Exercise 3. Determine the magnitude of θ_{pht} for enclosures of volume 1 mm^3 and 1 m^3.

The answer to Exer. 3 shows that, while θ_{pht} is sensitive to the volume of the enclosure, a combination of a very small enclosure at a very low temperature is required for the effect of the discrete spectrum to be noticeable. We will consider only the high temperature limit, $T >> \theta_{pht}$. In that case the spectrum of eqn. IIID-1a can be approximated as continuous.

$$n_j^o = n^o(\nu) = \frac{g(\nu)}{e^{h\nu/kT} - 1} \qquad \text{(IIID-1b)}$$

Thus the distribution of translating photons is similar to that of translating molecules. Both distributions can be approximated as continuous and both sets of allowed energies are prescribed by three distinct sets of positive integers (ℓ, m, n) representing three directions of translation.[4] Therefore, the degeneracy of translating photons can be adapted from that developed for translating independent molecules in Appendix IIIC-A

$$g_{tr}(\varepsilon) = \frac{4\pi V \cdot m^{*3/2}\ \varepsilon^{1/2}}{h^3} \qquad \text{(IIIC-A1)}$$

The adaptation consists of eliminating the molecular mass by substituting the energy-mass equivalence, $\varepsilon = m^* c^2$, and multiplying the result by two to account for the fact that the wave can be polarized in two perpendicular directions. Thus

$$g_{pht}(\varepsilon) = \frac{8\pi V \varepsilon^2}{(hc)^3}$$

To express this result in terms of frequency we must employ integral equivalence, $g(\varepsilon)d\varepsilon = g(\nu)d\nu$ where $\varepsilon = h\nu$. Thus

$$g_{pht}(\nu) = \frac{8\pi V \nu^2}{c^3} \qquad \text{(IIID-3a)}$$

With this result we have the distribution function of a photon gas in equilibrium in terms of frequency

$$n_{pht}(\nu) = \frac{8\pi V}{c^3} \frac{\nu^2}{(e^{h\nu/kT} - 1)} \qquad \text{(IIID-4a)}$$

The principal application of the characteristics of thermal radiation is to the determination of radiant heat transfer, see Unit IIIE. It is much more common in this field to specify the distribution by wavelength rather than frequency. To accommodate this preference we transform eqns. IIID-3 and 4 to a wavelength basis, $\nu = c/\lambda$, $d\nu = (-c/\lambda^2)d\lambda$. Then using the condition $g(\nu)d\nu = -g(\lambda)d\lambda$, we have

[4]The principal difference is that photons translate at the speed of light with their energies dependent on frequency, whereas molecules translate at various speeds with their energies being dependent on speed squared.