Detailed Description of Project

# Introduction

Our project is a scientifically accurate graphical simulation of a star as a function of mass and time. The user controls both of those quantities, and the graphics generated update dynamically via Manipulate.

# Data

In order to accomplish this task, we use a set of star data acquired from a website called [EZ-Web](http://www.astro.wisc.edu/~townsend/static.php?ref=ez-web#Using_EZ-Web). EZ-Web data appears next to our code in a folder called “Stellar Database” and is in the form of .txt files. Those text files consist of tabulated data of the star’s life, with rows representing different points in time and column representing different quantities (if you really want to examine this further, we recommend taking a look at the files and importing one into an excel spreadsheet to see it properly). When run, our program takes one of those files, imports it in the form of a two-dimensional list, and that list is organized in a way that allows for easy access by the rest of the code, using associations to define each quantity.

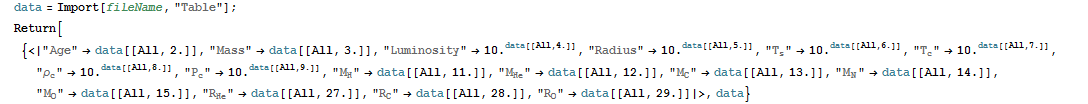


Figure : The main body of our dataset initialization function.

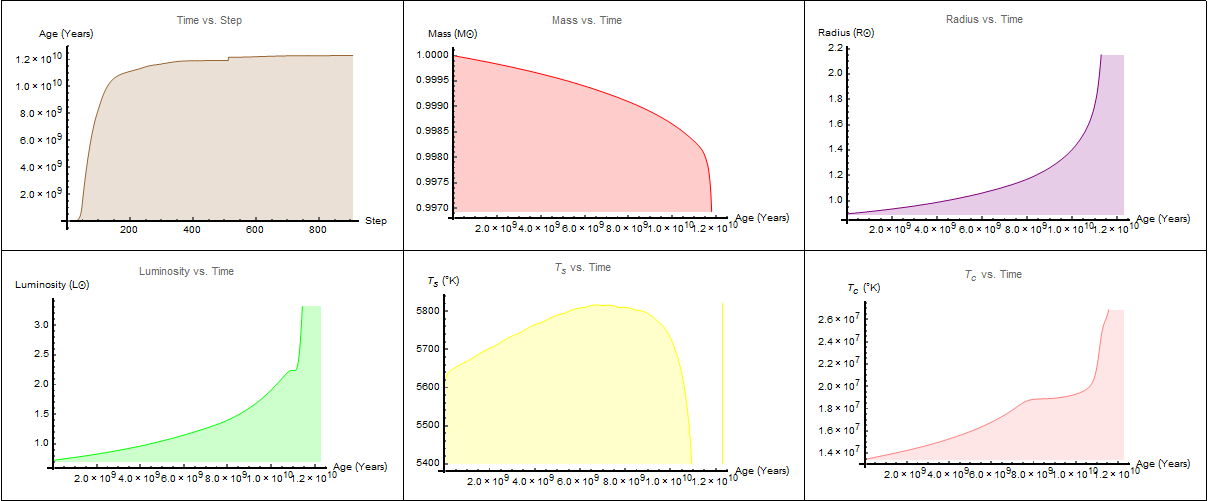
These data lists are then interpolated into functions of time, which lets us use realistic data for the star at *any* point in time within the bounds of the data provided. To avoid odd behaviors when there were large jumps in time, the interpolation order of all of the functions is one, meaning that the interpolation is linear.

Figure : Some of the functions created using our interpolation methods, displayed in graph form at the end of our project. Because the point density of the database is so high, the interpolation appears to be nonlinear even though it is.

# Display

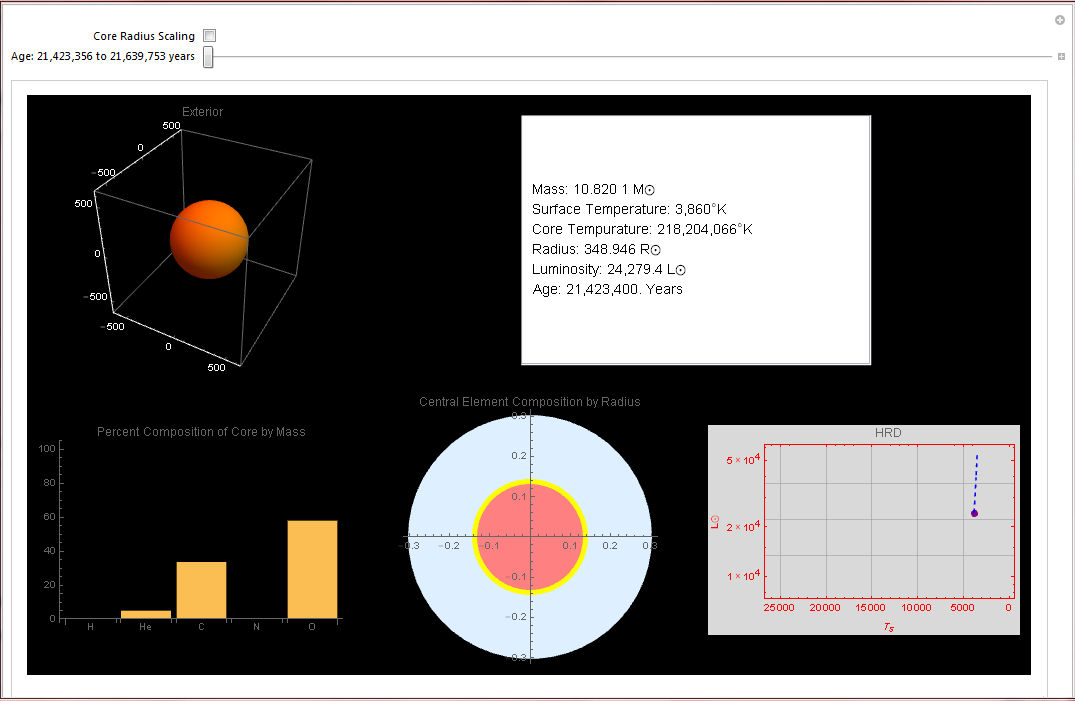


Figure : The full display generated by our code.

## Exterior

The top left graphic shows the exterior of the star as a whole. The surface of the star changes color in response to its changing radius over the range of its maximum and minimum radii. Generally the color scales as a function of radius, but in special cases (where the EZ-Web data runs all the way to a major event stage in the star’s life) other things will happen, such as the star turning white to symbolize collapse into a white dwarf or rings of different colors coming off of the star to symbolize a planetary nebula. These alternative cases are something we didn’t necessarily expect to have the time to set up, and we’re kind of proud of them.

Due to the wide range of sizes that a star can take, a scaling function had was created to switch the PlotRange of the graphic based on its current size, which will cause the star to sometimes look as if it has undergone major compression when it is simply a change of scale. We chose this arguably inelegant solution because we want the size change to be as obvious as possible, though that means nothing if you don’t understand it!

## Text Readouts

At the top right are a set of text readouts that give information about the mass, surface temperature, core temperature, radius, luminosity, and age of the star. These values are all compiled into a single formatted string and displayed in a panel for easy viewing.

## Bar Chart

Something else that was originally unanticipated but completed was a bar chart that expressed the elemental composition of the core of the star by mass (bottom left). This was not something we included in our original proposal, but it seemed prudent given the data we were provided and it’s proven very useful for understanding the core functions of the star.

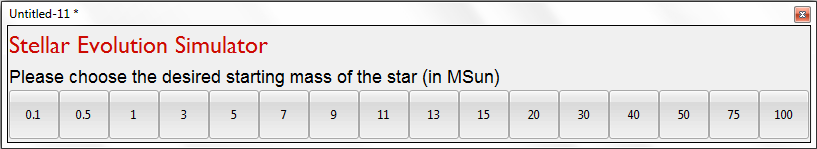
## Center Graphic

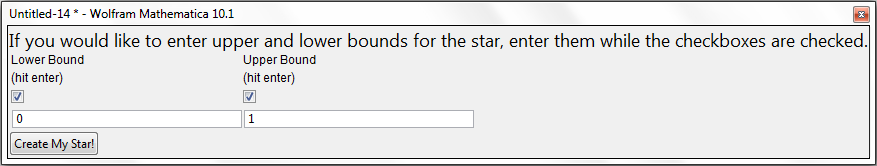
In the bottom center of our display is a graphic showing the internal elemental composition of the star, minus Hydrogen (Hydrogen is assumed to be everywhere that other elements are not and thus isn’t that important to visualize). The user can manipulate a checkbox which determines if the graphic is scaled to the entire radius of the star, or if it just shows the element composition scaled to fit the space provided. It’s interesting to note that at the beginning of our project we intended for this to be the only graphic shown. Thankfully, our mentor Dr. Carini dissuaded us from this notion. Astronomers have better tools and methods for visualizing stars than simple onion skin diagrams, and this form of readout doesn’t actually tell you as much as you’d expect.

## HRD

The bottom right graphic is a Hertzsprung-Russel Diagram, a staple of modern astronomy and a very useful tool overall. They vary in both measurements used and area shown, but in layman’s terms HRDs are effectively graphs of brightness (Y-Axis) of the star, vs. hotness (X-Axis) of the surface of the star, with the X-Axis reversed and the Y-Axis scaled logarithmically. Ours shows a point representing the star at its current position in time, as well as a dashed parametric which shows the path it will follow from the start of the time frame to the end. This was the most encouraged portion of our project by Dr. Carini, and for good reason. Until we had this portion of our project fully operational, no one (including Dr. Carini) fully understood how much of a star’s life the data we were using covered. Having this portion of our project done made it exponentially easier to finish the rest.

# UI





We did not originally propose to include a user interface, but this now been incorporated also. It consists of a home screen that allows for the user to pick the starting mass. This then leads to a window where the user is able to set a lower and upper bound on the region of the star’s life being viewed. This information is then used to initialize the star and the simulation.

# Final Notes

* Throughout our project, many quantities are expressed as multiples of the sun’s properties, with a circle-dot symbol showing when this is the case.
* From the beginning, we have worked with Dr. Carini concerning the Astronomical/Astrophysical aspects of our project. He has been an amazing help in shaping our project into something that is not only cool, but also legitimately useful to astronomers and those interested in this topic.
* Dr. Carini has also demonstrated interest in taking our program and using it in the future as a teaching tool. After this submission, we intend to take it to him and see if that is still the case, and if it is we would continue to make the project more user friendly with this goal in mind.