Topics: Stellar interiors, part 2

Reading:

- LeBlanc, Ch. 5 (the second half, from p. 176 through p. 202.
- Optionally, to supplement LeBlanc, you can read in Ch. 10 of Ostlie and Carroll's *An Introduction to Modern Stellar Astrophysics*, which is on reserve in Cornell.
- This week, you'll want to make use of those thermodynamics notes I gave you last week. They're still linked from the front of the class website.

Summary of work to be produced:

- There is just one warmup problem, due on Thursday at 6 pm: QW1.
- Bring solutions to seminar on Friday for all the (non-warm-up) numbered problems. Bring a xeroxed copy to give to me at the beginning of class, and expect to take notes on your original solutions.

Scope: We'll spend a fair amount of time on polytropic models – structure models that make some thermodynamic assumptions and thus enable models to be build without knowledge of the energy sources inside stars and indeed without explicit solving of the temperature structure within stars. Again, you might benefit from supplementing LeBlanc with Ostlie and Carroll, and the thermodynamics notes. Note the trend of density concentration with polytropic index (Fig. 5.7).

A solar structure model is presented in §5.5. You might look on *Astronomy Picture of the Day* for some images of the photosphere, chromosphere, and corona. How can you tell from Tab. 5.1 that the statement in the text that nuclear reactions cease at about 0.25 R_* is true?

Be prepared to discuss/derive the equation of state for degenerate matter.

Stellar pulsations are interesting. Understanding their basics can help us solidify our understanding of stellar structure. Make sure you understand the description of the workings of the *kappa mechanism* (p. 196).

Questions etc.:

QW1 Problem 5.8. Please try to think about the physical meaning of the weird, scaled variables as you're solving this problem.

Q2 Derive an expression for the total mass of an $n = 5$ polytrope, and show that although ξ_o goes to infinity, the mass is finite.

Q3 Problem 5.10

Q4 Problem 5.11 – you can start with eq. 5.117.

Q5 Problem 5.12 – then, assuming 2% metals by mass and typical metal is oxygen, how far off are we when we assume pure hydrogen and ignore metals?

Q6 Looking at Fig. 5.14, it's interesting that the star is brightest (around day 6.8) not when it's biggest but just about when it's smallest. Using the Stefan-Boltzmann law and the temperature and radius graphs, verify that the brightest phase is indeed around 6.8 days. Something fishy seems to be going on...because the previous brightest phase (around day 1.8) doesn't occur at the same time as that radius minimum. Hmmm, which is right? Maybe think about the expected relationship between the line-of-sight velocity and the size (what velocity do we expect the surface of the star to have when it's at its smallest?).

Q7 Using Fig. 5.13, how far away is a classical Cepheid variable star with a 30 day period and an apparent (bolometric) magnitude of $m_{\text{bol}} = +8$? You may assume that the luminosities plotted in that figure are bolometric luminosities. Roughly what uncertainty would you place on your distance estimate, considering the scatter seen in the empirical period-luminosity relationship seen in that figure?

Q8 Problem 5.13