Radiative Processes in Astrophysics
Problem Set 2

Due date: Monday, 19 March 2001

1. Radiation quantities

(a) Define the following monochromatic quantities:
- intensity I_ν
- mean intensity J_ν
- flux $\mathcal{F}_\nu$

(b) Why is it generally more useful to know I_ν than $\mathcal{F}_\nu$?

(c) For which kind of astronomical objects is it possible to measure I_ν directly?

(d) Does $\mathcal{F}_\nu = 0$ mean that there is no radiation?

2. Flux and Intensity

(a) Assume two detectors are standing at the same distance from a point source of radiation. What is the ratio $\mathcal{F}_2/\mathcal{F}_1$ of the measured fluxes if the detector areas are $A_1 = 10\,\mathrm{cm}^2$ and $A_2 = 30\,\mathrm{cm}^2$?

(b) Now assume there is a third detector which is twice as far away from the point source and has an area of $A_3 = 10\,\mathrm{cm}^2$. What is the ratio $\mathcal{F}_3/\mathcal{F}_1$?

3. Conversions

(a) Are I_ν and I_λ equal for a given beam?

(b) Show that $d\nu/\nu = -d\lambda/\lambda$.

(c) Show that $\nu I_\nu = \lambda I_\lambda$.

(d) Derive the expression for $B_\lambda(T)$ from

$$B_\nu(T) = \frac{2h\nu^3}{c^2} \frac{1}{\exp(h\nu/kT) - 1}$$

4. Radiation pressure

In the most general case, radiation pressure is defined as a tensor. Under which conditions can the radiation pressure be defined as the scalar quantity

$$P_\nu = \frac{1}{c} \int I_\nu \cos^2\theta \, d\Omega \quad ?$$

Use this equation along with the Stefan-Boltzmann law to show that

$$P_{rad} = \frac{1}{3} a T^4$$

where $a = 4\sigma/c$. Again, note what assumption(s) you made.