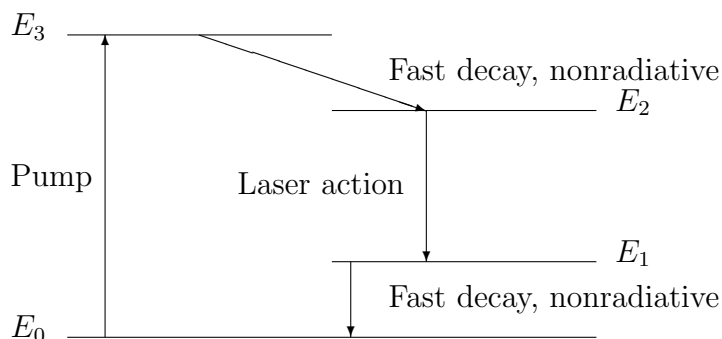


Problem 1.

Draw the energy level diagram for a 4-level laser and explain in words how it works.

Solution

An energy source excites the lasing material from the ground state, E_0 to the excited state, E_3 . The material then quickly relaxes to the E_2 state. Material in the E_1 state quickly decays to the E_0 state, where it can be excited $E_0 \xrightarrow{\text{Excitation}} E_3 \xrightarrow{\text{Fast decay}} E_2$. This forms the population inversion such that $N_{E_2} > N_{E_1}$. At this point, when a photon of energy $h\nu_{32}$ passes near the lasing material in state E_2 , it stimulates an emission of a second photon of the same energy ("stimulated emission"). This leaves the atom in state E_1 , where it non-radiatively relaxes to E_0 and can be excited again.

Problem 2.

Calculate the (a) peak output and (b) average power for a laser that produces 12 ps pulses at a repetition rate of 1000 kHz with an energy of 100 μJ /pulse.

Solution**Part (a)**

$$\begin{aligned} 100 \mu\text{J} &= \frac{100 \times 10^{-6} \text{ J/pulse}}{12 \times 10^{-12} \text{ s/pulse}} \\ &= 8 \text{ MW} \end{aligned}$$

Part (b)

$$100 \times 10^{-6} \text{ J/pulse} \times 1000 \times 10^3 \text{ s}^{-1} = 100 \text{ W}$$

Problem 3.

Briefly explain how a Q-switch works and the effect it has on the laser output.

Solution

Problem 4.

Explain how CW, pulsed, and Q-switched laser pulses differ from each other.

Solution

Problem 5.

Define the three χ terms which arise from the polarization in nonlinear optics and identify what frequency they oscillate at.

Solution

Problem 6.

A Nd:YVO₄ laser has two output wavelengths in the IR wavelength region, 1064 nm and 1342 nm. We would like to use non-linear optics to create the harmonics of the 1342 nm line. Identify the following wavelengths:

- (a) Fundamental,
- (b) Second harmonic, and
- (c) Third harmonic.

Solution

Problem 7.

Describe how a CCD works.

Solution

Problem 8.

What is the difference between random and non-random noise and is each one fundamental or non-fundamental?

Solution

Problem 9.

Identify the following types of noise as either fundamental (F) or non-fundamental (NF):

- (a) Shot noise,
- (b) Pink noise,
- (c) Interference,
- (d) Dark current noise,
- (e) Readout noise, and
- (f) Impulse noise.

Solution

Problem 10.

Identify and define the 3 types of atomic spectroscopy.

Solution**Part (a)**

Lorem ipsum dolor simet.

Part (b)

Lorem ipsum dolor simet.

Part (c)

Lorem ipsum dolor simet.