Fotónica I / Lasers e Óptica Não linear Problemas de Laser Physics (capitulo 3)

3.7. Estimate the temperature of a blacktop road on a sunny day. Assume the asphalt is a perfect blackbody.

(podem assumir que a irradiância solar na superfície da Terra é cerca de 1000W/m^2 e que a irradiância total emitida dum corpo negro é dada pela lei de Stefan Boltzman $I = \sigma_{SB} T^4$ com $\sigma_{SB} \approx 5.67x10^{-8} W/m^2/K^4$ o constante de Stefan Boltzman)

3.9. Compare Eq. (3.7.11) with Eq. (1.5.2) obtained in the simplified laser model described in Chapter 1. What term in Eq. (3.7.11) corresponds to the parameter f in Eq. (1.5.2)? What is the physical meaning of the differences in the form of these two equations?

$$\frac{dN_2}{dt} = -\frac{1}{c}(B_{21}N_2 - B_{12}N_1)I_\nu S(\nu) - A_{21}N_2. \qquad (3.7.11)$$

$$\frac{dn}{dt} = -anq - fn + p. \qquad (1.5.2)$$

3.10. Show that the number of atoms (or molecules) per cubic meter of an ideal gas at pressure P and temperature T is given by (3.8.20).

$$N = 9.65 \times 10^{24} \frac{P(\mathrm{Torr})}{T}, \qquad (3.8.20)$$

3.11. The CO_2 molecule has strong absorption lines in the neighborhood of $\lambda = 10\ \mu$m. Assuming that the cross sections of CO_2 molecules with N_2 and O_2 molecules are $\sigma(CO_2, N_2) = 1.20\ \mathrm{nm}^2$ and $\sigma(CO_2, O_2) = 0.95\ \mathrm{nm}^2$, estimate the collision-broadened linewidth for CO_2 in the atmosphere. (Note: Since the concentration of CO_2 is very small compared to N_2 and O_2 in air, you may assume that only N_2–CO_2 and O_2–CO_2 collisions contribute to the linewidth.) Compare this to the Doppler width.

3.12. Consider an atom of mass m with a resonance frequency ν_0 and an initial velocity v in a direction away from a stationary source of radiation of frequency $\nu \approx \nu_0$. Assume that a photon of frequency ν carries an energy $h\nu$ and a linear momentum $h\nu/c$, that $v \ll c$, and that $h\nu/c \ll mv$. Using the conservation of energy and linear momentum, derive the formula (3.9.4) for the Doppler-shifted absorption frequency.

$$v = \frac{c}{\nu_0}(\nu - \nu_0) \qquad (3.9.4)$$

3.15. Consider the absorption coefficient $a(\nu_0)$ of a pure gas precisely at resonance. Show that $a(\nu_0)$ is proportional to the number density of atoms when the absorption line is Doppler broadened, but is independent of the number density when the pressure is sufficiently large that collision broadening is dominant.

3.19. **(a)** What is the spontaneous emission rate for the helium $1S_0$–$2P_1$ transition at 58.4 nm?

(b) A cell is filled with helium at a temperature of 300K, and the density is sufficiently low that collision broadening is negligible. Calculate the absorption coefficient for the 58.4-nm transition.