SECOND ASSIGNMENT: DUE 18 FEBRUARY 2008
ASTRONOMY 8100: STELLAR STRUCTURE & EVOLUTION
Prof. Paul J. Wiita

1. If an A0V star were a 9900 K blackbody, where would its peak in the continuous spectrum lie? What fraction of the energy of such a perfect A0 main sequence star would lie in the visible band, defined for these purposes as 400–700 nm? (8 points)

2. Given the following momentum distribution functions for different kinds of particles:

$$dN(\vec{p}) = C(\exp\frac{w}{kT} + K)^{-1} dp_x dp_y dp_z$$

where $w = (p_x^2 + p_y^2 + p_z^2)/2m$, find expressions for C in terms of the total number of particles N, for the three cases where $K = -1$, 0, and $+1$, respectively. To what physical situations do these cases corrrespond? (18)

3. Recall that the mass-luminosity relation on the Main Sequence is roughly $L \propto M^{3.7}$.
   (a) Assume (incorrectly) that stars have a uniform probability of being formed between M_{lo} and M_{hi}. What would be the shape of the initial luminosity function $\Phi(L)dL$? Hint: you might wish to use the relation $\Psi(M)dM = \Phi(L)dL$, with $\Psi(M)$ as the mass distribution function. (The phrase "initial lumininosity function" means that you can assume that all of the relevant luminosity is generated by stars on the main sequence.) (8)
   (b) Find (and explicitly cite) a reference giving a more reasonable form for $\Psi(M)$, as well as a good value for M_{lo} and a good estimate for M_{hi}. From this, derive a more realistic expression for $\Phi(L)dL$. (10)
   (c) For which type of galaxy is this the best approximation and for which type of galaxy is this the worst approximation, and why? By "type", consider just Spiral, Elliptical and Irregular galaxies. (4)

4. Consider a simple linear stellar model, where

$$\rho(r) = \rho_c[1 - (r/R)].$$

   (a) Using the equations of mass and momentum conservation only, and assuming that the equation of state is that of an ideal gas, derive expressions for $m(r), \rho_c, P_c, P(r)$, and $T(r)$ as functions of M and R, the total mass and radius of the star, respectively. (18)
   (b) Plot $P(r), T(r)$, and $m(r)$ for this linear model where $M = 1M_\odot$ and $R = 1R_\odot$. Compare these results with overplots of a realistic interior model for the Sun (and tell me what source you used for that model). (8)

Please turn over

5. Energy generation and transport in the sun.
    (a) Note the temperatures, densities and compositions at the following locations: $\ell = 0.1$, 0.25, 0.5, 0.75, 0.99; $m = 0.05$, 0.1, 0.25. 0.5, 0.75. Within what volume of the sun is essentially all of its energy generated?(10).
    (b) Using a published (and properly cited) model, compare the local value of the radiative gradient with that of the adiabatic gradient at at least 10 points within the sun. Describe the regions of radiative and convective energy transport using those results, being sure to use the Schwarzschild criterion in your discussion. In what fraction of the solar volume does convection carry the bulk of the energy? (16)