جامعة الملك سعود
كلية العلوم
قسم الفيزياء والفلك
الأسم .... الرقم الجامعي

مسائل لمقرر ٥٣١ فيز (الفصل الدراسي الثاني ١٤٢٧/١٤٢٨ هـ)

TAKE HOME

(1) Instead of ρ_ν, a spectral energy density ρ_λ can also be defined, ρ_λ being such that $\rho_\lambda\, d\lambda$ gives the energy density for the e.m. waves of wavelength lying between λ and $\lambda + d\lambda$. Find the relationship between ρ_λ and ρ_ν .

(2) For blackbody radiation find the maximum of ρ_λ versus λ. Show in this way that the wavelength λ_M at which the maximum occurs satisfies the relationship $\lambda_M T = hc/ky$ (Wien's law), where the quantity y satisfies the equation $5[1\text{-exp}(- y)] = y$. From this equation find an approximate value of y ($y = 4.965$).

(3) The R_1 laser transition of Ruby has a good approximation a Lorentzian shape of width (FWHM) 330 GHz at room temperature. The measured peak transition cross-section is $\sigma = 2.5\times10^{-20}$ cm^2. Calculate the radiative lifetime (the refractive index is n=1.76). Since the observed room temperature lifetime is 3 ms, what is the fluorescence quantum yield?

(4) The quantum yield of $S_1 \rightarrow S_0$ transition for Rhodamine 6G is 0.87, and the corresponding lifetime is ≈ 5 ns.

(i) Calculate the radiative and nonradiative lifetimes (τ_{sp} and τ_{nr}, respectively) of the S_1 level (assume n=1.36 for ethanol).

(ii) From a knowledge of the radiative life time τ_{sp} of Rhodamine 6G (from part i), Calculate the corresponding $|\mu|$, where λ =0.59 μm at the maximum of the emission curve.

(iii) Calculate the effective atomic dimension, a.

(5) Consider two-level system, with level energy separation of $h\nu_0$, and transition cross-section $\sigma(\nu)$. We wish to investigate the absorption characteristic of the system as a function of the input flux and temperature. The rate equation governing the population density in level 2 is $\frac{dN_2}{dt} = N_1 W_i - N_2 W_i - \frac{N_2 - N_2^{eq}}{\tau_{21}}$ where $N_2^{eq} = N_1 e^{-h\nu_0/kT}$ is the

 Dr. Abdallah Azzeer

equilibrium thermal population of level 2. The total population density N_a , and $N_a = N_1 + N_2$.

(i) Show that in steady-state, in presence of a resonant optical field, the relationship between the populations in the two levels is $N_2 = \frac{N_1 W_i \tau_{21} + N_2^{eq}}{W_i \tau_{21} + 1}$.

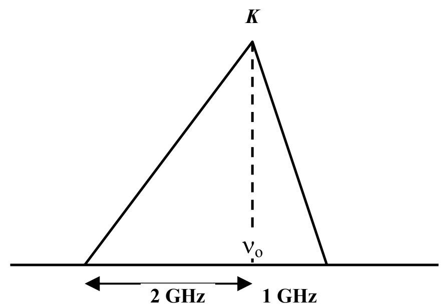
(ii) Using this result, show that the steady-state population inversion is given by $N = \frac{-N_a(1 - e^{-h\nu_0/kT})}{2W_i \tau_{21} + 1 + e^{-h\nu_0/kT}}$.

(iii) What is the expression for the absorption coefficient of this material?

(6) For inhomogeneous line shape function shown of the laser with;

$\lambda = 8\times10^{-5}$ cm , $A_{21} = 2.5\times10^{6}$ s^{-1} , n = 2.75

Calculate the stimulated emission cross section.



(7) The Nd:YAG laser transition has, to a good approximation, a Lorentzian shape of width (FWHM) -195 GHz at room temperature (see Fig. 2.9). The upper state lifetime is $\tau = 230\mu s$, the fluorescence quantum yield of the laser transition is ~0.42, and the YAG refractive index is 1.82. Calculate the peak transition cross section.

(8) The Nd:YAG laser ($\lambda = 1.06\mu m$) operates as a four-level laser with a peak transition cross section of $\sigma_p = 3.5 \times 10^{-19}$ cm^2 and a lifetime τ = 0.23 ms. Calculate the gain saturation intensity.

(9) At short wavelengths (vuv, soft x-rays) the predominant line-broadening mechanism is natural broadening. In this case, show that the peak cross section is $\sigma_0 = \lambda_0^2 / 2\pi$.

(10) An absorption band in merocyanine dye has oscillator strength of 0.3 and an absorption maximum at 470 nm.

(i) Find the transition dipole moment.

(ii) Find the Einstein B coefficient.

(iii) Find the radiative lifetime.

مع نيا لكم بالتوفيق والنجاح