Radiative Processes & Radiation Transport

Homework #2
Due September 22, 2009

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1. (30 points) Consider a slab of homogeneous gas of thickness d. Gas in this slab both absorbs and scatters radiation passing through it. The absorption coefficient is α_ν and the scattering coefficient is σ_ν; the reduction to specific intensity (I_ν) of radiation traveling a distance δs in this medium is $(\alpha_\nu + \sigma_\nu) I_\nu \delta s$. **Calculate how far would a photon of frequency ν travel, on average, from its initial position within the slab where it was created, before it is absorbed (NOT scattered BUT absorbed).** [Assume that $d \gg (\alpha_\nu + \sigma_\nu)^{-1}$].

2. (70 points) Consider a different slab of homogeneous gas of thickness d_0, and take its cross-sectional area to be infinite for all practical purposes. The gas in this slab only scatters photons and does not absorb them, i.e. $\alpha_\nu = 0$. And moreover the scattering is elastic i.e. the frequency of scattered photons is same as incident photons. A flux F_ν from some very distant source is incident at the top of this medium. **Calculate the amount of radiation flux that emerges at the bottom of this atmosphere.** This is a steady state situation i.e. there is no time dependence in this problem. If the emergent flux at the bottom is less than F_ν you should explain what happens to the missing flux that was incident at the top of this slab. *Hint: you would need to make use of the Eddington approximation and most other things covered in lectures.*

(The result of this problem can be used to estimate the optical depth of clouds on Earth, and from this optical depth one can make a crude, order of magnitude, estimate of water content in clouds.)