Blackbody Emittance

An ideal blackbody at a non-zero absolute temperature $T$ emits radiation, according to the Planck's Law:

$$M^B_\lambda(T) = \frac{2\pi\hbar^2}{\lambda^5 \left[ \exp\left(\frac{\hbar c}{kT\lambda}\right) - 1 \right]} = \frac{c_1}{\lambda^5} \exp\left(\frac{c_2}{T\lambda}\right) - 1$$

where $M^B_\lambda(T)$ is the temperature and wavelength dependent spectral emittance, i.e. power emitted per unit area of the surface per unit wavelength interval.

However, a real surface is seldom a perfect blackbody. The emittance from the surface is modeled by the equation,

$$M_\lambda(T) = \varepsilon_\lambda M^B_\lambda(T)$$

where the wavelength dependent parameter $\varepsilon_\lambda$ is the emissivity of the surface.

For a Lambertian surface, the emitted radiance is given by

$$L_\lambda = \frac{M_\lambda}{\pi}$$

Emission and Absorption

For a surface at thermal equilibrium with the surrounding, the rate of radiant energy absorbed is equal to the rate of radiant energy emitted. If the absorptance is $\alpha_\lambda$, then the rate of absorption per unit surface area is $\alpha_\lambda E_\lambda$. The rate of emission per unit area is $M_\lambda = \varepsilon_\lambda M^B_\lambda$. If the surface is at thermal equilibrium with the surrounding radiation field, then the incident radiation must be a blackbody radiation field. Thus,

$$\alpha_\lambda E_\lambda = \varepsilon_\lambda M^B_\lambda.$$

Since $E_\lambda = M^B_\lambda$, we get

$$\varepsilon_\lambda = \alpha_\lambda.$$

For an opaque surface at thermal equilibrium with zero transmittance, $\alpha_\lambda + \rho_\lambda = 1$, and $\varepsilon_\lambda = \alpha_\lambda = 1 - \rho_\lambda$. 