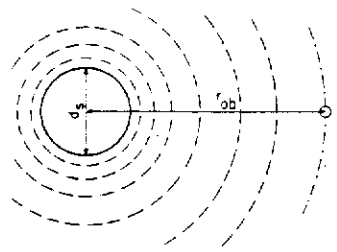
This function has the same form as that for the energy density, see Fig. IIID-1. Therefore, the position of the maximum radiant emission is determined from *Wein's Law* derived in Unit IIID.

$$\lambda_{max} T = 2898 \ \mu m \ K \qquad \text{(IIID-6)}$$

Example 7. Measurements of the wavelength distribution of the solar radiation incident on the outer fringes of the atmosphere indicates that the sun's black body emission temperature is 5600 K. The total solar constant is 1330 W/m^2. Independent celestial measurements have shown that the average distance from the sun to the earth is $150 \cdot 10^6$ km. Use this data to deduce the diameter of the sun.

The sun emits uniformly in all directions at the total rate, $\dot{Q}_s = A_s \dot{e}''_b(T_s)$. This total emission is diminished in intensity as it spreads over the increasing area spherical surfaces that it passes through at increasing distances from the sun. The total radiation crossing each larger radius sphere is the same. Finally, at the earth's orbit, r_{ob}, we have



$$\dot{Q}_s = \pi d_s^2 \ \dot{e}''_b(T_s) = \pi (2r_{ob})^2 \ \dot{q}''_{solar}$$

or

$$d_s = \frac{4 r_{ob}^2 \ \dot{q}''_{solar}}{\sigma T_s^4} = \left[\frac{4 \cdot (1.50 \cdot 10^8 km)^2 \cdot 1330 \ W/m^2}{5.668 \cdot 10^{-8} W/(m^2 K^4) \cdot (5600 \ K)^4} \right]^{\frac{1}{2}} = 1.465 \cdot 10^6 km$$

The eyes of earthlings are sensitized to perceive radiation above a threshold intensity in the wavelength range from 0.4 to 0.7 μm that spans the peak emission from the sun. Our vision is based on observing differences between the partial reflection of the available natural light within the visible spectrum. An object is green because it preferentially absorbs radiation from other colors, reflecting a combination of wavelengths that the eye perceives as a particular green hue. For an object to be visible as a result of its own emission, it must be hot enough to *emit* with sufficient intensity in the visible to be above the threshold level of optical sensitivity.

Exercise 15. What is the magnitude of solar emission $\dot{e}''_{b\lambda}$ at the maximum and at both extremes of the visible spectrum 0.4 and 0.7 μm? What are the intensities of natural solar radiation incident on the atmosphere at the same wavelengths?

Exercise 16. An object is said to be red hot when its emission at the long wavelength (red) end of the visible is sufficient that the eye can detect its emission. This condition is achieved at about 1200 K. What are λ_{max} and $\dot{e}''_{b\lambda max}$ at this temperature? What is the magnitude of emission at 0.7 μm?

Our discussion of photon transport in gases has been based on the free particle mode. Molecular transport at very low pressures (see Exmp. 6) and free electron and phonon transport at very low temperatures (discussed briefly below) must also be modeled on this basis. Though these processes are significant to certain engineering designs, we will not consider free particle transport further. Instead we devote the remainder of the unit to the far more typical case— transport within the continuum regime.