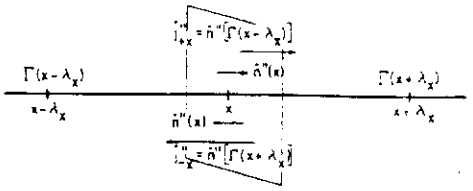
the flux in the positive direction at point x is governed by the average value of the conserved quantity at the position of the last collision, that is at $x - \lambda_x$. Thus, $j''_{+x} = \dot{n}''(x)\hat{\Gamma}(x - \lambda_x)$. Similarly, the flux in the negative direction is $j''_{-x} = \dot{n}''(x)\hat{\Gamma}(x+\lambda_x)$.



The net flux is the difference between these two quantities. And since the system is a continuum we can simplify by expanding $\hat{\Gamma}(x)$ in a Taylor series. Thus the net transport of the conserved quantity Γ is

$$j''_\Gamma = j''_{+x} - j''_{-x} = \dot{n}''\left[\hat{\Gamma}(x-\lambda_x) - \hat{\Gamma}(x+\lambda_x)\right] = \dot{n}''\left\{\left[\hat{\Gamma}(x) - \lambda_x \frac{\partial\Gamma(x)}{\partial x}\right] - \left[\hat{\Gamma}(x) + \lambda_x \frac{\partial\Gamma(x)}{\partial x}\right]\right\} = -2\dot{n}''(x)\lambda_x \frac{\partial\hat{\Gamma}(x)}{\partial x}$$

This is a general differential expression for the transport flux in a continuum. It is written in terms of the mean free path component in a single direction. This directional mean free path can be related to the general, nondirectional mean free path, λ_c, by integration using a particle's collision probability, see Ref. 1. The result is $\lambda_x = (2/3)\cdot\lambda_c$. With this substitution, the *continuum transport flux without net carrier particle flux* is

Ans. 15. The maximum for solar radiation occurs at λ_{max} = 2898 μmK/5600 K = 0.518 μm. At this peak, $x_{max} = hc/\lambda_{max}kT = 4.965$ and

$$\dot{e}''_{b,\lambda_{max}} = \frac{2\pi hc^2}{\lambda^5_{max}} \frac{1}{(e^{x_{max}}-1)} = \frac{2\pi \cdot 6.625\cdot 10^{-34}\text{Js}}{(0.518\ \mu\text{m})^5} \frac{(2.998\cdot 10^8\text{m/s})^2\cdot(10^6\mu\text{m/m})^4}{(e^{4.965}-1)} = 7.05\cdot 10^7\text{W/(m}^2\mu\text{m)}$$

Similarly, at 0.4 and 0.7 μm,

$$\dot{e}''_{b,0.4\mu m}(5600\text{ K}) = 5.98\cdot 10^7\text{W/(m}^2\mu\text{m)} \qquad \dot{e}''_{b,0.7\mu m}(5600\text{ K}) = 5.84\cdot 10^7\text{W/(m}^2\mu\text{m)}$$

The radiation incident on the atmosphere is attenuated by the factor

$$\left(\frac{d_{sun}}{d_{orb}}\right)^2 = \left(\frac{1.465\cdot 10^6\text{km}}{150\cdot 10^6\text{km}}\right)^2 = 9.54\cdot 10^{-5}$$

So the intensities of natural solar light are

$$i''_{max} = 6792\text{W/(m}^2\mu\text{m)}, \quad i''_{0.4\mu m} = 5705\text{W/(m}^2\mu\text{m)}, \quad i''_{0.7\mu m} = 5571\text{W/(m}^2\mu\text{m)}$$

Ans. 16. λ_{max} = 2898 μmK/1200 K = 2.416 μ. At this maximum:

$$\dot{e}''_{b,\lambda_{max}} = \frac{2\pi hc^2}{\lambda^5_{max}(e^{4.965}-1)} = 3.19\cdot 10^4\text{W/(m}^2\mu\text{m)}$$

But at λ = 0.7 μm, λT = 840 μmK and hc/λkT = 17.14. Thus

$$\dot{e}''_{b,0.7\mu}(1200\text{ K}) = \frac{2\pi hc^2}{\lambda^5[e^{(hc/\lambda kT)}-1]} = 80.48\text{ W/(m}^2\mu\text{m)}$$

Notice that this threshold level for visibility is about two orders of magnitude less than that of natural light (see Exer. 15, i")