1E الدكتور خالد العمار

Some practical laser system:

1. Ruby laser → 3 level laser
   → High power, pulsed (red)

2. { Nd - glass / Nd - YAG } lasers → 4 level laser
   → very high power, pulsed (infrared)
   Q - switching

3. Atomic gas lasers: Helium - Neon
   ⇒ Low power, very monochromatic very stable C.W. or pulsed (red)

4. Molecular gas lasers: Carbon dioxide
   → very high power C.W. (infrared)

5. Atomic ion gas lasers: Argon ion
   → Medium power, Monochromatic, C.W. or pulsed (visible)

6. Semiconductor lasers: Gallium Arsenide
   → Low power, Broad lines, Cheap, small (infrared)

7. Excimer lasers: Krypton Fluoride → very high power, pulsed, (U.V)

8. Tuneable liquid dye lasers: Rhodamine 6G low power, visible very monoch., C.W. or pulsed

2E الدكتور خالد العمار

The Ruby laser:

- Flashlamp pumped (Xe) ~ 5 msec usually
- Laser - 3 level system, with $\lambda = 694.3$ nm (red), $\Delta\lambda \simeq 0.05$ nm
- Laser of Cr^{3+} ion (0.05%) in Al_2O_3 (pink ruby)

[when $Cr^{3+} \to 0.5\%$ red ruby has λ 700.9 nm, 704.1 nm]

- Multimode operation usually at room temp., but can be Single longitudinal mode at liquid N_2 temp.
- ~~total~~ overale efficiency (coherent output) is below 1%.
- Some more recent developments are into quasi-contineous operation (10 ~ 100 Hz) by more efficient cooling.

Then, Ruby is Al_2O_3

and Cr^{3+} → responsible for energy level formation.

3E أنور ضار النجار

2. Neodymium / YAG / glass lasers

Nd^{3+}

– 4 level laser

- Since threshold is also lowered by a narrow linewidth the fact that most of these rare-metal ion lasers operate in the infra-red where linewidths are narwar, is large advantage

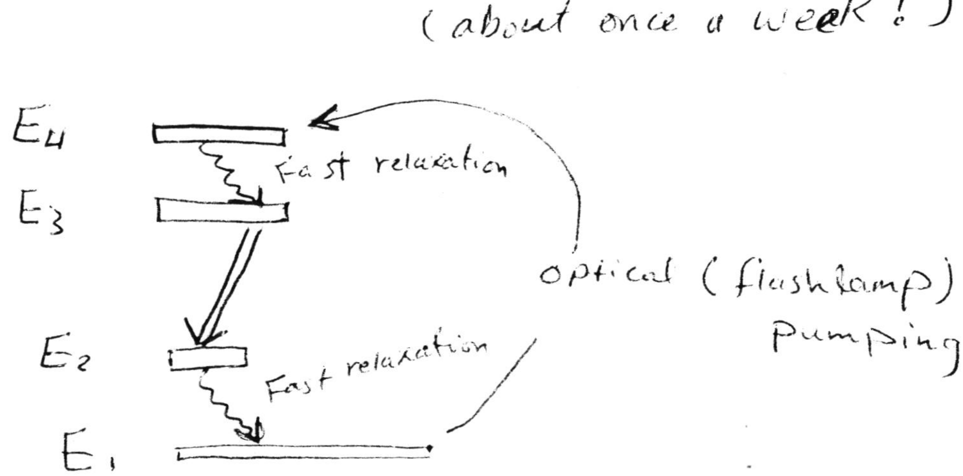
Nd^{3+} in YAG (½ – 2%) $\lambda = 1.06\ \mu m$ (1060 nm)
or glass (2 – 6 %) $\Delta\lambda \sim 10\,nm$ in high powe.

- Since very large crystals of Nd-doped glass can be made very large power levels are possible with Xe flashlamp system and the threshold level of pumping is much lower.

- 'Q switching' technique allows high power pulses.

for example: At Rutherford lab.:

Nd/glass : 2×10^{12} watt in 0.1 ns
(about once a week!)



4E د. ضالد العمار

Semiconductor lasers:

Diode injection lasers – GaAs

- Very heavily doped P–n junction diode.
  Large forward current driver electron–hole recombination at junction.

  - below threshold current:
    incoherent
    infra-red
    ~840 nm
  - above threshold current:
    Coherent radiation
    infra-red
    $h\nu \simeq eV$ (band gap)
    very high efficiency

- poor collimation (for a laser) due to diffraction
- poor monochromaticity (for a laser) $\Delta\lambda \sim 1.5$ nm
- multimode operation normally.
- Low power ~ 300 Watts for 1 μs
- Pumping can also be via optical power or electron beams.

Atomic gas lasers- Helium-Neon laser

- $\lambda_1 = 632.8$ nm red
- $\lambda_2 = 1.15\ \mu m$ (near ir)
- $\lambda_3 = 3.39\ \mu m$ "

- much smaller gain/unit length than solid ion lasers.
- Long plasma tube
- output power ~ 4 m.Watt c.w

Molecular gas lasers - Carbon dioxide laser:

- $\lambda = 10.6\ \mu m$ or $\lambda = 9.6\ \mu m$

- large power input/input.
- Infrared region requires gold-surfaced mirrors with small ~~koll~~ hole for output.
- N_2 is added as excitation transfer
- He/H_2O to lower laser level.