Stellar Astronomy and Astrophysics (SS12)

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Exercise 4 for May 22, 2012

1. Absorption of a photon by an isolated electron:

Use the laws of the conservation of relativistic energy and momentum in order to show that an isolated electron cannot absorb a photon

2. Mean free path of a photon:

Assume that we have pure (true) absorption, i.e. there is not way of replenishing the photons lost from the beam. In the solar photosphere the typical density is about $\rho = 2.1 \cdot 10^{-4}\,\mathrm{kg\,m^{-3}}$, the opacity at 5000 Å is $\kappa = 0.03\,\mathrm{m^2\,kg^{-1}}$.

a What is the characteristic distance traveled by a photon before being removed from the beam?

b Assume that we had the same opacity in the Earth's atmosphere ($\rho = 1.2\,\mathrm{kg\,m^{-3}}$). How far could we see?

3. Blackbody:

1. By what factor should the temperature of a black body be increased so that

a: The integrated flux (over all frequencies) is doubled?

b: The frequency at which the intensity is greatest is doubled?

2.a Find an expression for $n_\lambda \mathrm{d}\lambda$, the number density of blackbody photons (the number of blackbody photons per cm^3) with a wavelength between λ and $\lambda + \mathrm{d}\lambda$.
2.b What is the total number of photons inside an oven set at 200 Celsius with a volume of 1 m^3.

3. The tungsten filament of a light bulb has a temperature of 2700 K. If we assume blackbody radiation:

a: What amount of the energy is radiated in the visible range of the electromagnetic spectrum (4000-7000 Å).

b: What is the energy per blackbody photon at the center of the sun ($T = 1.58 \cdot 10^7\,\mathrm{K}$ and in the solar photosphere ($T = 5770\,\mathrm{K}$) expressed in electron Volts (1eV=$1.6 \cdot 10^{-12}$ erg).