Stellar Atmospheres, Ht 2002
Problem Set 3

Due date: Tuesday, 1 October 2002

1. Hydrostatic equilibrium

How reasonable is the assumption of hydrostatic equilibrium given the short-term changes that we see on the Sun?

As part of your discussion, include an estimate for the time scale on which the Sun radiates an amount of energy equal to the internal energy contained in the gas of the solar photosphere. (You can assume $\rho \approx 2.8 \times 10^{-7}$ kg/m^3 for the density).

2. Radiation pressure

Discuss the difference between radiation pressure and the mechanical force exerted by radiation on stellar material.

Your answer should include an explanation of how to derive the formulas below. Why does Eq. (2) depend on the opacity even though Eq. (1) does not?

$$P_{rad,\nu} = \frac{1}{c} \oint I_\nu \cos^2\theta \, d\Omega \tag{1}$$

$$\frac{dP_{rad}}{dx} = -\frac{\rho}{c} \int_0^\infty \kappa_\nu \mathcal{F}_\nu \, d\nu \tag{2}$$

3. Equivalent widths

A weak spectral line from neutral iron has been observed for a number of solar-type stars. Its lower level has an excitation energy of 2 eV.

If the line's equivalent width is twice as large for star A as for star B, how great is the difference in temperature (in the layers where the line is formed) between the two stars?

Assume that no hydrogen is ionized, nearly all iron is singly ionized, H^- is responsible for all the continuous opacity, the partition functions are independent of temperature, and both stars have the same iron abundance. The dissociation energy of H^- is 0.75 eV.

4. Line broadening

List and describe all the different types of stellar line broadening that you can find in the literature (e.g., Stark broadening). Which type of broadening is important in which types of stars?