Homework Assignment 7 **ASTR4201, Fall 2020**

Corresponds to Chapter 7 of "To Build a Star" (TBS) by E.F. Brown

1. *See below* Team: 1 Lead: Anthony
   A nucleus is held together by the strong force, which is mediated by virtual pions. In order for a conglomeration of nucleons to be considered a "state", the nucleons in a nucleus need to have time to have exchanged some pions. The virtual pions are created from the vacuum and exist for a lifetime limited by the uncertainty principle. This then sets the lower limit on what qualifies as a "state". Calculate this time given that the pion mass is ~140MeV/c^2.

2. TBS exercise 7.1 Team: 1 Lead: Brit

3. TBS exercise 7.2 Team: 2 Lead: Michael

4. *See below* Team: 3 Lead: Josh
   In the supergiant phase, a star that initially had 15 $M_\odot$ ZAMS will be have ~10 $M_\odot$ mass and ~50 $R_\odot$ radius. In table 7.1, you'll notice that the surface luminosity hardly changes beyond the carbon burning phase. Show why.

5. *See below* Team: 1 Lead: Gavin
   What would the maximum mass of an H-rich white dwarf be? How can a hydrogen white dwarf be ruled-out observationally?

6. *See below* Team: 3 Lead: Ryan
   How much heat does it cost to have electron capture on ^{56}Fe? BE(^{56}Fe)= 492.26 MeV and BE(^{56}Mn)=489.35 MeV.

7. TBS exercise 7.3 Team: 3 Lead: Harshil

8. *See below* Team: 2 Lead: Sam
   Suppose you're standing on the surface of a white dwarf. What is the difference in force between your upper 10 kg and your lower 10 kg? What about on a neutron star? Compare to the typical tensile strength of a human tendon of ~1,000N.

9. *See below* Team: 2 Lead: Quinn
   A black hole is "black" because light can't escape. Find the radius within which a given amount of mass will have an escape velocity equal to the speed of light. This is the Schwarzschild radius. For a solar mass, what would the average density of this object be?

10. TBS exercise 7.4 Team: 5 Lead: Robert

11. *See below* Team: 4 Lead: Jacob
    Consider the core of a massive star. Prior to collapse, suppose it has roughly a solar mass, white dwarf radius, and is uniformly rotating at the solar surface rotation frequency of 4×10^{-7} Hz. Assuming no angular momentum is lost and both objects are uniform spheres, what will the rotation rate be when this core collapses to the size of a neutron star?

12. TBS exercise 7.5 Team: 5 Lead: Justin

13. *See below* Team: 4 Lead: Gula
    Follow TBS 7.5, but assume this is an accreting white dwarf, where the radius is 6,500 km and the accretion rate is 10^{18} g/s.