Homework Assignment 5 **ASTR4201, Fall 2020**

Corresponds to Chapter 5 of "To Build a Star" (TBS) by E.F. Brown

1. TBS exercise 5.1 Team: 3 Lead: Josh

2. TBS exercise 5.2 Team: 2 Lead: Quinn

3. *See below* Team: 1 Lead: Gavin
   Considering the terms of the semi-empirical mass formula, which parameter is responsible for the following feature of the nuclear landscape:
   a. Location of the valley of stability for low A?
   b. Bend of valley of stability away from N=Z for large A?
   c. Large A/Z ratios?
   d. Lack of ultra-high A nuclides?
   e. Existence of nuclides in the first place?

4. *See below* Team: 3 Lead: Harshil
   Calculate the experimental binding energy difference between 15N and 15O [See http://amdc.impcas.ac.cn/masstables/Ame2016/mass16.txt]. Assuming this is due to the Coulomb term of the SEMF, what radius corresponds to A=15? Note that compared to a point-charge, a uniformly charged sphere has $U_{sphere} = (3/5)U_{point}$. Compare this to the usual approximation for the nuclear radius (using r_0=1.2fm).

5. TBS exercise 5.3 Team: 2 Lead: Michael

6. *See below* Team: 1 Lead: Anthony
   There's a maximum in the Binding energy per nucleon (found in TBS 5.3 and shown in the Quick Notes). For measured masses, this is at ^{58}Fe. Why isn't everything made of ^{58}Fe?

7. *See below* Team: 3 Lead: Ryan
   In a single-degenerate scenario, a Type-1a supernova converts a white-dwarf's mass of roughly ^{12}C (B = 92.162 MeV) to roughly ^{60}Fe (B = 525.351 MeV). How much energy is this? How does this compare to the gravitational binding energy of the white dwarf? What does this say about the power source of Type-1a's?

8. TBS exercise 5.4 Team: 4 Lead: Jacob

9. *See below* Team: 4 Lead: Gula
   If the ^{3}He+^{3}He cross section were purely geometric, what would the S-factor be for a 100keV interaction energy? What about for p+d? Compare to the measured values of 5MeV*b for ^{3}He+^{3}He and 1MeV*b for p+d.

10. TBS exercise 5.5 Team: 1 Lead: Brit

11. TBS exercise 5.6 Team: 5 Lead: Justin

12. *See below* Team: 2 Lead: Sam
    Which of the following reactions are possible without non-standard model physics? For invalid reactions, indicate what the issue is.
    a. $^{137}Cs \rightarrow {}^{137m}Ba + e^-$
    b. $^{12}C(\alpha,\gamma)^{16}O$
    c. $^{144}Sm(\gamma,\alpha)^{140}Nd$
    d. $^{126}Te(n,\gamma)^{127}I$

13. *See below* Team: 5 Lead: Robert
    For the CNO cycle at near-solar temperatures, the process piles-up at ^{14}N because this rate is the slowest. Where would the process pile-up at if the temperature were very high?