Astro 112 – Physics of Stars
"Sample Exam Questions"

The exam is open note, open book. You have 9:30-10:40 a.m. to complete the exam. Partial credit will be given. If you can answer a question with a few lines of math or text, as opposed to filling up the whole page, great! Don't feel like you need to go on at length.

1) Show that the equation of hydrostatic equilibrium can also be written in terms of the optical depth τ, as $dP/d\tau = g/\kappa$.

2) In the atmospheres of K stars bound-bound and bound-free opacity are more important than electron scattering, but the opposite is true in O stars. Why is this?

3) Calculate the gravitational potential energy released in the collapse of a constant density 1.2 M⊙ star from an initial density of 10^{12} kg/m^3 to 10^{18} kg/m^3.

4) The naked eye can only see stars brighter than magnitude m=6.0. How far away (in parsecs) could the Sun be, and still be seen?

1) $$\frac{dP}{dr} = -\rho g \qquad d\tau = -\kappa\rho\, dr \quad \therefore \quad dr = \frac{-d\tau}{\kappa\rho}$$

$$\frac{dP}{d\tau} = \frac{-\rho g}{-\kappa\rho} = \boxed{\frac{g}{\kappa}}$$

2) BOUND-BOUND (BB) AND BOUND-FREE (BF) OPACITY ARE IMPORTANT FOR ATOMS AND IONS THAT ARE NOT FULLY IONIZED. K STARS ARE RELATIVELY COOL AND HAVE ATOMS IN THEIR ATMOSPHERES, SO BB AND BF ARE IMPORTANT. O STARS ARE THE HOTTEST, AND ALL H AND He ARE NEARLY FULLY IONIZED (BARE NUCLEI!) SO THAT BB AND BF ARE LESS IMPORTANT. O STARS HAVE LOTS OF FREE e^-, MAKING e^- SCATTERING AN IMPORTANT OPACITY SOURCE.

6) Calculate the gravitational potential energy released in the collapse of a constant density 1.2 $M_\odot$ core from an initial density of 10^{12} kg/m^3 to 10^{18} kg/m^3. (*10 points*)

$1.2 M_\odot$ → 2.4×10^{30} kg

$$\bar{\rho} = \frac{M}{\frac{4}{3}\pi R^3}$$

$$10^{12} = \frac{1.2 M_\odot}{\frac{4}{3}\pi R_{BEFORE}^3}$$

$$1.75 \times 10^{-18} = \frac{1}{R_{BEFORE}^3} \Rightarrow R_{BEFORE} = 8.3 \times 10^5 \text{ m}$$

$$10^{18} = \frac{1.2 M_\odot}{\frac{4}{3}\pi R_{AFTER}^3} \Rightarrow R_{AFTER} = 8.3 \times 10^3 \text{ m}$$

$$GPE = \frac{3}{5}\frac{GM^2}{R}$$ FOR A CONSTANT DENSITY SPHERE

$$\Delta GPE = \frac{3}{5}GM^2\left(\frac{1}{R_{AFTER}} - \frac{1}{R_{BEFORE}}\right)$$

$$= 2.30 \times 10^{50}\left(\frac{1}{8.3 \times 10^3} - \frac{1}{8.5 \times 10^5}\right)$$

$$\boxed{\Delta GPE = 2.8 \times 10^{46} \text{ J}}$$

7) The naked eye can only see stars brighter than magnitude m=6.0. How far away (in parsecs) could the Sun be, and still be seen? (*10 points*)

ABSOLUTE MAGNITUDE

APPARENT MAGNITUDE $= 6.0$

$$m - M = 5 \log d - 5$$

$$m - M = 5 \log\left(\frac{d}{10}\right)$$

$$M_{SUN} = 4.74$$

$$d = 10\left(10^{\frac{m-M}{5}}\right) = 10^{\left(\frac{m-M+5}{5}\right)}$$

$$d = 10\left(10^{\frac{6-4.74}{5}}\right)$$

$$\boxed{d = 17.9 \text{ PARSECS}}$$