5. **How much energy is produced by nuclear fusion in the core of the Sun each second?**

$\cdot\; L_\odot = \frac{\text{Energy}}{\text{sec}} \Rightarrow \boxed{\text{Energy in 1 sec}} = L_\odot \cdot 1\,\text{sec} = 4\times10^{33}\,\frac{\text{erg}}{\text{s}} \cdot 1\text{s}$

$\boxed{= 4\times10^{33}\ \text{ergs}}$

6. **How long will a $0.3M_\odot$ star with $L = 0.01L_\odot$ spend on the main-sequence? (Hint, the main-sequence lifetime of the Sun is 10 billion years).**

$\cdot$ From $L = \frac{\Delta E}{\Delta t} = \frac{\Delta M c^2}{\Delta t} \Rightarrow \Delta t_{life} \propto \frac{M}{L} \Rightarrow t_{life} = t_{life,\odot} \cdot \frac{M/M_\odot}{L/L_\odot}$

$\Rightarrow \boxed{\Delta t_{life} = \frac{0.3 M_\odot/M_\odot}{0.01 L_\odot/L_\odot} \cdot 10 \text{ billion years} = \frac{0.3}{0.1} \cdot 10 \text{ bill yrs} = 300 \text{ billion years}}$

7. **In the fusion of four protons into helium, 4.7×10^{-26} grams of matter is turned into energy. How much energy does this amount of matter produce?**

$\cdot\; \boxed{\Delta E = \Delta M c^2 = (4.7\times10^{-26}\,g)(3\times10^{10}\,cm/s) = 4.23\times10^{-5}\ \text{ergs}}$

8. **Four stars occupy the four corners of an H-R diagram (UL, LL, UR, LR).**

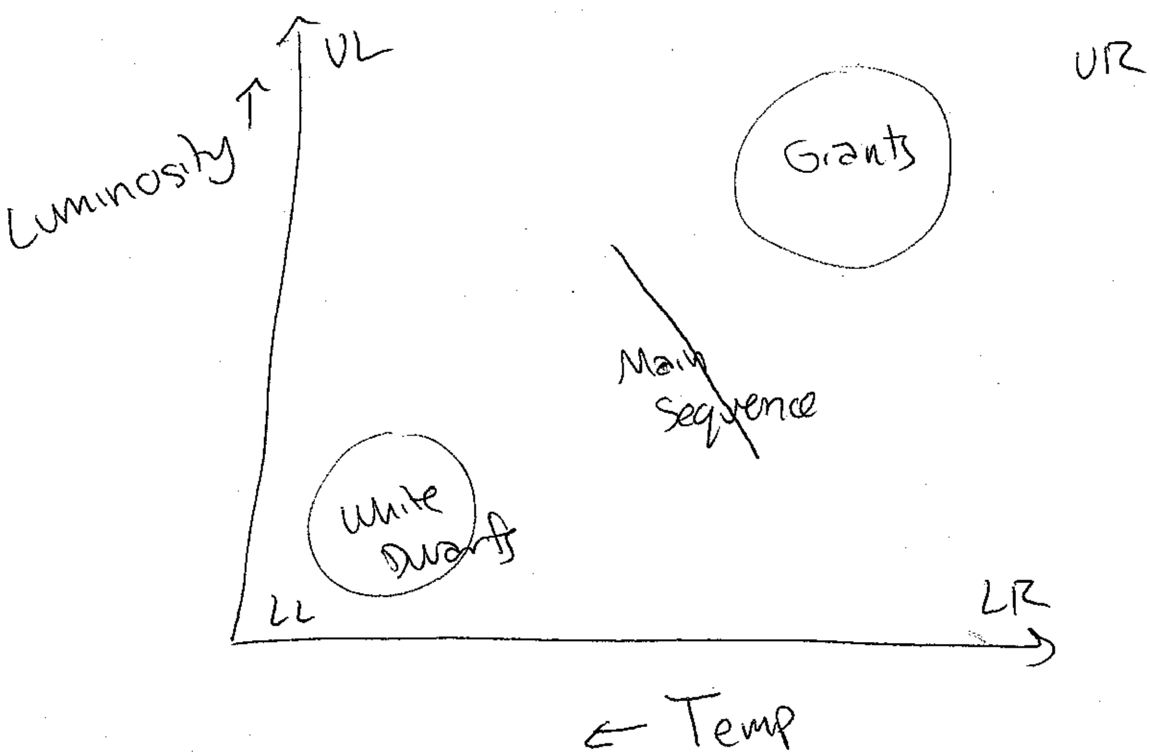
UR In which corner(s) is (are) the largest star(s)? (low T, high $L \Rightarrow$ big R since $L = 4\pi\sigma T^4 R^2$)

UL, UR In which corner(s) is (are) the most luminous star(s)?

UL, LL In which corner(s) is (are) the hottest star(s)?

LR In which corner(s) is (are) the lowest mass main-sequence stars?

(on M.S. $L \propto M^{3.5} \Rightarrow$ low L means low M)



Homework 3 Spring 2008 .... YOUR NAME:______________________

Some numbers: $L_\odot = 4 \times 10^{33}$ ergs/second $M_\odot = 2 \times 10^{33}$ grams c= 3×10^{10} cm/second.

1. **What is the energy source for the Sun? (select one)**

   ___Nuclear fission reactions

   _X_Nuclear fusion of hydrogen into helium

   ___Conversion of gravitational potential energy into heat and light

   ___None of the above

2. **Why are high temperatures required for fusion reactions? (select one)**

   ___The high temperature is required to counteract gravity

   _X_Only at high temperature do the nuclei in a gas approach close enough for the nuclear force to overcome electrical repulsion

   ___Uranium only undergoes radiactive decay at high temperature

   ___The strong force only exists in high temperature environments.

3. **Label the following questions about star formation processes True or False.**

   _F_Dust is required to shield molecular cloud cores from starlight and thereby allow the cores to cool

   _F_Protostars enter the HR Diagram from the upper left corner (upper right)

   _T_Most or all stars form in groups or clusters of stars (Pleiades)

   _T_Protostars stop their gravitational contraction when their central temperature is high enough for hydrogen fusion to begin

4. **Coal burning releases 4×10^{12} ergs per gram of coal.**

   (a) What is the total amount of energy that could be generated if the Sun were coal-powered and made of coal?

$$E_{tot} = M_\odot \cdot \left(\frac{\#\,ergs}{gram}\text{ released}\right) = 2\times10^{33}\,g \cdot 4\times10^{12}\,\frac{erg}{g} = 8\times10^{45}\,erg$$

   (b) How long would the coal-powered Sun of part (a) last before running out of fuel?

$$L = \frac{\Delta E}{\Delta t} \Rightarrow \Delta t_{life} \simeq \frac{\Delta E}{L} = \frac{\Delta E\text{ from (a)}}{L_\odot}$$

$$= \frac{8\times10^{45}\,ergs}{4\times10^{33}\,erg/s} = 2\times10^{12}\,s \cdot \frac{1\,min}{60\,s} \cdot \frac{1\,hr}{60\,min} \cdot \frac{1\,day}{24\,hr} \cdot \frac{1\,yr}{365\,d}$$

(canceling unit terms)

$$\Rightarrow \Delta t_{life} \simeq 63420\text{ years}$$

assuming all of sun's mass is turned into energy