ASTP 720 Homework Assignment 3

Isabella Cox – igc5972@rit.edu

September 23, 2020

Task 1

For central densities in the rangec= 1E4 to 1E6 g/cm3, solve via your RK4 solver the hydrostatic equilibrium equations above for white dwarfs and plot the mass-radius curve. That is, chose a central density. You will then integrate over radial slices dr, and once you have M and R, you will store that and move onto the next central density. Since you are feeding your solver a list of radial slices to solve at, you can either determine some stopping criterion internally or just give the code a list of slices out to a few R earth radii (since we know that white dwarfs can't be much larger than this), thereby ensuring that you will hit P is approx. equal to 0 somewhere in the array.

NOTE: I know the labels on all my plots are way too small, I just ran out of time to fix things.

For a range of densities in the necessary range, I solved the differential equations using my RK4 solver from last week to solve for the pressures and masses. When the pressure had dramatically dropped (to less than 10% of its central pressure), I considered that to be the location of the edge of the galaxy. For the corresponding radius and enclosed mass at those radii, I plotted mass versus radius to show the Mass-Radius plot for a white dwarf, shown in Figure 1.

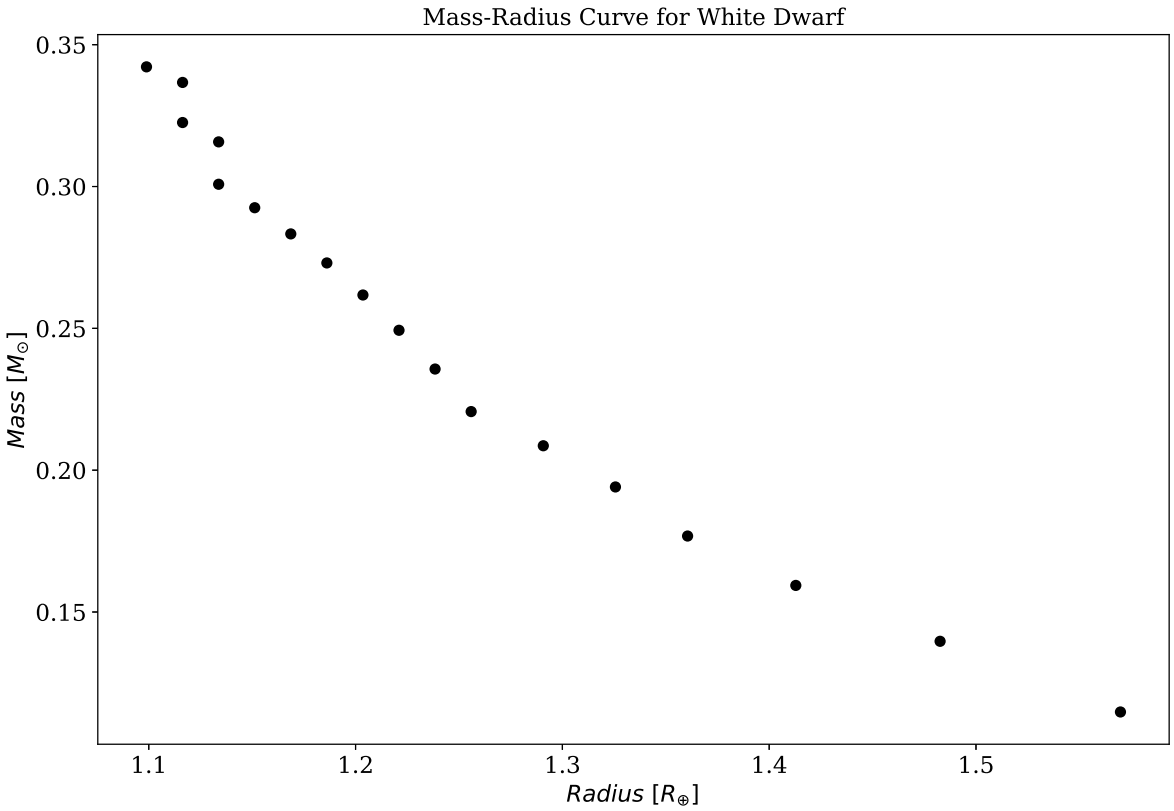

Figure 1: Mass-Radius plot for a White dwarf, with the axes in CGS units.

Task 2

For central densities in the rangec= 1E141E16 g/cm3, solve the relativistic hydrostatic equilibrium equations above for neutron stars and plot the mass-radius curve. In this case, your slices only need to go out to maybe 20 km.

Same setup as Task 1 except a different equation of state (the TOV equation). Honestly, when I use the TOV equation, my plot looks all messed up as it has mass increasing with radius. So I did something wrong (you can check this out in Figure 2)....

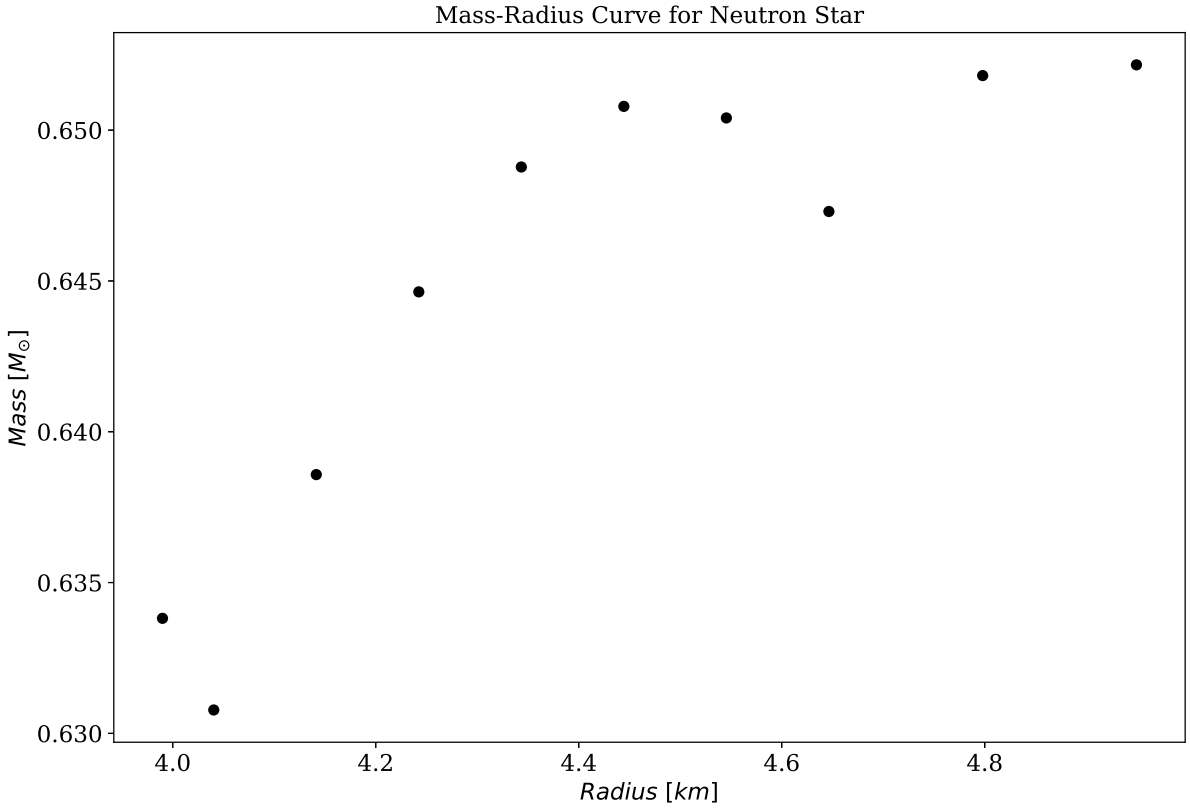

Figure 2: Mass-Radius plot for a White dwarf, with the axes in CGS units.

Task 3

The Neutron Star Interior Composition Explorer (NICER) measured the radius and mass of PSRJ0030+0451 to be R is $13.02^{+1.24}_{1.06}$*km and* $M = 1.44^{+0.15}_{0.14}$ $M_\odot$*, respectively. Numerically calculate the expected mass of a neutron star with an equation of state governed by the TOV equation and with a radius of 13.02 km.*

I did not get my Task 2 working, but had I did, I would have interpolated through the Mass-Radius curve to determine the mass value corresponding to a radius of 13.02km and then compared to see if it agreed within error with the value cited.