Ay121

Fall 2007

RADIATIVE PROCESSES

Problem Set 1

Due in class Thursday, Oct 11, 2007

1. A converging lens is used to focus sunlight onto a piece of wood. (a) Derive an expression for the surface temperature of the wood in terms of its albedo, A (ratio of total reflected flux to total incident flux), the focal ratio of the lens, f, and the effective temperature of the sun, $T_\odot$. (b) Is this a practical way to start a fire?

2. The Eddington-Barbier approximation and limb darkening: Consider a plane-parallel atmosphere that has an optical depth τ_ν such that $\tau_\nu = 0$ and increases as one goes downward in the atmosphere in a direction perpendicular to the surface. Let θ be the angle from the vertical and let $\mu = \cos\theta$ (see Fig 1.13 in RL). Assume that the source function obeys the Eddington-Barbier approximation: $S_\nu = a_\nu + b\tau_\nu$, where a_ν and b_ν are constants. (a) What is the specific intensity I_ν (expressed in terms of a_ν, b_ν, and θ) measured by an observer viewing the atmosphere from an angle θ from the vertical? What is the "characteristic" optical depth at which the specific intensity can be said to emerge? (b) Remembering that the solar photospheric layers get hotter the deeper down you go, explain how your answer to (a) can help explain limb darkening. (c) Now integrate I_ν appropriately to obtain the specific flux F_ν as measured by an observer outside the atmosphere, in terms of a_ν and b_ν. What is the "effective" (i.e., average) optical depth from which the flux can be said to emerge? This is a good definition of the continuum photosphere of the Sun.

3. This problem is meant to review some basic EM in an astrophysical context. Magnetic fields, organized into loops, are believed to confine the 2×10^6 K gas in the solar corona, which has a density $\sim 10^{11}$ cm^{-3}. (a) Estimate the strength of the field in these loops by equating the magnetic pressure to the gas pressure. (b) Now imagine two loops approaching each other, so that a sheet (of thickness smaller than the width of the loops) of field reversal occurs between them. Assuming a thickness for this sheet ~ 10 km, find the current density within the sheet. (HINT: Use Ampere's law.) (c) Suppose the loops approach each other at a velocity ~ 10 km/sec. Compare the rate of energy dissipation to the rate of desctruction of the magnetic field to estimate the resistivity of the ionized gas within the sheet. (d) Estimate the electric field strength within the sheet.