# Homework # 5 - Giant Stars

**Due:** Thursday, April 6 at 2:00 pm.
**Reading:** Lecture Notes, Pols chapter 10, BOB chapter 13.

**Instructions:** Homework must be highly legible, on white paper, and with multiple pages stapled. List at the top:

- Your name.
- Collaborators (if applicable).
- Estimated time spent to complete.

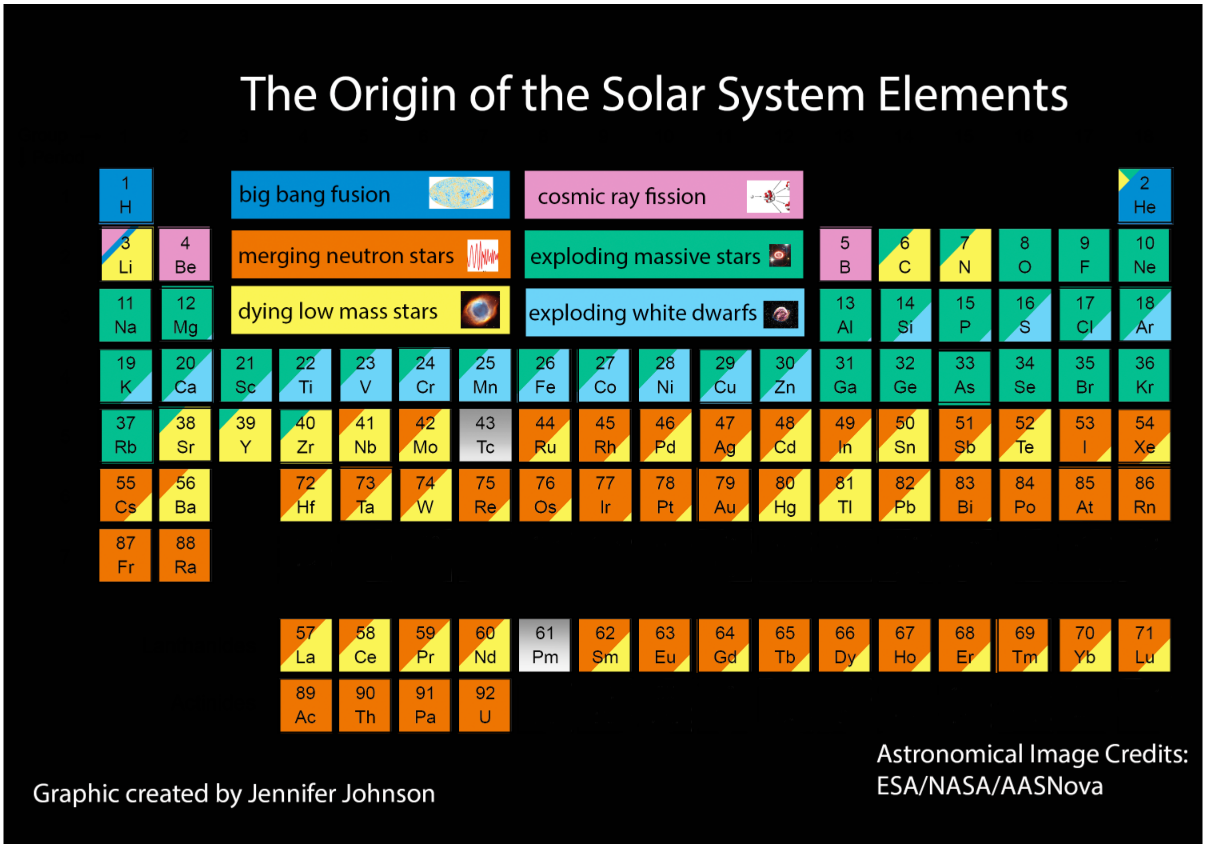
Homeworks are due at the beginning of class. Late homeworks will be marked down by 50% until the assignment is graded and returned, and will receive no credit after that. Clearly outline the process for solving the problem: partial credit will be given for presenting the correct steps to solve problem, even if you do not achieve the correct numerical answer.

**Problems (3 questions, 20 total points):**

1. Polaris is a supergiant star with a mass of $5.4 M_\odot$, a radius of $37.5 R_\odot$, and a luminosity of $1260 L_\odot$. (**10 pts total**)
   (a) What is the effective surface temperature of Polaris? (**2 pts**)
   (b) Polaris is on the asymptotic giant branch: it has exhausted its hydrogen and has a luminosity powered almost entirely by helium fusion. Assume that Polaris has $Y = 0.9$ (and $X = 0$, $Z = 0.1$) and half of the star is available for $3\alpha$ reactions. How long will Polaris survive on the AGB? (Remember that 3 He nuclei are burned in each $3\alpha$ fusion reaction.) (**4 pts**)
   (c) Like many massive ($2 < M < 8 M_\odot$) supergiant stars, Polaris is a Cepheid variable star. Cepheid variability is driven entirely by dynamical effects, with no heat transfer. What is the period of variability for Polaris? (*Hint*: Look back at the Lecture 4 notes.) (**4 pts**)

2. The "Helium flash" is tremendously luminous but very short lived, emitting $L = 1 \times 10^{10} L_\odot$ in about 3 s. By what factor does the radius of the core expand due to the Helium flash? Assume that all of the Helium flash energy goes into expanding the core, and the initial degenerate core can be approximated as a white dwarf. (Both assumptions are reasonably accurate.) (**5 pts**)

3. The periodic table below is a great general visualization of where the elements come from, but it skips the details. Describe the following. (**5 pts total**)
   (a) The different nuclear reactions in "dying low mass stars" that lead to carbon (C) as opposed to tin (Sn).
   (b) The different nuclear reactions in "exploding massive stars" that lead to elements lighter than iron (e.g., oxygen O, neon Ne, and magnesium Mg) as opposed to elements heavier than iron (e.g., arsenic As, selenium Se, and krypton Kr).
   (c) The nuclear reactions in "merging neutron stars" that lead to elements like gold and uranium.




**Extra Question for 6710 and 4710 Honors Option (1 question, 5 total points):**

4. The table below shows the abundance of the elements in our solar system. Why are lithium, beryllium, and boron much less abundant than the other elements? (**5 pts**)