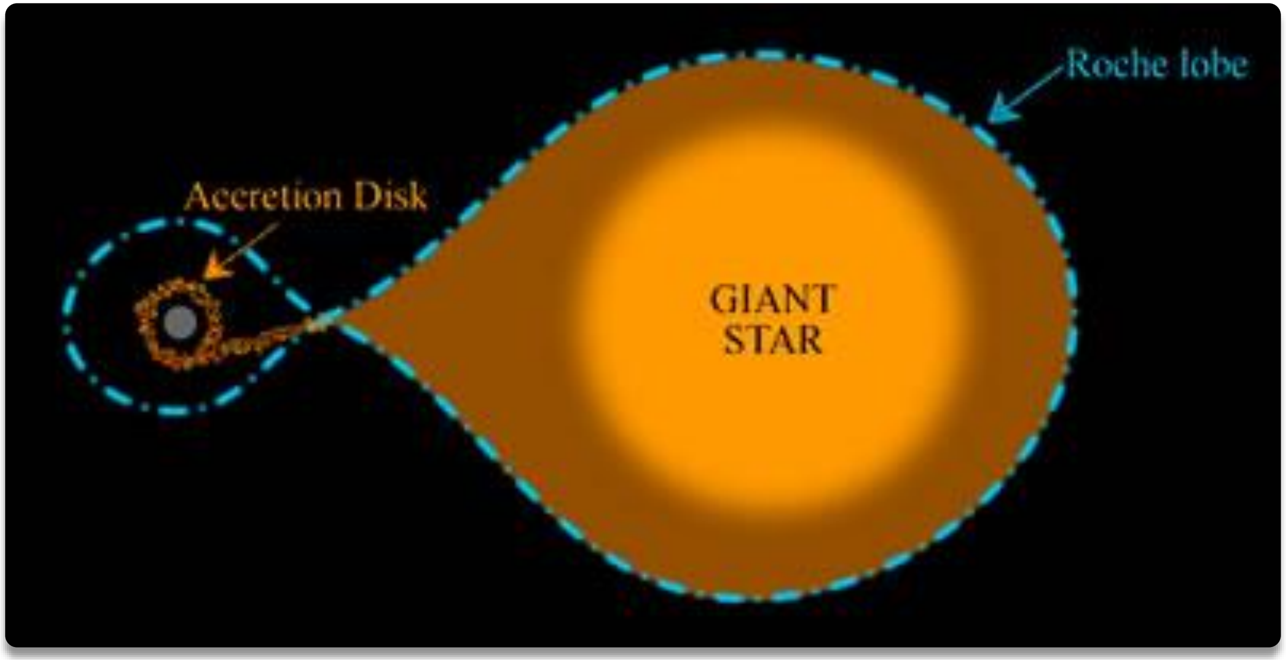
Computational Methods Final Project: AGB-WD Binary Mass Transfer

ZACH DIERMYER

GITHUB LINK: HTTPS://GITHUB.COM/ZRD7527/ASTP720.GIT

Background

- If 2 stars are in a binary orbit, mass can be transferred between them
- Mass is transferred when one star (or both) fill their “Roche Lobe”
- The “Roche Lobe” is an area surrounding a star where material is gravitationally bound to that star (ref. 1)



User Inputs

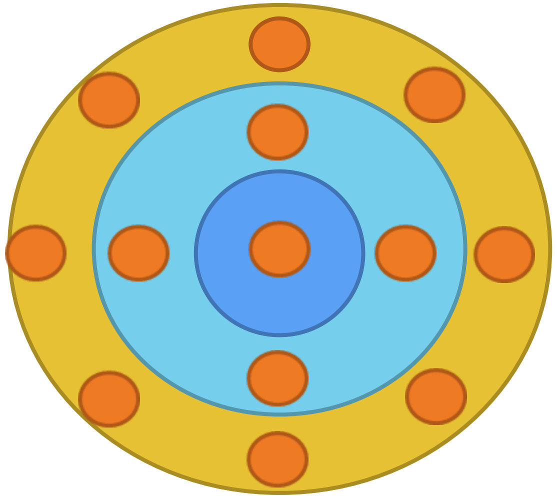
- My code is interactive!
- It requires a lot of inputs and gives warnings if the inputs are outside of normal physical values

```
main()
```

```
Mass of red giant star (solar masses): 150
Mass must be between 0.1 and 100 solar masses!
Mass of red giant star (solar masses): 18
Mass of white dwarf star (solar masses): 4
Mass must be between 0.4 and 1.44 solar masses!
Mass of white dwarf star (solar masses): 0.9
Initial rotational velocity of AGB star (km/s): 15
Initial rotational velocity of WD star (km/s): 50
Binary separation (AU): 0.01
```

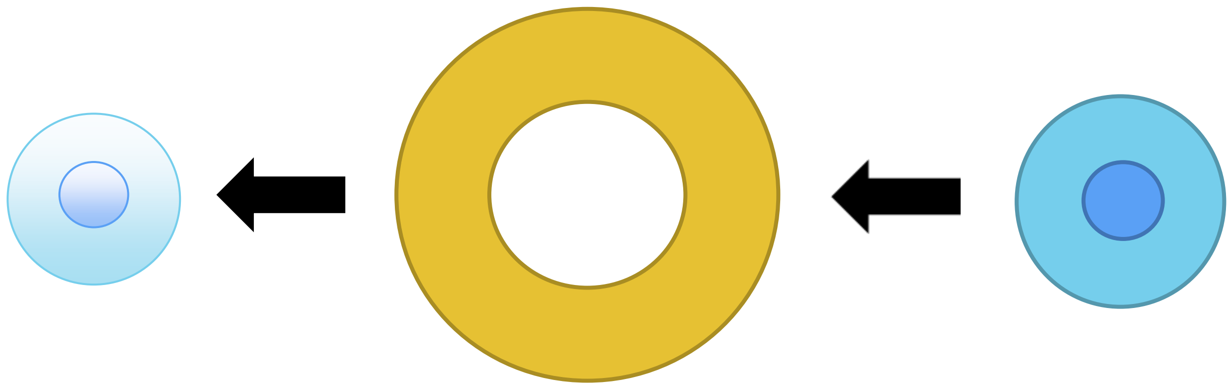
Creating an array of "Star Particles"

- A variable called resolution is used to build up the star (integrating dm)
- A resolution of 0.01 corresponds to each "star particle" having a mass of 0.01 solar masses
- My code builds the star with these by adding shells containing many particles



Solving the Gravitational Potential

- Once the array is built, the potential from each star is found for shells of the giant star
- Any outer shells with a greater potential from the white dwarf star are transferred



Exchange of Mass and Angular Momentum

- The total transferred mass is added to the white dwarf star
- The transferred angular momentum is used to find the new rotational velocity of each star

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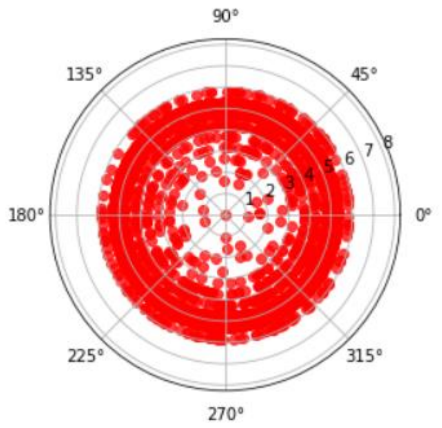
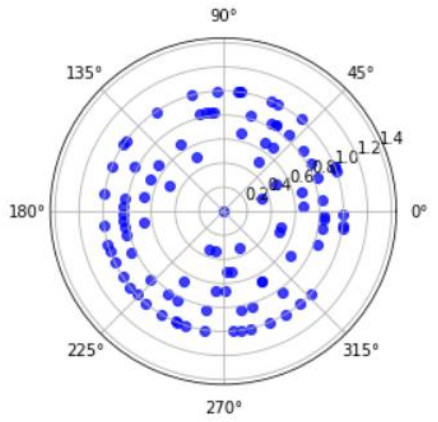
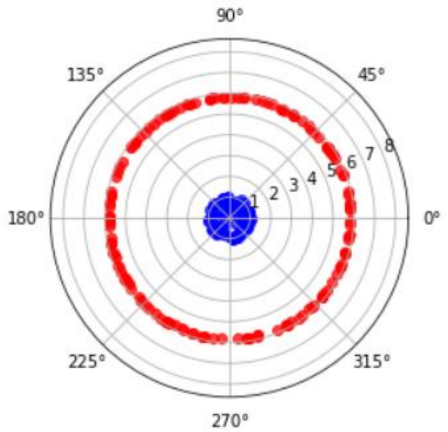
Mass transferred from AGB star to white dwarf: 7.79 Solar Masses
AGB star rotational velocity after mass transfer: 6.8854166666665435 (km/s)
WD star rotational velocity after mass transfer: 58.13858776796397 (km/s)
```

Simulation

- For my simulation I used the radial dimension of each star particle to project the stars onto 2D polar coordinates
- The red giant star is shown in red and the white dwarf in blue
- The last plot shows the outer layers of the AGB star that are transferred to the white dwarf

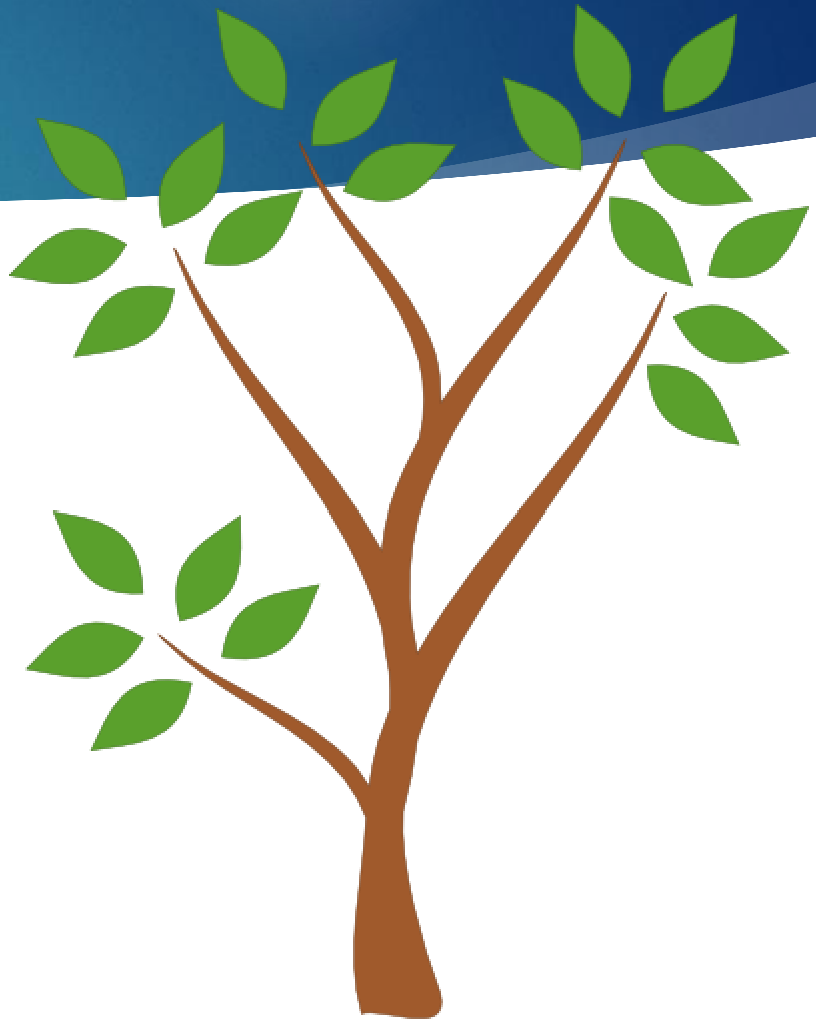






Future Updates: Algorithm

- My code would benefit greatly from a tree structure
- The star particle cluster is currently just a clunky 2D array
- A tree containing branches for each shell of the star and a leaf for each particle would be much more efficient than an array.



Future Updates: Accuracy and Simulation

- The system only has 1 time step; having intermediate time steps would increase accuracy
- My code does not consider orbital velocity or change in orbital separation
- The mass transfer is lossless
- Entire shells are removed for the mass transfer
- The simulation is not 3D

Questions?

References

- Paczynski, B. (1971). "Evolutionary Processes in Close Binary Systems". Annual Review of Astronomy and Astrophysics. **9**: 183–208. Bibcode:1971ARA&A...9..183P. doi:10.1146/annurev.aa.09.090171.001151.
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