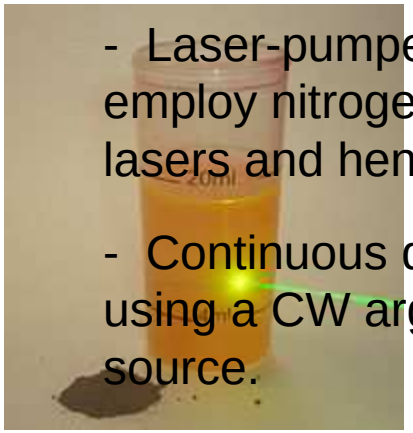
Tunable Dye Lasers:

- In a dye laser the active lasing medium is an organic dye dissolved in a solvent such as alcohol.

- The major advantage of this laser over other types is continuous tunability over a wide range.

- These lasers may be pumped by either flashlamps or by another laser.



- Laser-pumped dye lasers normally employ nitrogen or excimer pump lasers and hence are pulsed.

- Continuous dye lasers are possible using a CW argon-ion laser as a pump source.

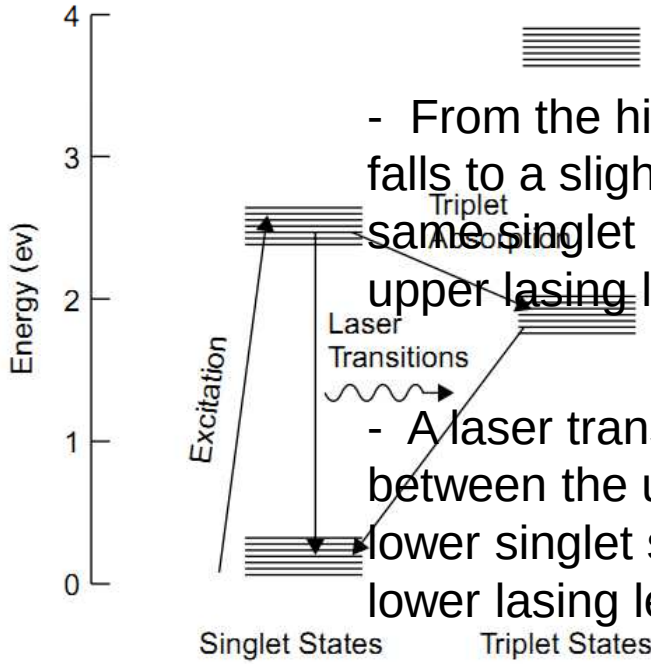
Emitting yellow light under the influence of a green laser [1].

[1] http://en.wikipedia.org/wiki/Dye_lasers

Lasing Medium:

- Active lasing medium is an organic dye dissolved in a solvent such as alcohol.

- Incident energy is absorbed by the dye, exciting it from the lowest singlet state to a high-energy level within the upper singlet band.

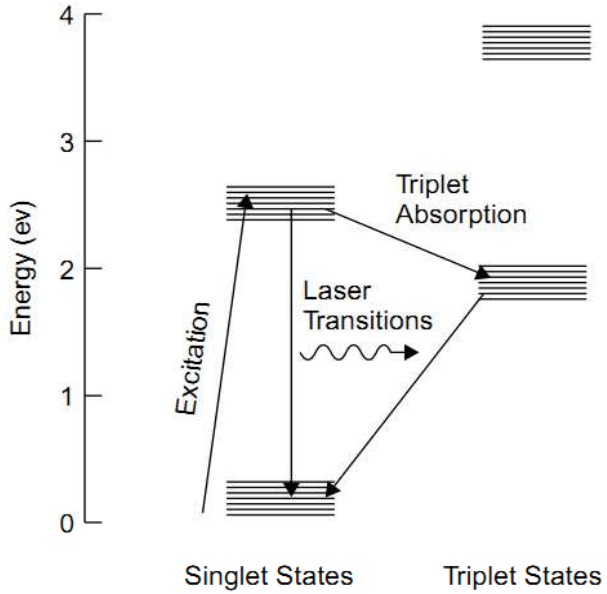


- From the high-energy level the dye falls to a slightly lower state within the same singlet band, which serves as an upper lasing level.

- A laser transition can then occur between the upper lasing level and the lower singlet state, which serves as a lower lasing level.

Laser dye energy levels

Lasing Medium (cont…):



Laser dye energy levels

- Because triplet states have lower energie[redacted]ing singlet states, [redacted]can easily migrate[redacted] in doing so depopu[redacted] level.

- Triple[redacted]stable and have m[redacted]s than the singlet [redacted]

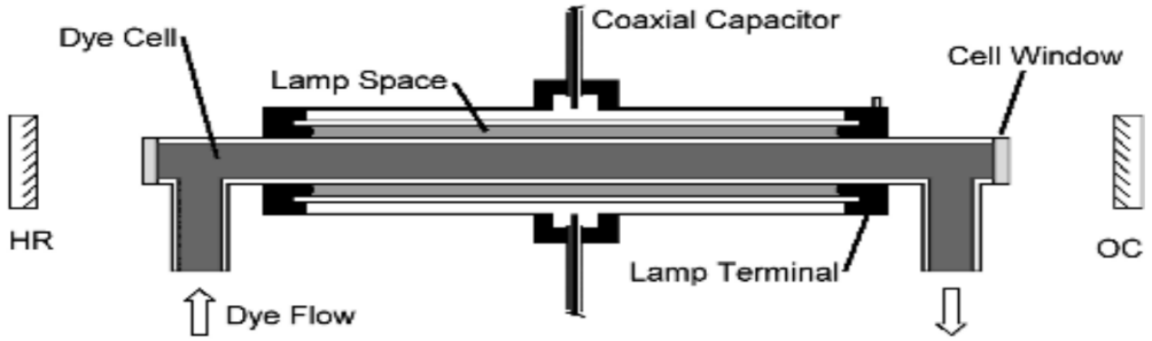
Flashlamp being fired

- When a short pump pulse such as that from a nitrogen laser (at 10 ns) is employed, triplet states do not form and do not present a problem for lasing.

But when a flashlamp is used, triplet states can form.

- For this reason, flashlamps must be designed to discharge as quickly as possible.

Laser Structure:



Flashlamp-pumped dye laser configuration.

- Circulation of the dye is required to keep the temperature of dye across the cell consistent.

- If one region of the dye is warmer than another region, a thermal gradient develops.

- A difference of indexes of refraction of liquid in the dye cell is developed which degrade the laser oscillation.

Laser Structure (cont…):

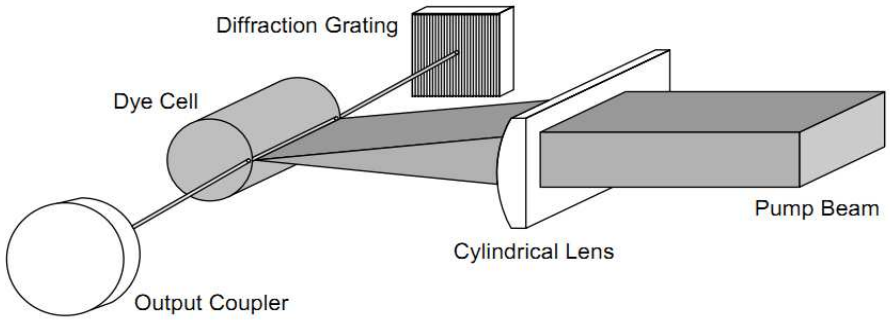
- Other configurations for a flashlamp-pumped dye laser:

  - A slab configuration is used in which the dye cell is formed between two slabs of glass that have a different index of refraction than the dye solution between the slabs.

  - Total internal reflection confines light within the cavity, producing a long optical path and hence large amplification.

Laser Structure (cont…):

Laser pumped dye laser:



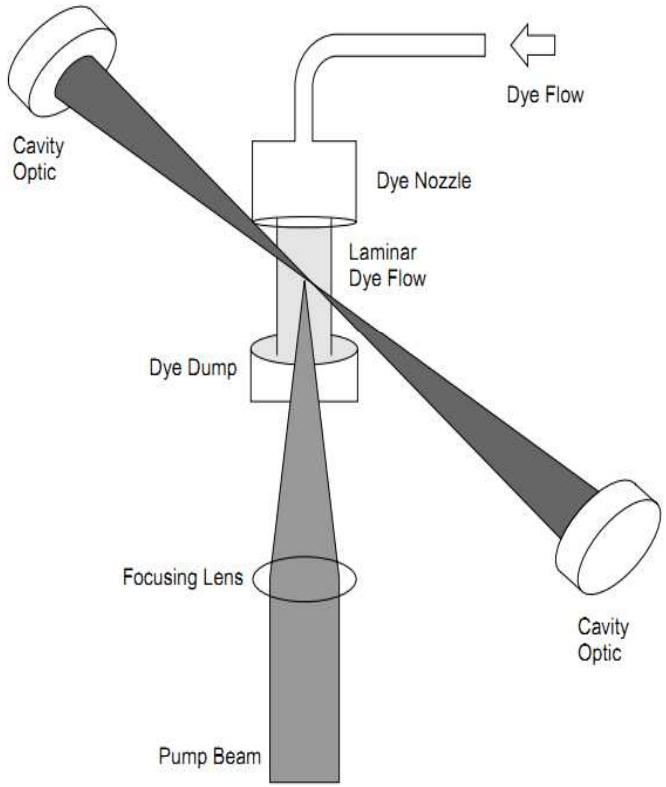
Flash Laser-pumped dye laser

- The pump laser beam is focused to a line on a dye cell using a cylindrical lens.

- Penetration of the pump light into the cell is minimal, and essentially all is absorbed within the first few millimeters of dye within the cell.

Laser Structure (cont…):

CW dye laser:



CW dye laser

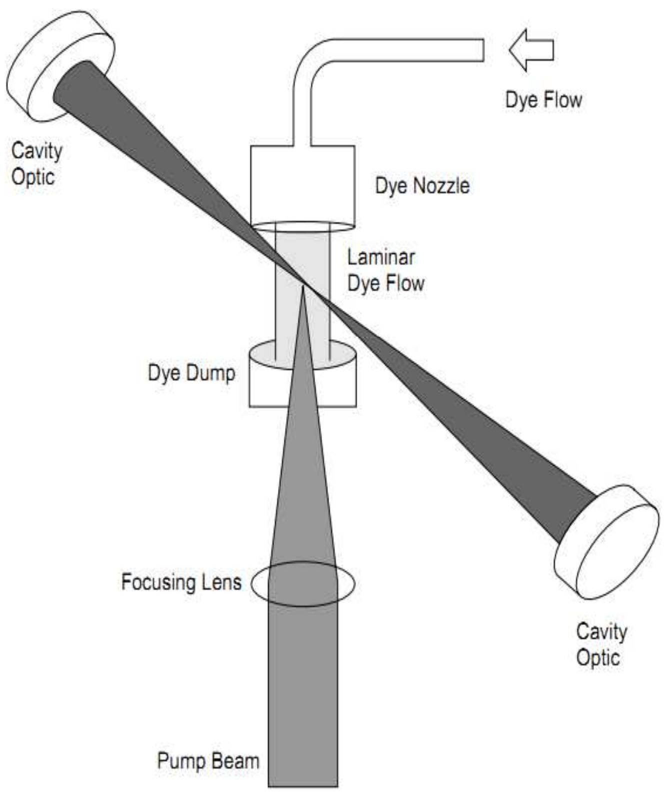
- CW dye laser pumped by a CW laser source such as an ion laser.

- In this case the biggest problem becomes heat management and degradation of the dye itself.

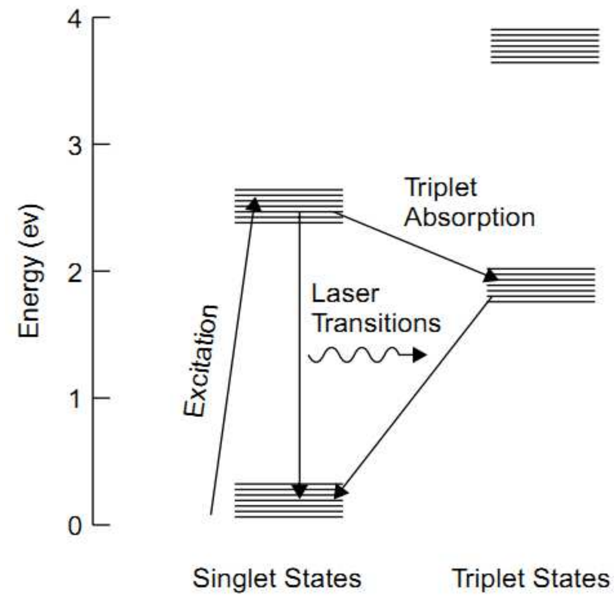
- Both problems are alleviated by forming the dye into a continually flowing sheet of liquid called a laminar flow.

Laser Structure (cont…):

CW dye laser:



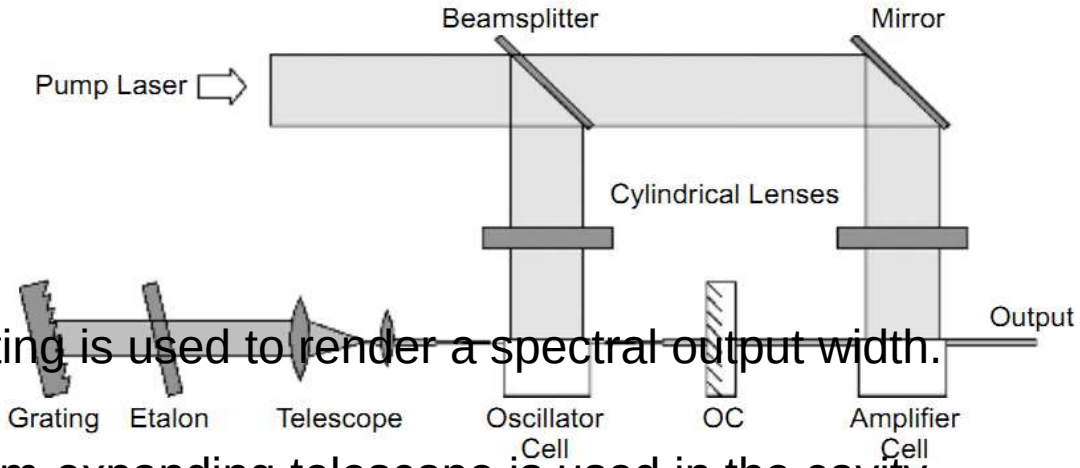
CW dye laser



-Fast dye flow helps to suppress the effects of triplet absorption in the dye by ensuring a fresh supply of dye in the area irradiated by pump laser light.

-Dye flow is hence required since triplet molecules are exchanged before triplet absorption becomes problematic and affects lasing action.

Optics and Cavities:



Optics for a dye laser

- A grating is used to render a spectral output width.
- A beam-expanding telescope is used in the cavity
  - The telescope can also collimate the highly divergent beam exiting from the dye cell.
- An etalon is included to reduce output bandwidth.

Output Characteristics:

- The output characteristics of a dye laser are highly dependent on the optics employed.

- Use of a diffraction grating alone as a wavelength selector renders a spectral width of 0.01 nm

- Use of an etalon along with a diffraction grating can render spectral widths as low as 0.0005 nm.

Applications:

- As a source for spectroscopy, the dye laser is ideal given the wide range over which tuning may be accomplished and the narrow spectral width of the output.

- It is used atomic absorption spectroscopy.

- Compact flashlamp-pumped dye lasers are occasionally employed in the field of ophthalmology for retinal photo- coagulation.

Thank You