Type Ia Supernovae Flame Explosion Model

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Abstract

The focus of the study is to analyze the structure of the Type Ia supernova explosion model. The Type Ia supernovae focuses on the stellar flame model of this white dwarf structure. The estimations of these flame properties have the potential to be improved, specifically the predictions of the flame speed. Although there is current data on the Supernovae model, further statistics with an approximate flame speed formula will solidify the pre-existing data. In order to compute the data, the MESA code is utilized. By basing the inputs off of fuel density and composition in reference to the explosion problem, flame properties can be analyzed. With these results, a flame speed model can be produced. There is no data currently as the flame models are in progress of being retrieved accurately and checked for marginal error. However, data can be compared to the relevant to Timmes and Woosley's results. Nevertheless, final results are on the verge of being produced. Regardless, the conclusions will be based on the output of the composition of the flame model's parameters, given the density input. With the higher density of 6d9 to 1d10, the densities will converge to similar trends. In future studies to build off of this knowledge, this nuclear network with the MESA code is considered simple compared to the actual complexity of the Supernovae model. Efforts to refine and improve the models is always encouraged.

Objectives

- Predict the flame speed and flame width of the Type Ia Supernovae Flame Model using density as the input
- Compare the linear regression lines and marginal error of the results at varying densities ranging from 1d6 to 1d10.
- Observe the convergence of the graphs compared to Timmes and Woosley's results

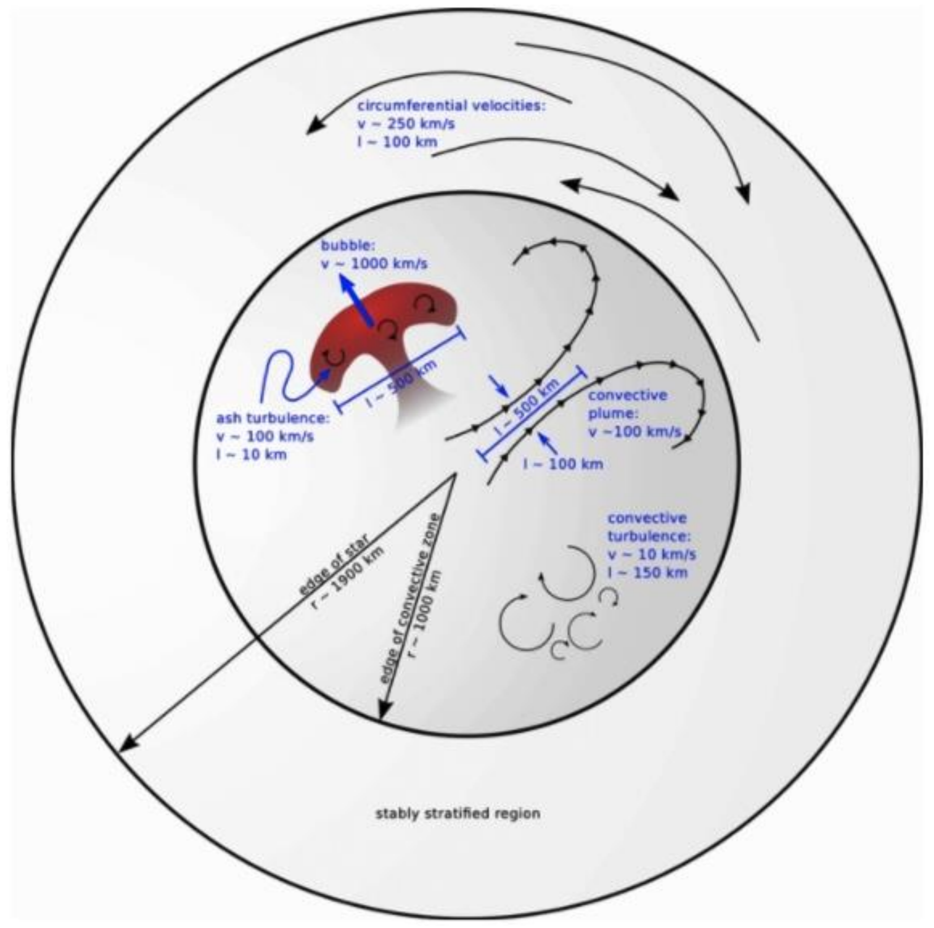
Density	Mass	Flame Speed xcrtl (5) cm/s	Flame Width (cm)	mdc (mesh delta coeff)	CPU	Dt (sec/initial dt)
3d8	2d6 5.d9	1.44d6	4.51d-3	0.5	35	1d-15 300
6d9	1d2 5.d9	1.24d7	4.80d-5	0.5	39	1d-15 300
1d10	1d1 5.d9	1.70d7	3.20d-5	0.5	31	1d-15 300

This table is retrieved from the American Astronomical Society.

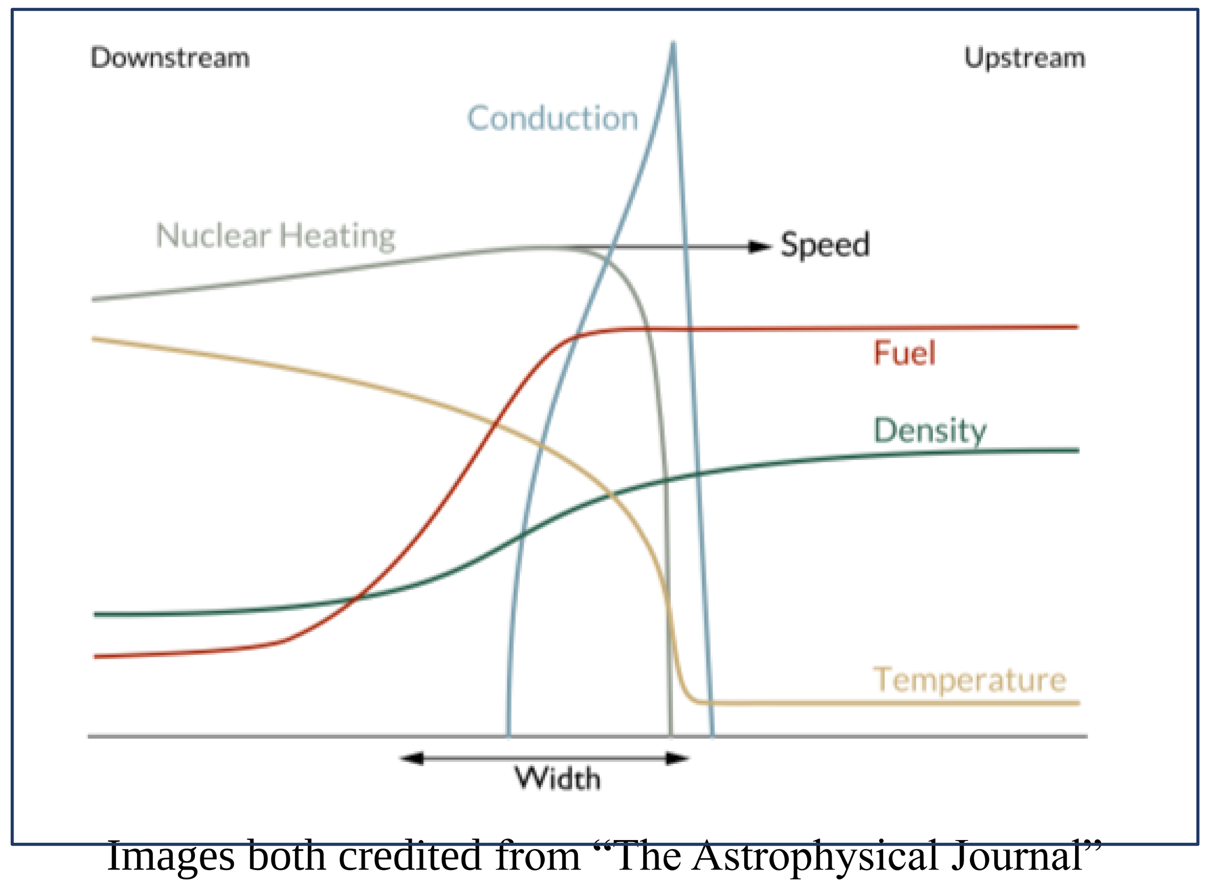
Methods

1. Download the remote desktop on a personal PC or IOS device.
2. Code a tunnel to connect the remote desktop to the hallway computer.
3. Use either the remote desktop or hallway computer to download MESA.
4. Import the downloaded MESA onto the hallway computer software.
5. Copy the star/work directory and observe the inlist files.
6. Practice running the MESA code with results of a terminal output and pgstar plots.
7. Ensure to save any models for future runs.
8. Proceed to use pgstar and obtain png output files.

Here is a simulation displaying the burning of a Supernovae Ia Flame in high-resolution.



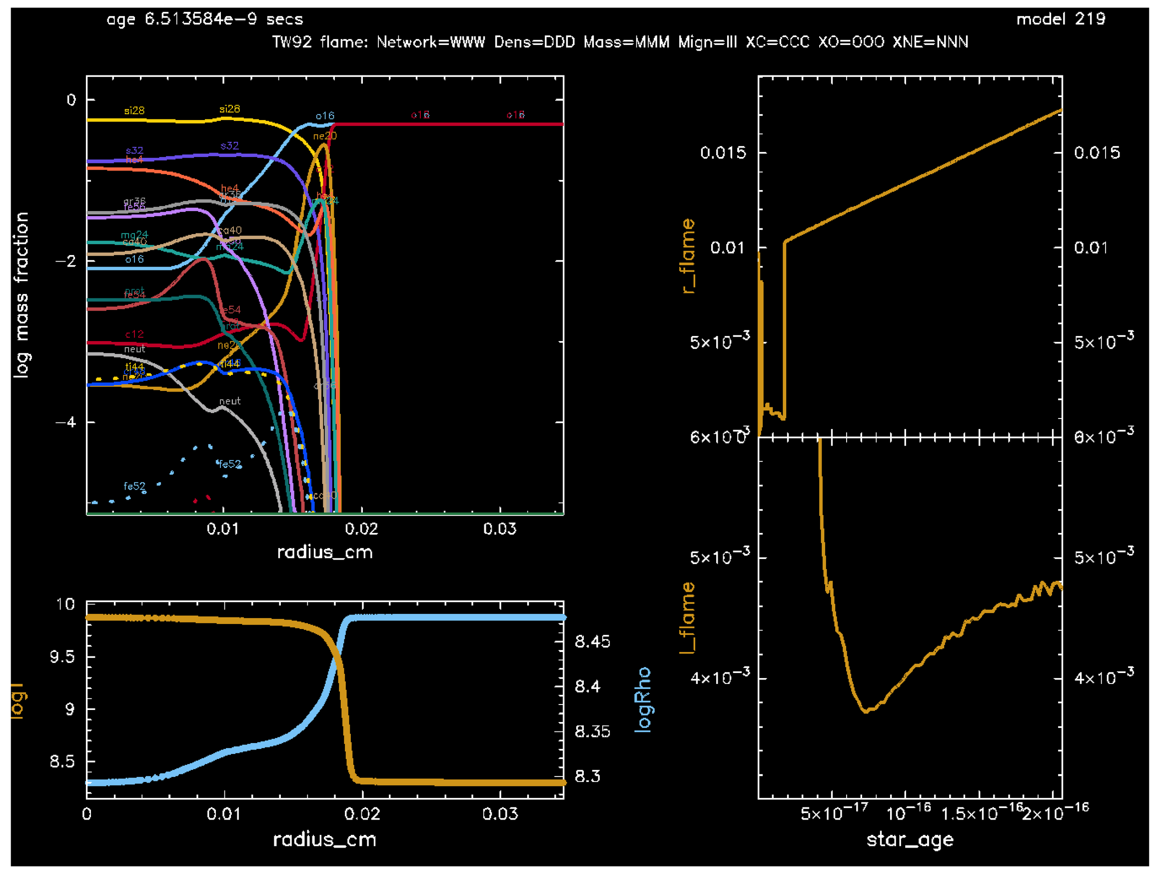
Below explains the burning of a flame star with oxygen and neon compositions. This is relevant to show the properties of density, speed, and temperature.

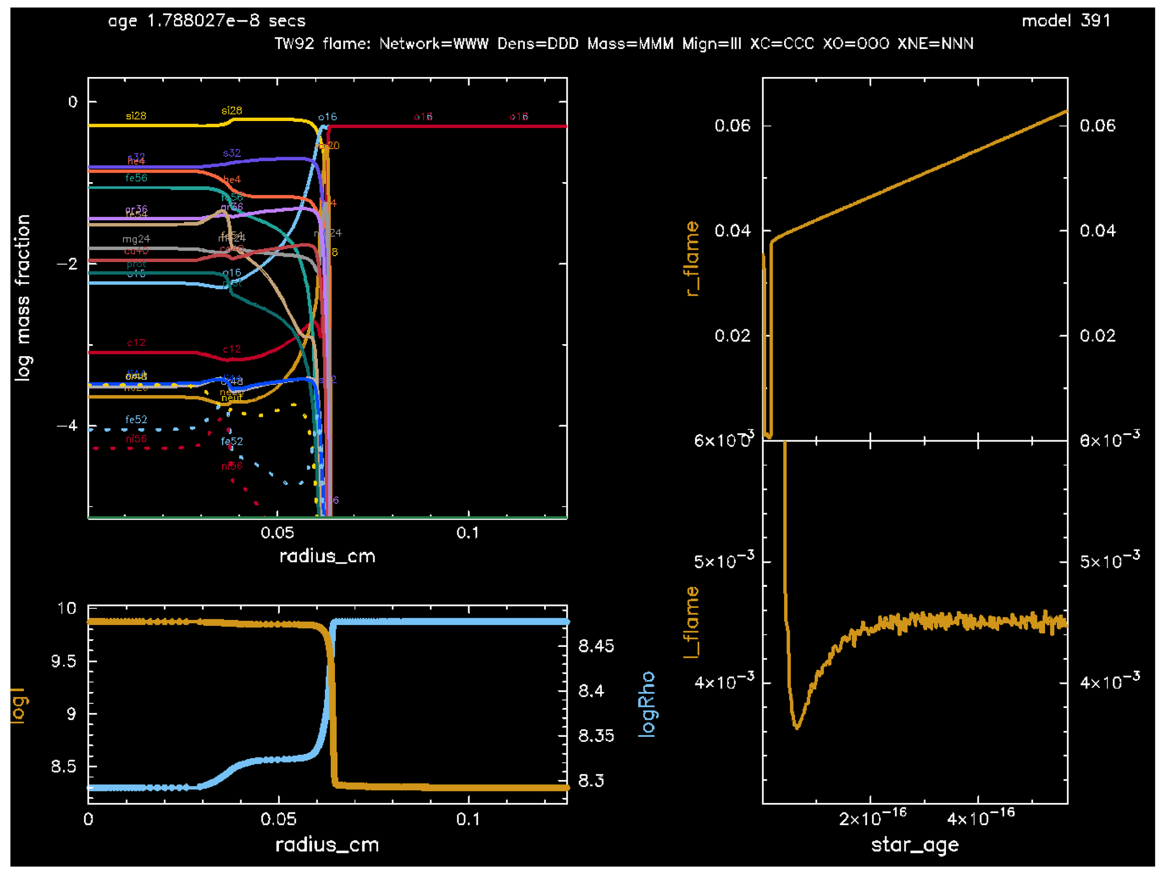


Images both credited from "The Astrophysical Journal"

Expected Results

Currently, this project is still in the process of collecting data. Simulations are still being run to predict the speed and width of the supernova star at densities ranging from 6d9 to 1d10. Consequently, marginal error will also be calculated within these results. To reference off of pre-existing data in the MESA code, it is essential to check for any statistical error and explain the reasoning behind any differences. The data will be the set of final MESA runs, including png files with graphs such as displaying the stars speed over time. The overall characteristics of the speed and size of the flame should follow along similar results made in the following graphs below.





These results follow the input density at 3d8. Similarly, since 3d10 is at a relatively higher density in the MESA runs, 6d9 to 1d10 should follow a similar pattern, where the lines converge and level off at a certain point after half of the carbon is burned in the flame explosion model.

Conclusions Based on Expected Results

As of the progress so far on the MESA runs, the code is still being troubleshooted before any finalized data is presented. With the future results, the density and composition will model the parameters of the Supernova flames. Based off of these models, conclusions can be made on the accuracy of the code and the speed and width of the flame over time. If the numbers converge, this will also draw more conclusions that the code is accurate and that the speed of the flame increases with size. A direct relationship can also be predicted with the higher the temperature, then the faster the speed, higher the density, and larger the width of the flame will be. If the data does not converge, there may be possible error in the code or another factor influencing the flame's speed and width that is not accounted for. However, the larger the densities, such as 1d10, typically follows this direct correlation with temperature, density, and speed. There are exceptions with smaller densities, especially with 1d6, but the given data range in this research focuses on larger densities that does not really concern any of these discrepancies.

References

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