Modeling Stars:
Two Method Comparison and Analysis

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We were to create code that would be able to take a stars composition and mass to determine mainly temperature, luminosity and surface radius so we can build an HR diagram. To begin we must first ensure we can build a code that will run for a single star. To do this we use the initial conditions for our sun.

To perform the calculations we started from the core and integrated outward using the fourth order Runge Kutta method. We specified a core pressure, core temperature, and composition of the star. From there, the outward integration calculates total mass, luminosity, pressure and temperature at every other radius. The integration stops when the boundry conditions are met, that is, the pressure goes to zero. Once this point is reached it means we are at the surface, we can take the temperature here, and use it for the HR diagram. The following plots show our results using the initial conditions of the core of the sun.

These plots perform as we would expect for a 1 solar mass star but they do not get the exact values as expected. One thing that differs from our star to the sun is that it is only radiative for two radius steps, which is about 2×10^5 meters, and convective for the rest. This is in contrast to the sun, where the radiative zone is aout 70% of the whole star. We were also unable to incorporate the optical depth so we used the surface temperature instead. The surface temperature should go to zero but our pressure hit zero first triggering the integration to stop. If we were able to use the temperatiure at a specific optical depth, we would have expected temperatures that produced a better HR diagram. We expect the final values for mass, temperature, pressure, luminosity to be

Knowing our model works properly but does not get proper values we can go farther and get a general form of an HR diagram. By running this program for a total number of **number of stars** times we got the following HR diagram.

We can see that is **looks similar to/does not really resemble** the known HR diagram. We can explore a well known program to get a sense of what the HR diagram should look like and compare it to our own model. We will use MESA to do the comparison. This might not allow for a proper comparison because our model is static and has no rotation but it should give a general shape of the HR diagram.
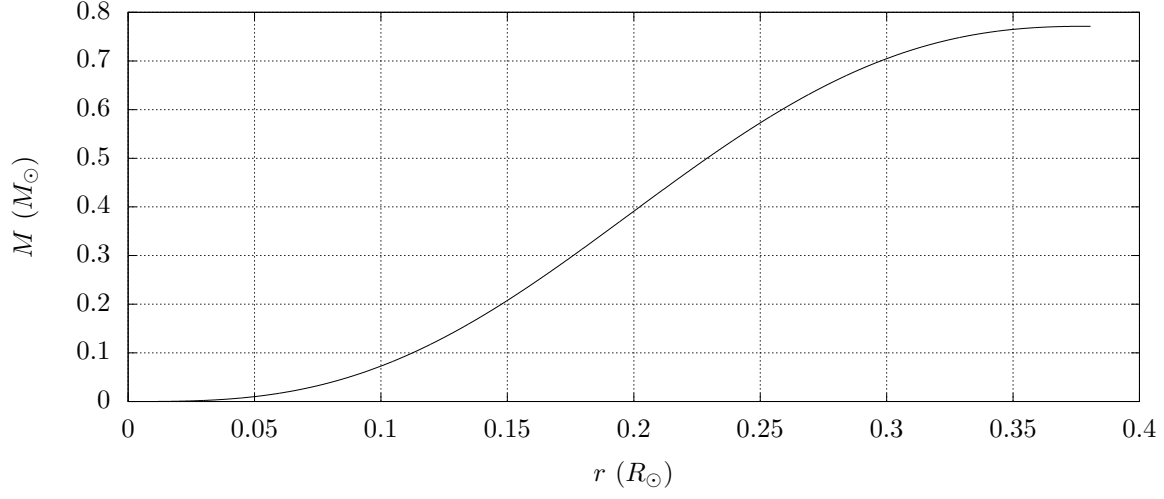
(a) Mass profile of the Sun.
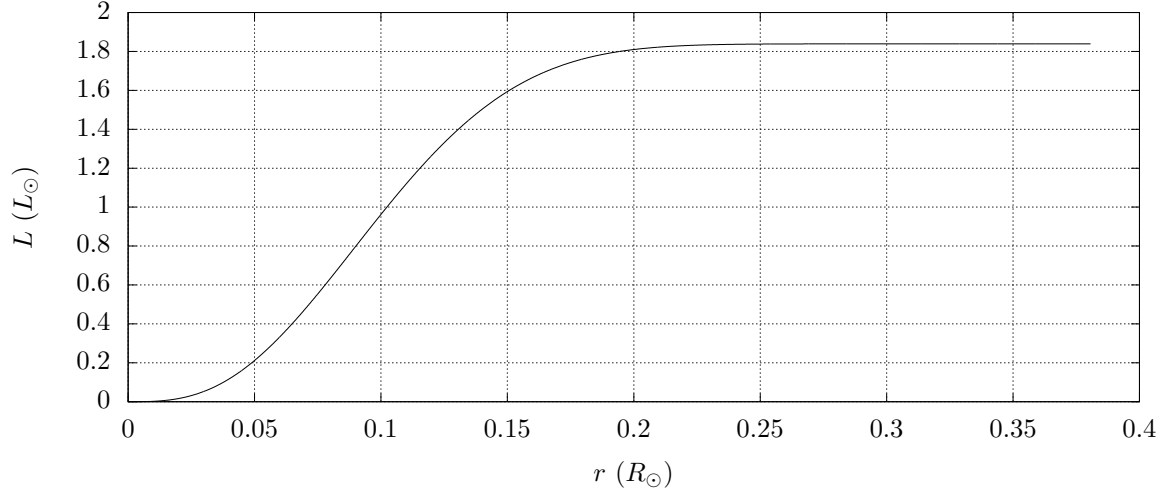
(b) Luminosity profile of the Sun.
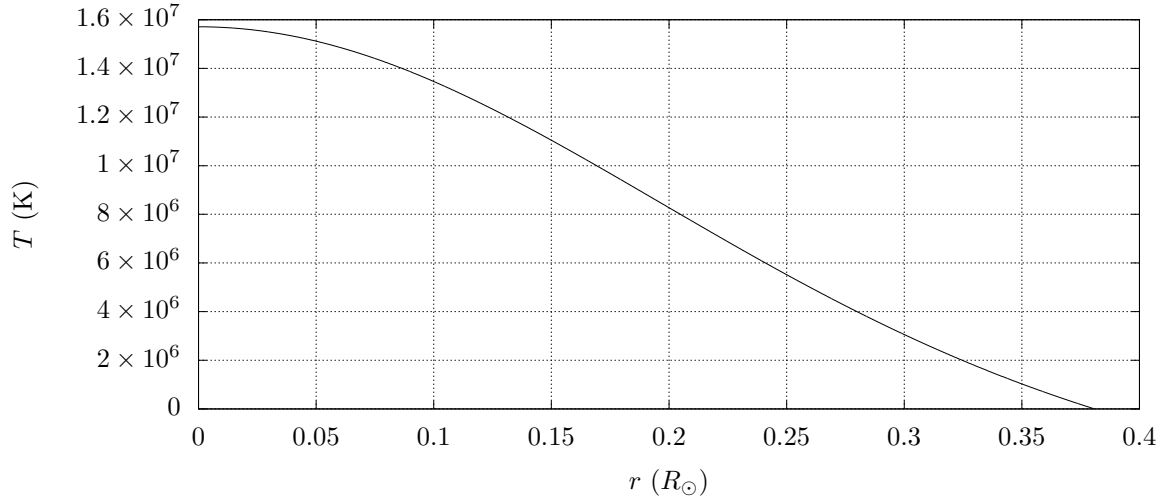
(c) Temperature profile of the Sun.

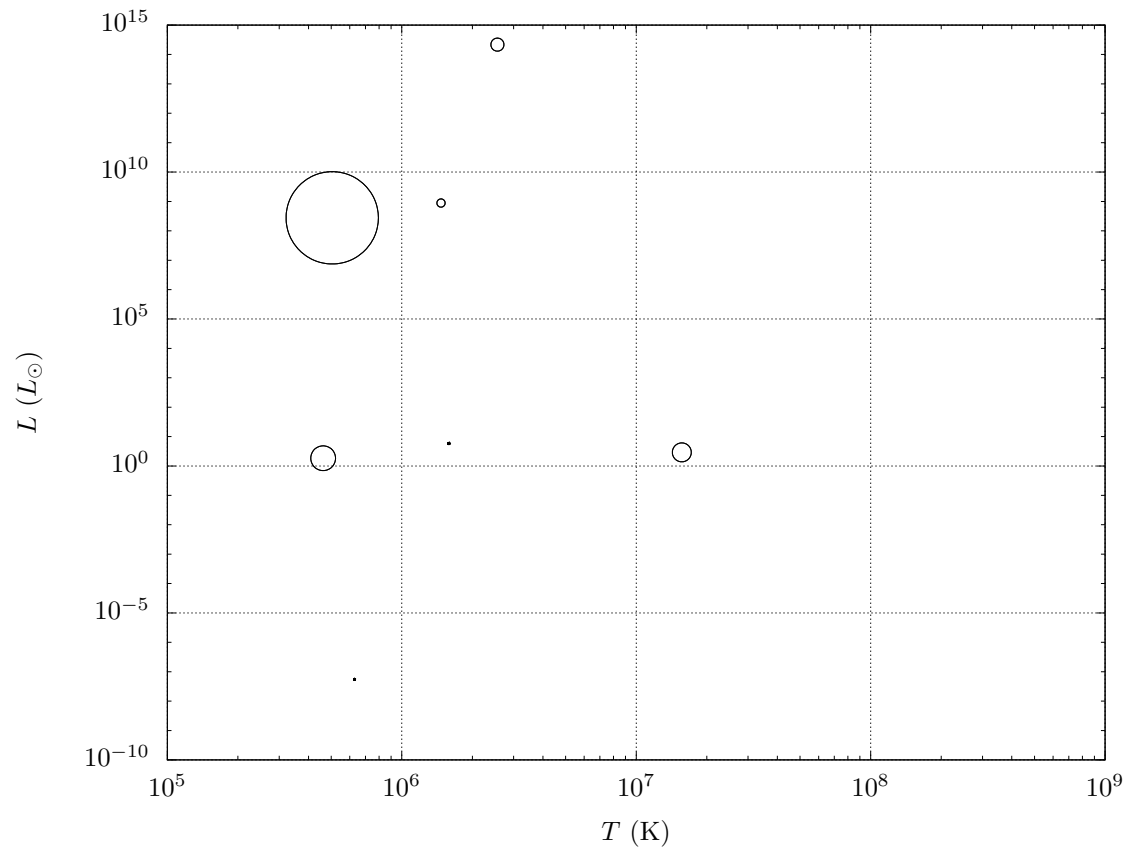Figure 1: Simulation results of the Sun.

Figure 2: Our reproduction of the HR diagram. The radius of the circles represents the radius of the stars.