Radiative Processes in Astrophysics
Problem Set 4

Due date: Tuesday, 13 May 2003 at 10:15

1. Plane-parallel atmospheres

(a) Why are plane-parallel layers often assumed for stellar atmospheres? Can you guess when this approximation is good and when not?

(b) Explain how one gets the radiative transport equation and its formal solution in the case of a plane-parallel atmosphere. Include a sketch showing the geometry.

2. Eddington-Barbier approximation and limb darkening

(a) What is the Eddington-Barbier approximation? Explain what assumptions went into deriving it, and what it means. Why is it useful?

(b) What do we mean by "limb darkening"? Use Eddington-Barbier to explain this phenomenon.

(c) Pretend that you have measured limb darkening observationally, and make plot(s) of your results. What would cause a limb *brightening* effect?

3. Bremsstrahlung example

Consider a sphere of ionized hydrogen plasma that is undergoing spherical gravitational collapse. The sphere remains at constant isothermal temperature T_0, uniform density and constant mass M_0 during the collapse, and has decreasing radius $R(t)$. The sphere's luminosity comes from bremsstrahlung radiation in its interior. Initially, at time $t = t_0$, the sphere is optically thin.

(a) What is the total luminosity of the sphere as a function of M_0, $R(t)$ and T_0 while the sphere is optically thin?

(b) What is the luminosity of the sphere as a function of time after it becomes optically (very) thick?

(c) Draw a qualitative curve of the luminosity as a function of time and ***interpret*** this graph.