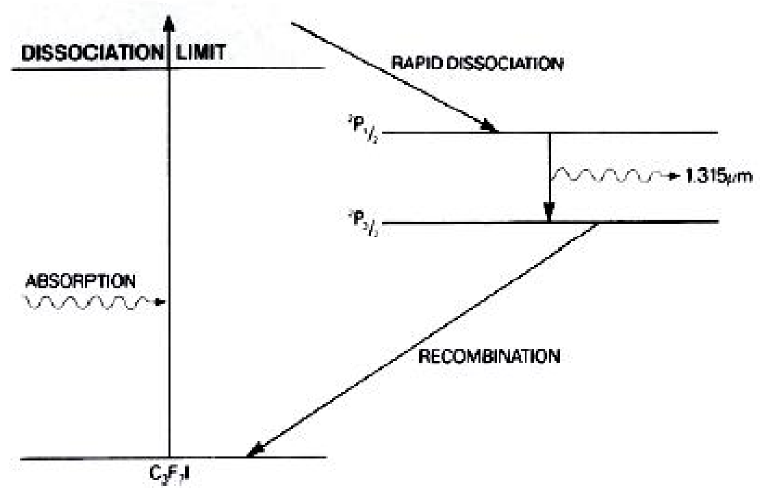
Chemical LASERs

Iodine LASER

- Population inversion is created directly through an exothermic chemical reaction or other chemical means.
- The driving principle involved in the iodine laser, is the photolysis of iodohydrocarbon or iodofluorocarbon gas by ultraviolet light from a flash lamp.



$$C_3F_7I + h\nu_p \longrightarrow C_3F_7 + I^*$$

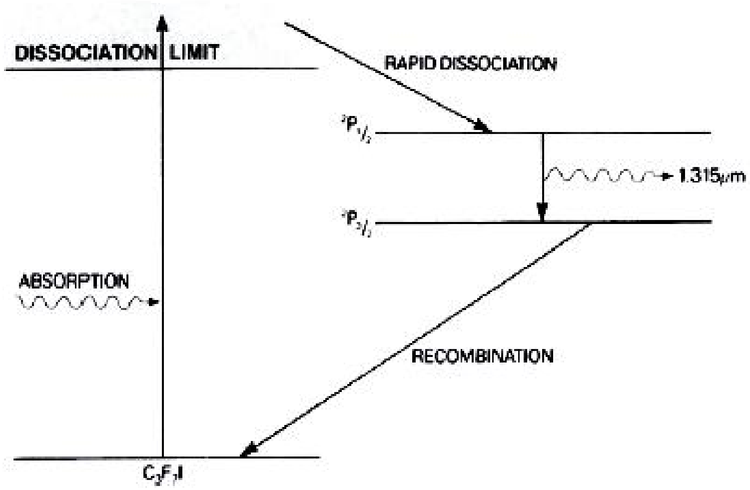
$$I^* \longrightarrow I + h\nu_l$$

$$C_3F_7 + I + M \longrightarrow C_3F_7I + M$$

hvp = pump photon

hvl = laser emission photon

C3F7I, is stored in an ampoule and introduced into the silica laser tube at a pressure of between 30 and 300 mbar.



- Laser action takes place between excited metastable $^2P_{1/2}$ state and the ground $^2P_{3/2}$ state of atomic iodine this results in narrow linewidth output at a wavelength of 1.315 µm.
- An important advantage of the iodine laser is the fact that the active medium is comparatively cheap and, hence, available in large quantities.

Excimer LASER

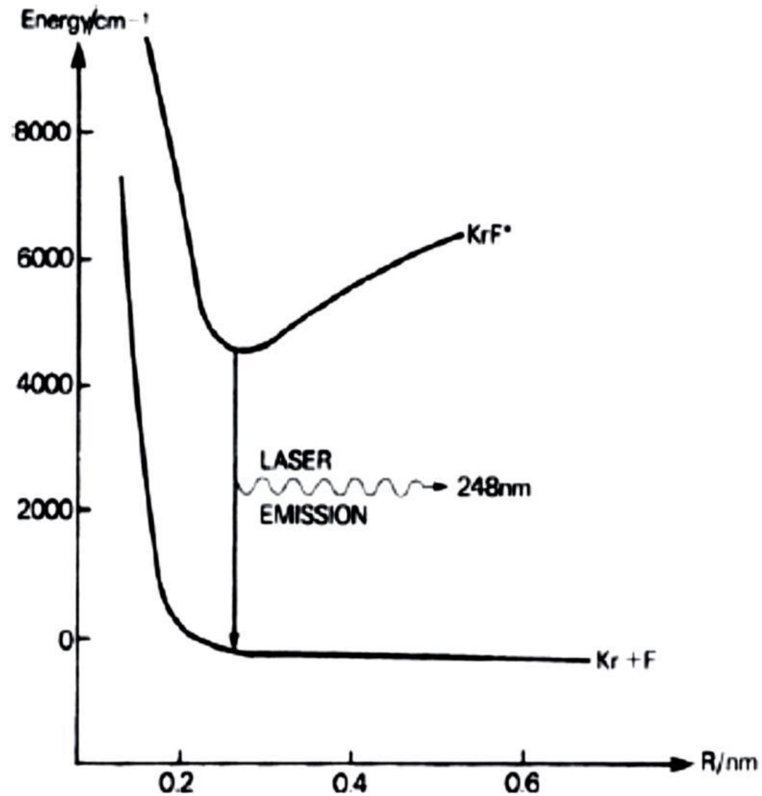
- The active medium is an ***exciplex***, or excited diatomic complex.
- The crucial feature of an exciplex is that only when it is electronically excited, it exists in a bound state with a well-defined potential energy minimum.
- The exciplex is generally formed by chemical reaction between inert gas and halide ions produced by an electrical discharge.

$Kr + e \longrightarrow Kr^+ + 2e$

$F_2 + e \longrightarrow F^- + F$

$F^- + Kr^+ + He \longrightarrow KrF^* + He$

- Helium simply acts as a buffer.



KrF* is electronically excited and has a Very short life time, it rapidly decays by photon emission.

- Since this is an unbound state, hence the force between the atoms is always repulsive, the exciplex molecule then immediately dissociates into its constituent atoms.
- This state never attains a large population, and a population inversion, therefore exists between it and the higher energy bound exciplex state. In the case of KrF the krypton and fluorine gas is regenerated.

$$KrF^* \longrightarrow Kr + F + h\nu_L$$

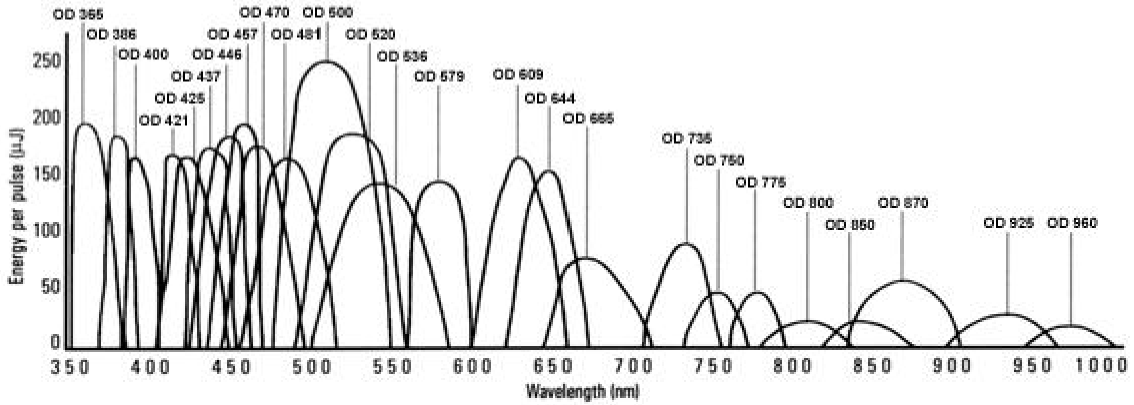
$$F + F \longrightarrow F_2$$

- The laser can be operated continuously without direct consumption of the active medium.
- Excimer lasers are superradiant and produce pulsed radiation with pulse durations of 10-20 ns and pulse repetition frequencies generally in the 1 to 500 Hz range.
- Pulse energies can be up to 1 J, with peak pulse power in the megawatt region and average power between 20 and 100 W.

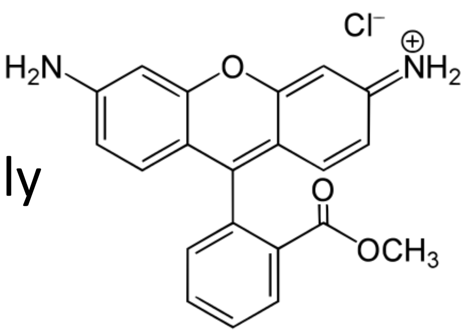
Dye LASERs

- The active medium is a solution of an organic dye.

- A wide range of over 200 dyes can be used for this purpose
  the only general requirements are an absorption band in the visible spectrum and a broad fluorescence spectrum.

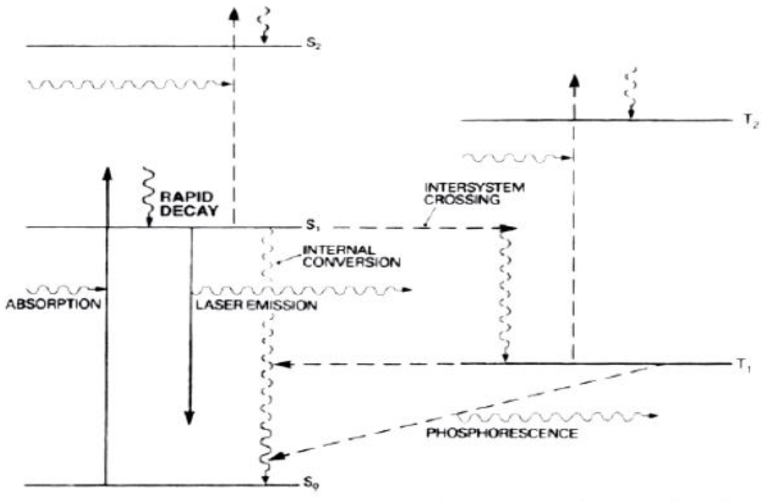


- The most widely used example is the dye commonly
- known as Rhodamine 6G ($C_{28}H_{31}N_2O_3Cl$)



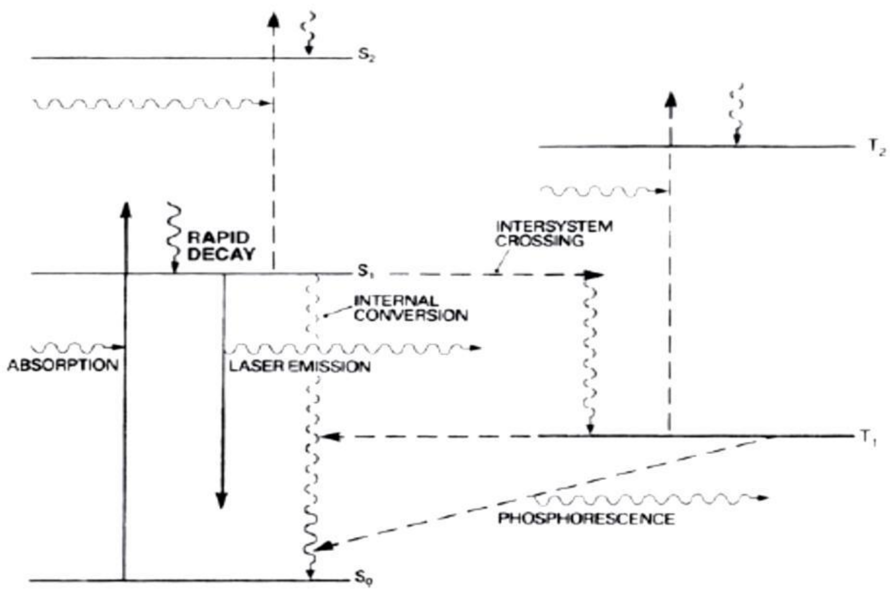
In solution, the corresponding energy levels are broadened due to the strong molecular interactions of the liquid state, and they overlap to such an extent that an energy continuum is formed for each electronic state.

the absorption of visible light results in a transition from the ground singlet state S_0 to the energy continuum belonging to the first excited singlet state S_1



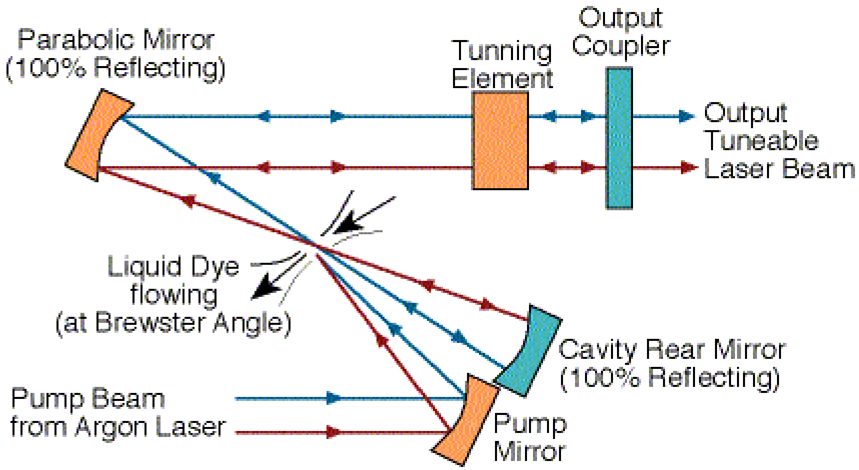
This is immediately followed by a rapid radiationless decay to the lowest energy level within the S_1 continuum

- Fluorescent emission then resu
levels within the S_0 continuum,
decay.



- It is the fluorescent emission p
basis of laser action, provided a
between the upper and lower l

- A dye laser based on a solution of Rhodamine 6G in methanol, for example, is continuously tunable over the range 570-660 nm.


Parabolic Mirror
(100% Reflecting)
Tunning
Element
Output
Coupler
Output
Tuneable
Laser Beam
Liquid Dye
flowing
(at Brewster Angle)
Cavity Rear Mirror
(100% Reflecting)
Pump Beam
from Argon Laser
Pump
Mirror