PHY 521: Stars

Final Project

Due by the last day of class, 2021-12-06 (by 5pm)

Below is a list of suggested projects, but you are free to do something else on your own, but please discuss it with me before starting. Think of the project as being equivalent to 2 homeworks—that's a good guide on how in-depth you should go.

Some of the ideas below are just suggestions on something to get started on, and we can discuss in more detail one-on-one about what you should try to do.

1. Download and run MESA for yourself and explore some property of stellar evolution in detail, for example:
   (**a**) the effect of mass loss
   (**b**) convergence of models with resolution
   (**c**) WD masses and structure from a range of different main sequence star masses
2. Read about the relaxation / Henyey method for solving the stellar structure equations and solve the polytrope equations using this method.
3. We only did very basic gray models for a stellar atmosphere. Find a text on stellar atmospheres and compute some more realistic atmospheres (either gray or frequency-dependent).
4. Find some papers that give expressions for neutrino losses (as a function of density, temperature, and composition) and compute ignition curves for H, He, C, O, and Ne burning (these will be curves in the $\log \rho$-$\log T$ plane) such that the energy release exceeds the neutrino losses.
5. Solve for the abundance of nuclei in nuclear statistical equilibrium as a function of temperature.
6. Solve for the structure of a ZAMS star using simple physics (ideal gas, electron scattering opacity, power law energy generation rate). You can do this using the shooting method. A sample code and description of a method is in Carroll & Ostlie and other texts, and can serve as a starting point for your own version.

   Alternately, solve for the structure of a plane-parallel atmosphere with energy generation in the context of an X-ray burst.
7. Numerically evaluate the Fermi integrals for non-zero temperature and write your own electron EOS.
8. Make a M vs. R diagram for a WD with a zero temperature, but arbitrary relativity EOS. (You'll need to integrate the equation of HSE using this EOS). Also include ions as an ideal gas, and adjust the temperature until they have a significant effect on the structure and explore this temperature effect.
9. Investigate the data releases from the GAIA mission and explore some stellar properties (e.g., make an HR diagram, looking at the current distribution of stellar masses, ...)
10. Give a 30-minute presentation to the class on a topic about stars that we did not cover in class (this will be during the last week of classes).