Engineering Optics

Lecture 24

31/05/2022

by

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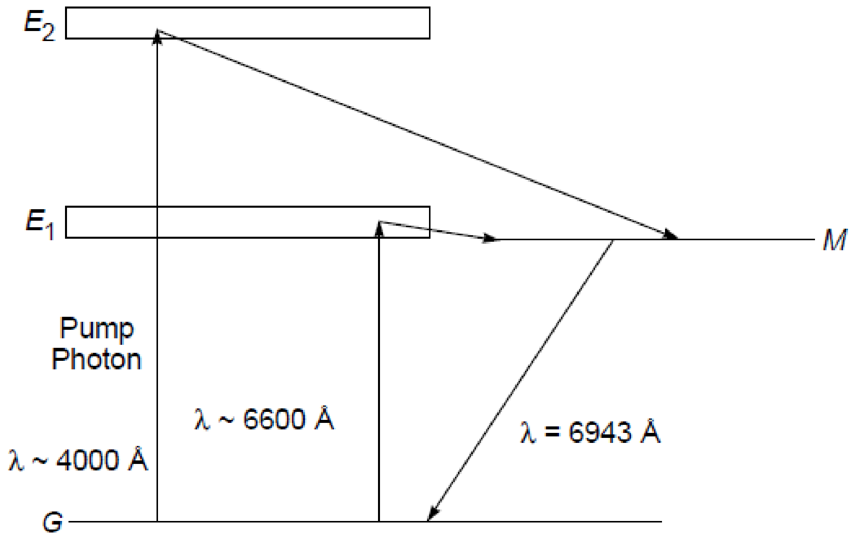
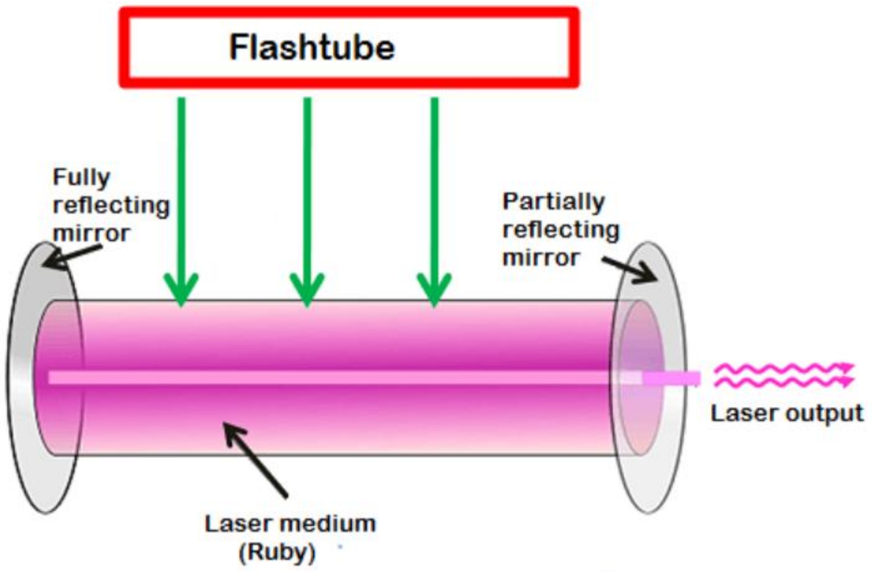
Working principle

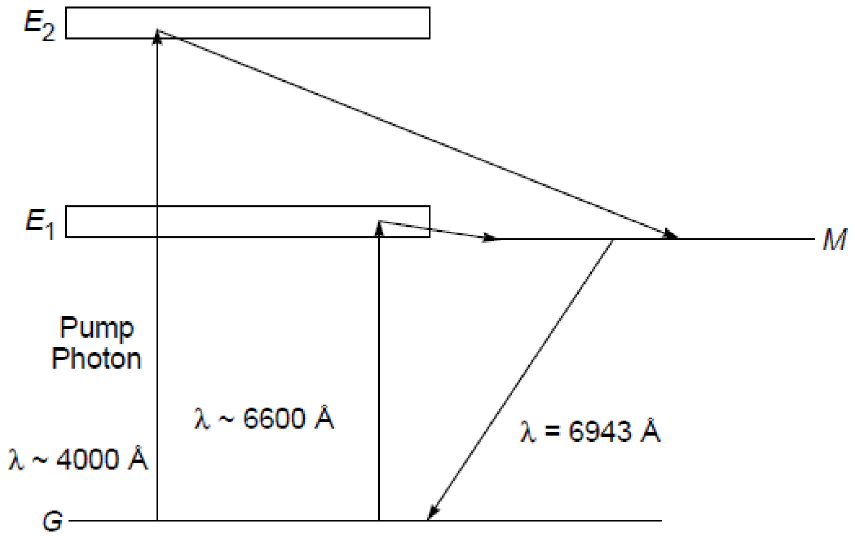


The energy levels of the chromium ion; G and M represent the ground and metastable states, respectively.

- Ruby laser → <u>three/four </u>level laser
- Pumping type → <u>optical/electrical </u>discharge
- Ion responsible for lasing → <u>Al^{3+} / Cr^{3+}</u>
- Example of → <u>Semiconductor / Gas / Solid state/ Liquid laser</u>

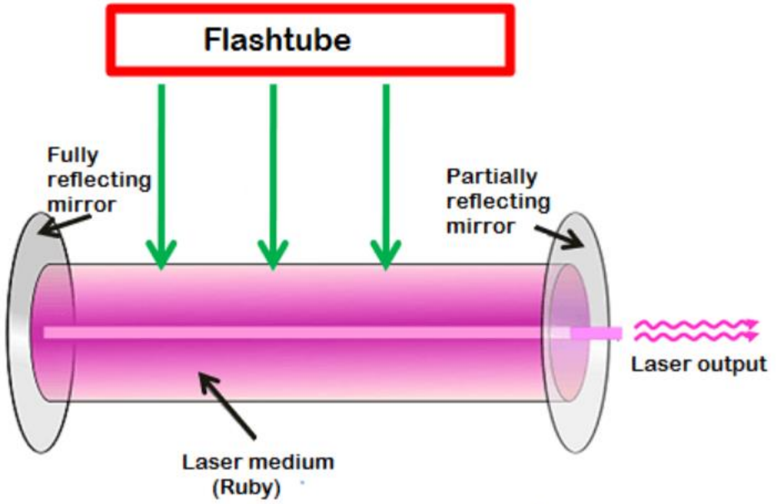


Working principle

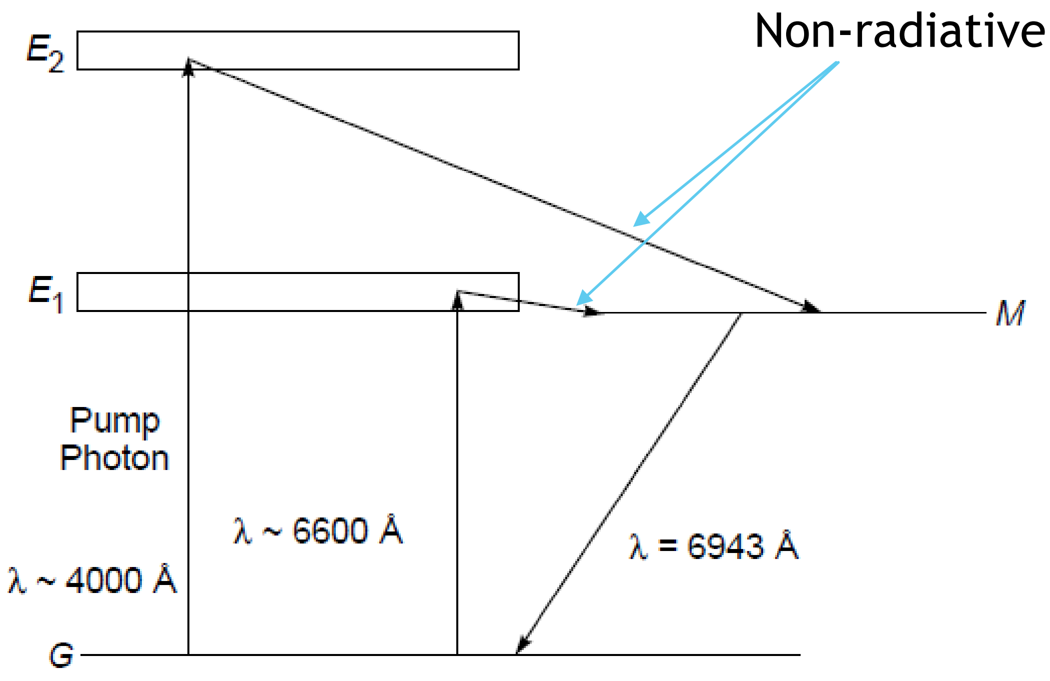


The energy levels of the chromium ion; G and M represent the ground and metastable states, respectively.

- Ruby laser → three level laser
- Pumping type → optical
- Ion responsible for lasing → Cr^{3+}
- Example of → Solid state laser



Working principle/(non)radiative



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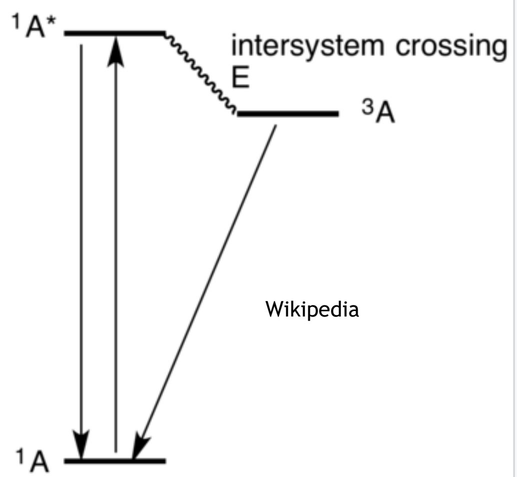
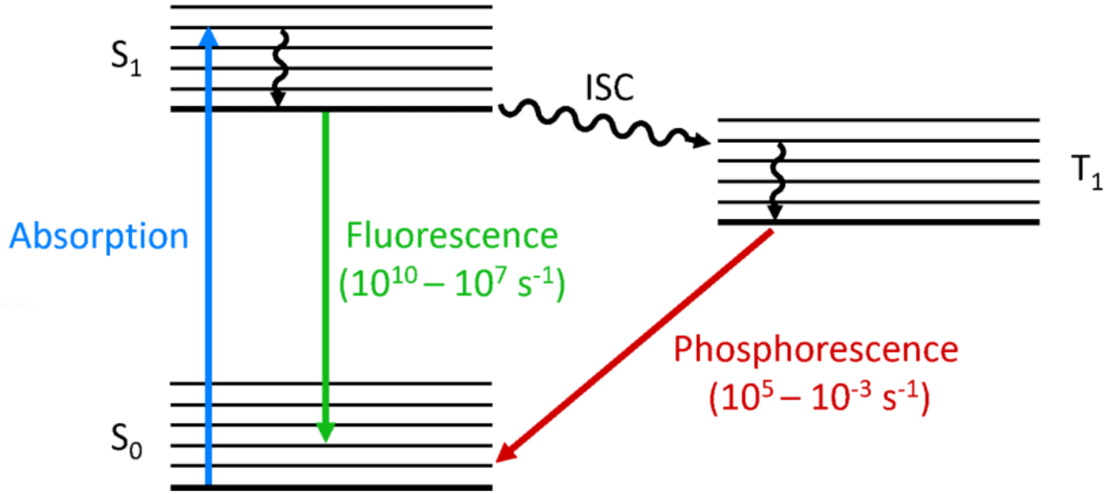


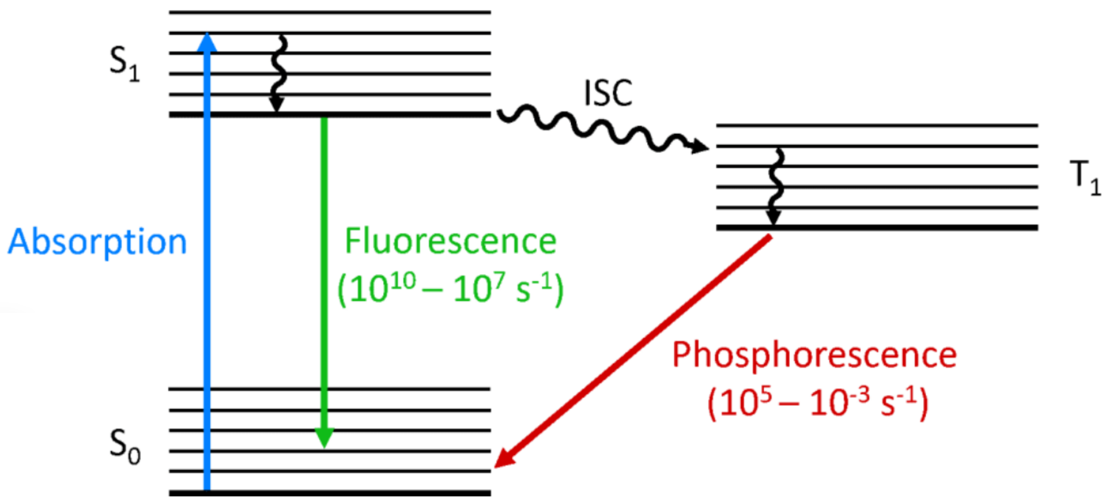
A Jablonski diagram showing the excitation of molecule A to its singlet excited state ($^1A^*$) followed by intersystem crossing to the triplet state (^3A) that relaxes to the ground state by phosphorescence.



https://www.edinst.com/blog/photoluminescence-differences/

Jablonski diagram of **fluorescence** and **phosphorescence** processes

Fluore-/phosphore-scence



Jablonski diagram of **fluorescence** and **phosphorescence** processes

https://www.edinst.com/blog/photoluminescence-differences/

Fluorescence	Phosphorescence
It is the absorption of energy by atoms or molecules followed by immediate emission of light or electromagnetic radiation	It is the absorption of energy by atoms or molecules followed by delayed emission of electromagnetic radiation
The emission of radiation or light suddenly stops on removal of source of excitation	The emission of radiation remains for some time even after the removal of source of excitation
In Fluorescence, the excited atom has comparatively short life time before its transition to low energy state	In Phosphorescence, the excited atom has comparatively long life time before its transition to low energy state
The time period or interval between the absorption and emission of energy is very short	The time period or interval between the absorption and emission of energy is comparatively long
Absorption process occurs over short time interval and involves the transition from ground state to singlet excited state and do not change the direction of the spin.	Phosphorescence involves the transition from the single ground energy state to excited triplet state and involving a change of spin state
In fluorescent materials, gives an **'an immediate flash or afterglow'** on excitation	Phosphorescent materials appears to **'glow in the dark'**, because of slow emission of light over time.
Examples of Fluorescence: Gemstones fluoresce, including gypsum, talc. Jelly fish, chlorophyll extract, vitamins etc	**Examples of Phosphorescence**: Glow of clock dial or toys or in bulbs after switching off the light in the room. The glow remains for some minutes or even hours in a dark room

https://www.majordifferences.com/2016/11/7-differences-between-fluorescence-and-Phosphorescence.html

Solid-State Lasers

- Along with **ruby**, great many other solid-state lasers whose outputs range from 170 nm to 3900 nm.
- lasers use a glass or crystal rod doped with ions capable of supplying the needed energy states.
- Recall that ruby is corundum doped with chromium.
- The trivalent rare earths Nd^{3+}, Ho^{3+},Gd^{3+} Tm^{3+}, Er^{3+}, Pr^{3+}, and Eu^{3+} undergo laser action in hosts, such as $CaWO_4$, Y_2O_3, $SrMoO_4$, LaF_3, yttrium aluminum garnet (YAG for short), and glass.
- Nd:YAG (Nd:$Y_3Al_5O_{12}$) lasers are among the most widely used solid-state laser.
- Applications in surgery, target designation, range finding, frequency doubling, and material processing, among others.

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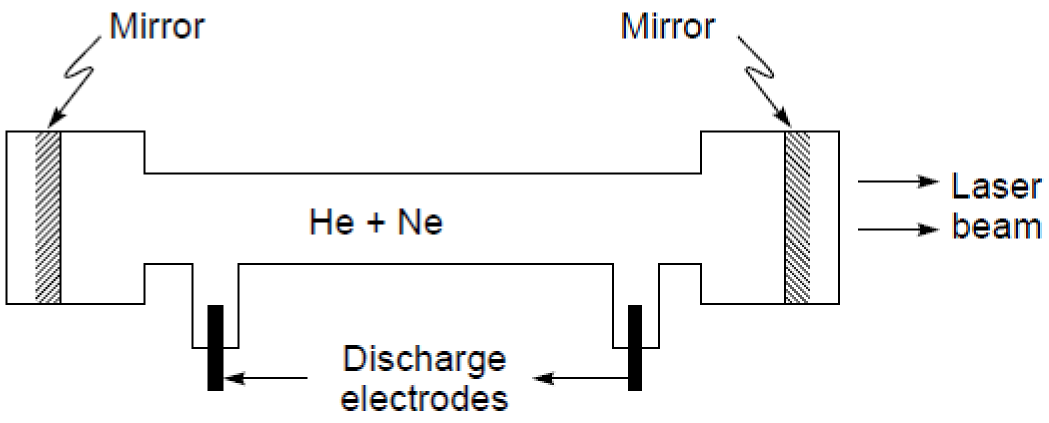
Solid-State Lasers

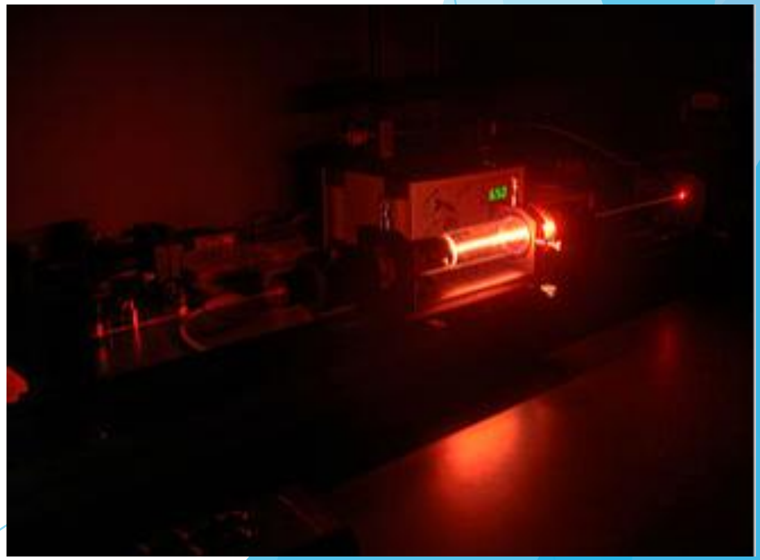
Type	Wavelengths (nm)
Cr:Al_2O_3 (Ruby)	694.3
Cr:$BeAl_2O_3$ (Alexandrite)	700–830
Cr:LiCaF	700–830
Cr:LiSrAlF	800–1050
Cr:ZnSe	2200–2800
Er:YAG	2940
Ho:YAG	2100
Nd:Glass	1080, 1062, 1054
Nd:YAG	1064.1, 266, 355, 532, 1320
Nd:YCOB	$\approx$ 1060
Nd:YLF	1047, 1053
Nd:YVO_4	1064
Pr:Glass	933, 1098
Sm:CaF_2	708.5
Ti:sapphire	650–1180
Tm:YAG	2000
U:CaF_2	2500
Yb:Glass	1030
Yb:YAG	1030

He-Ne LASER

- He-Ne laser which was first fabricated by *Ali Javan* and coworkers at Bell Telephone Laboratories in the United States. → 1st gas laser to be operated successfully.
- The He-Ne laser consists of a mixture of He and Ne (ratio ~10 : 1), placed inside a long, narrow discharge tube
- Fixed pressure inside the rube (1 torr).
- system → enclosed between a pair of plane mirrors → resonator



The helium-neon laser.



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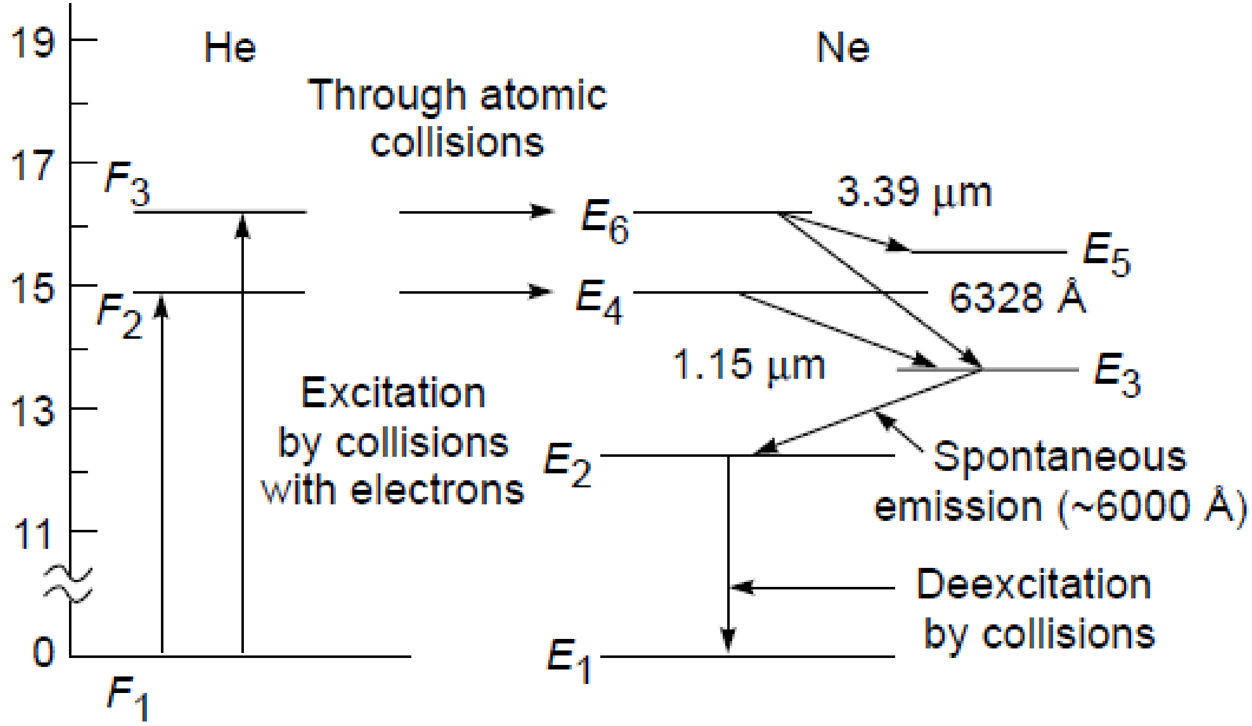
He-Ne LASER



Relevant energy levels of helium and neon.

- When an electric discharge is passed through the gas, the electrons → collide with the ***He atoms***
- ***He atoms excited*** *from the ground state F_1 to F_2 and F_3.*
- He atoms excited to these states stay in these levels before losing energy through collisions.
- Collisions with whom?? → Ne atoms present in the same tube
- Due to collision → these collisions, the Ne atoms are excited to E_4 and E_6
- Thus when the atoms in levels F_2 and F_3 collide with unexcited Ne atoms, they raise them to the levels E_4 and E_6, respectively.

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Thank You