Ay101

Fall 2002

PHYSICS OF STARS

Problem Set 4

Due Mon, October 28, 2002

1. In this problem we apply the Eddington approximation with boundary conditions from the two-stream approximation to determine what happens when an incident radiative flux F_I falls on a planetary atmosphere that only scatters radiation (no absorption or emission) that lies above a ground that absorbs all radiation. Let F_R be the reflected flux. Take the atmosphere to have optical depth τ_* and the ground to be completely absorbing (i.e., neglect any energy emitted by the ground).
   a. Calculate the mean intensity $J(\tau)$ as a function of optical depth τ in the atmosphere.
   b. Solve for F_R/F_I.
   c. Determine the limb darkening function $I(\mu)/I(0)$.

2.
   a. Calculate the ratio of H^- to neutral hydrogen for $T = 6000$ K and an electron pressure of 30 dynes/cm^2. Assume all the atoms in a given ionization state are in the ground state of that ion. The statistical weight for the ground state of neutral hydrogen is 2 and that for H^- is 1. The ionization potential of H^- is 0.7 eV.
   b. For a wavelength near 6000 Å, which levels of H can contribute to the bound-free opacity? What is the population of those levels relative to the ground state? What is the ratio of the H^- bound-free opacity to that of H at that wavelength? What happens at a wavelength of 3000 Å? What has changed there?

3. Make a flow chart for a program that computes model stellar atmospheres. Your flow chart should contain at least 5 and not more than 25 subroutines. Provide a few-sentence description of the function of each of the subroutines in your program.

4. Imagine that for the stellar atmosphere for the Sun, the only source of opacity was hydrogen absorption; i.e., neglect H^-, metals, etc. Calculate the emergent energy distribution in the continuum. For simplicity, use a grey atmosphere temperature distribution and a depth-independent absorption coefficient; i.e., use $\kappa(H)$ for $T_{\rm eff} = 5800$ K. Plot the emergent flux $F_\lambda(0)$ for the surface. Describe qualitatively how inclusion of H^- and free-free emission would change your results.