Mid-Term Exam: November 5th, AST403 (Fall 2003)

The exam is out of 50 points and you have 45 minutes. The points for each question are provided; pace yourselves accordingly. Attempt *all* questions and be specific wherever possible. Good luck!

1. Measuring Temperatures (5 points)

Why do we refer to the 'effective' temperature of a stellar atmosphere and how do we define this quantity? Describe three observational methods by which an astronomer can estimate the effective temperature of a stellar atmosphere (write down both the technique and the physical rationale for employing the technique). Rank the methods in order of accuracy.

2. Radiative Transfer (10 points)

Define each of the following quantities (including units): (a) the intensity I_λ, (b) the flux F_λ, (c) the mean intensity J_λ, and (d) the source function S_λ. Describe how the ratio of the mean intensity to the intensity varies from deep inside a star to the surface (try to be quantitative). How does the flux vary over this same range?

3. Stellar Atmospheres (15 points)

Write down the general equation of radiative transfer in a plane parallel atmosphere and define each term. Assume the source function takes the linear form $S_\lambda(\tau_\lambda) = a_\lambda + b_\lambda \tau_\lambda$, where a_λ and b_λ are constants. Determine the intensity at the surface of the star, where $\tau_\lambda = 0$, as a function of angle. Given your knowledge of the Sun, is b_λ positive or negative for the linearized source function (assume $\lambda \sim 5000\mathring{A}$)? Are a_λ and b_λ functions of wavelength λ in a grey atmosphere? Explain how you reached your answers.

4. Stellar Lines (5 points)

Define the equivalent width W. Why do astronomers use the equivalent width as a measure of the strength of spectral lines? What are the two main broadening mechanisms for spectral lines and what line shapes do they produce? Why are strong absorption lines not black (radiating no energy)?

5. Under Pressure (15 points)

What is meant by 'hydrostatic equilibrium'? Complete the formula (making sure to define all quantities)

$$\frac{dP_g}{dt} = ?, \tag{1}$$

where P_g is the gas pressure and t is the depth. Show how this formula can be modified to measure the change in the pressure as a function of optical depth τ. Assume the mean opacity is neither a function of temperature or pressure and solve for P_g as a function of optical depth. Is this a reasonable assumption in the atmosphere of the Sun (why or why not)?

In a stellar atmosphere the temperature varies slowly compared with the pressure. If the temperature is taken to be constant then the pressure can be immediately determined as a function of depth t. Show this calculation. For the assumptions used in this problem, there is a simple relationship between $P_g(\tau)$ and $P_g(t)$. What is this relationship?

END OF MID-TERM