Similarly, photons incident on a surface from its exterior will either be reflected, or will be transmitted into the interior and subsequently absorbed. The proportion that is absorbed is also a property of the surface called the *absorptance (or absorptivity)*.

Implicit to the preceding discussion is the assumption that photon transmission through the enclosure walls is unlikely; that is, the walls are assumed to be "optically thick." Photon mean free paths are relatively short in most solids.[12] The free electrons of a metallic solid have especially large cross sections for photon collisions. Thus metallic solids are seldom transparent and the probability of photon reflection at the surface is high; metals have low emittance and absorptance coefficients.[13] The bound electrons of nonconducting solids are not as efficient at scattering photons. Thus nonconductors are much more likely to be semitransparent and their emittance and absorptance properties may approach unity.[12]

Exercise 13. Determine the magnitude of black body radiant emission at 300, 1000, 3000 and 10,000 K.

Exercise 14. A galactic probe coasts at speed with its engine shut down, far from any appreciable radiant source. It expends energy at a rate of 450 W to run its systems. After use, this power is dissipated from a radiator whose area is $2m^2$. The radiator is constructed of aluminum because of its light weight and high thermal conductivity. Its uncoated emittance is 0.05. A design alternative calls for coating the radiator with a nonconducting "nearly" black coating with an emittance of 0.95. What will be the steady state temperature of the radiator for the two conditions? What is your recommendation?

In Unit IIID the photon energy density was obtained by integration of the wavelength distribution of photon energy— Planck's Law, eqn. IIID-5. When this expression is substituted into eqn. IIIE-16a, we obtain the wavelength distribution of black body radiant emission. This expression is also called *Planck's Law*

$$\dot{e}''_{b\lambda}(T) = \frac{u_{v\lambda}(T)c}{4} = \frac{2\pi hc^2}{\lambda^5}\,\frac{1}{\left[e^{(hc/\lambda kT)}-1\right]} \qquad \text{(IIIE-18)}$$

[12]Photon transport through a solid should be modeled as a continuum. Its contribution to net transport is usually much less than that of the phonons and/or free electrons and is, therefore, neglected.

[13]The process of transmission and subsequent absorption of a photon incident on the surface from the exterior is the reverse of that for transmission of a photon incident on surface from the interior, viz., emission. Thus the emissivity and absorptivity are identical at every point for photons of the same wavelength traveling at the same angle.

Ans. 12. From Table IIIE-2, $\sigma^+_{N_2} = 44.2\ \mathring{A}^2$/part. Thus

$$\lambda^*_c = \frac{1.38\cdot 10^{-23}\,\text{J/(part K)}\cdot 300\ \text{K}}{\sqrt{2}\cdot 44.2\ \mathring{A}^2\cdot 10^{-20}\,\text{m}^2/\mathring{A}^2\cdot 1.013\cdot 10^5\,\text{N/m}^2} = 6.54\cdot 10^{-8}\,\text{m}$$

and

$$\hat{V} = \left(\frac{8RT}{\pi}\right)^{\frac{1}{2}} = \left[\frac{8}{\pi}\cdot\left(\frac{8317}{28.01}\right)\text{J/(kg K)}\cdot 300\ \text{K}\right]^{\frac{1}{2}} = 476\ \text{m/s} \qquad \tau_c = \frac{\lambda_c}{\hat{V}} = 1.37\cdot 10^{-10}\,\text{s}$$