Homework 2

1. Calculate mean intensity and radiative flux for a radiation field characterized by

   a) an isotropic specific intensity: $I_\nu(\cos\theta) = \text{const.}$

   b) an extreme anisotropic intensity: $I_\nu = I_0\, \delta(\cos\theta - 1/3)$ (delta function in cosθ)

   (3 points)

2. A photon is created in the interior of the sun. It travels its mean free path <Δs>, until it is scattered by a free electron, then it travels again a distance <Δs>, is scattered again, and so on. The process is finally finished, when the electron reaches the solar surface at $R=7\times10^{10}$ cm and emerges from the sun. How many times is the photon scattered, until it leaves the solar surface? How long is its "random walk" through the sun and how much time did it take from the photon's creation to its arrival at the solar surface?

   Assume $\langle\kappa_{e\text{-}sc}\rangle = \langle n_e\rangle\sigma_{e\text{-}sc}$ for the electron scattering absorption coefficient, where $\sigma_{e\text{-}sc} = 6.6\times10^{-25}$ cm^2 is the electron scattering cross section and $\langle n_e\rangle$ is the mean electron number density in the sun. Calculate $\langle n_e\rangle$ from the mean mass density of the sun assuming that the sun consists of (fully ionized) hydrogen only. The mass of the sun is $M = 2\times10^{33}$ g. The mass of the hydrogen atom is $m_H = 1.67\times10^{-24}$ g.

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To calculate the "random walk" you also need to know <cosθ>, the average cosine of the angle between the radial direction and the photon path direction after the scattering. A very good assumption is "isotropic scattering", i.e. the probability of the photon to be scattered into the solid angle interval (ω, ω+d ω) is $p(\omega)d\omega = d\omega/4\pi$. Calculate <cosθ> using this probability and then use <cosθ> and <Δs> to compute the new radial coordinate of the photon after each scattering.

(4 points)

3. Repeat the calculation under 2., but now assume that the photon is absorbed by an atom after the travel of the mean free path <Δs> and then re-emitted after $\langle \Delta t \rangle = 10^{-8}$ sec. Assume $\langle \kappa_{true} \rangle = \langle n_p \rangle \sigma_{true}$ for the average absorption coefficient for this alternative "true absorption" process. $\langle n_p \rangle$ is the mean proton density in the sun. Assume $\sigma_{true} = 2\times10^{-24}$ cm^2 for the "true absorption" cross section.

(2 points)

Please return homework on Monday, September 19