Tareas 12 Tópicos de la Física Moderna

27 de noviembre 2020

1. The daytime sky is full of light from the sun, scattered by the atmosphere of the earth. Since the scattering varies as λ^{-4}, why doesn't the sky have a violet color?

2. Consider a system where transitions between two energy levels occur by absorption and emission of photons. At approximately what wavelength is the ratio of stimulated emission probability equal to the spontaneous emission probability at (a) room temperature, (b) liquid nitrogen temperature (77 K), and (c) a temperature of 5800 K?

3. (a) Why is a population inversion necessary for amplification by stimulated emission? (b) Is it easier to achieve a population inversion at higher or lower temperature? Explain!

4. Why was the first maser built several years before the first laser?

5. How can the helium-neon laser be made to emit yellow or green light? (What energy levels are involved?)

6. In a certain four-level laser, the laser transition is to a state that is 0.042 eV above the ground state. Calculate the fraction of atoms in the exited state as a function of temperature in the range from 70 K to 300 K when no pumping radiation is present. Make a graph of your results. What does your result say about the efficiency of such a laser?

7. Laser action has been observed in the far ultraviolet region with quintuply ionized carbon (C^{+5}). The wavelength of the radiation is about 18 nm (see figure 13-15 in the book). What transition produces the laser radiation?

8. Estimate the contribution to the bandwidth ($\Delta\lambda$) from Doppler broadening for a helium-neon laser operating at $\lambda = 633\,\text{nm}$ at room temperature.

9. Why is the helium-neon laser not optically pumped?

10. Consider a laser designed for operation at $\lambda = 633\,\text{nm}$. The cavity length is 0.01 m. (a) Estimate the photon lifetime in the cavity. (b) Use the uncertainty principle to estimate the laser bandwidth ($\Delta\lambda$). (c) Estimate the number of modes for a cavity volume of $10^{-6}\,\text{m}^3$. (d) Determine the Q factor of the resonator, defined by $Q = \Delta\lambda/\lambda$. (e) The mirrors are designed so that only a small number of modes have a large Q factor. Find the relationship between the photon cavity lifetime and the Q factor.

11. A laser has mirrors with a reflection coefficient of 0.99. What is the maximum length of a laser cavity if the stimulated radiation is to be contained for $10^{-8}\,\text{s}$?

12. A laser operating at $\lambda = 550\,\text{nm}$ has a bandwidth of $10^{-8}\,\text{nm}$. The lifetime of radiation in the cavity and the spontaneous decay lifetime are both equal to $10^{-8}\,\text{s}$. Estimate the pumping power.

13. The CO_2 laser operates in the infrared at $\lambda = 10.6\,\mu\text{m}$. What type of transition is involved?