50645, Physics, Molecular Physics — Thermodynamics

Question i) Write an expression for Plancks law for energy density of photons in a cavity and calculate total energy density, u. ii) Consider sun as a black body whose interior consists of photons gas at $T = 3 \cdot 10^6$ K Calculate the energy density of the solar radiations. Take $\sigma = 7.56x10^{-16} Jm^{-3}k^{-4}$

Solution Planck's law for energy density of photons is

$$B_\nu(\nu, T) = \frac{2h\nu^3}{c^2} \frac{1}{e^{\frac{h\nu}{k_\mathrm{B}T}} - 1}$$

where ν is frequency of photons.
Total energy density is Planck's law integrated over all frequencies:

$$P = \int_0^\infty d\nu \int_0^{\pi/2} d\theta \int_0^{2\pi} d\phi \, B_\nu(T) \cos(\theta) \sin(\theta) = \sigma \, T^4$$

Now we can find energy density of the solar radiation. Real value of Boltzman constant is $\sigma = 5.67 \cdot 10^{-8} Js^{-1}m^{-2}K^{-4}$. Hence

$$P = \sigma T^4 = 5.67 \cdot 10^{-8} \cdot 3 \cdot 10^6 \approx 0.17 Js^{-1}m^{-2}$$