Simulating stars with MESA
Project plan

Kaydo Alders
13196634

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Modules for Experiments in Stellar Astrophysics (MESA) is an open source code library and simulation program for the simulation of stellar objects in one-dimension [1, 2, 3, 4, 5, 6]. MESA is used to calculate evolution tracks of stellar objects and to determine at any time properties such as the mass, metallicity, temperature, density, angular momentum and age of the stellar object at different stages of its lifetime.

In this project, we will use MESA to investigate the effects of mass transfer between two stars in binary systems. We compare the properties of the accretor after a transfer of mass from the donor to the properties of the same stellar objects as they are found in isolation.

The comparison of these properties provides valuable information on the differences between stars in binary systems and stars in isolation. A situation that can occur in binaries, for instance, is that a star of lesser mass is more advanced in its evolution than its companion of greater mass. This is not observed when we compare the stars in isolation. A fortiori, the equations that determine stellar evolution dictate that a star of lesser mass always evolves less rapidly than a star of greater mass. The situation that occurs in such binaries is an example of the famous Algol paradox. It is resolved by taking mass transfer into account: an initially more massive donor transfers its mass to an initially less massive accretor such that, at a later stage, it appears that the less massive star has evolved more rapidly than its more massive companion.

Motivated by the Algol paradox, we wish to discover more about the properties of the stars that can result from mass transfer in the binary. Specifically, we will compare the mass, metallicity, density, temperature, convective zones, nuclear reaction rates and opacity of the stars in the binary with the same properties of the stars in isolation. First, we consider an accreting main sequence star and donor main sequence star, where the donor exceeds its Roche lobe such that mass transfer occurs through the Lagrangian point L_1 due to Roche lobe overflow (RLOF). Then we consider the same with a donor red giant star and a donor white dwarf star respectively. Finally, we also consider an accreting red giant and an accreting white dwarf, and consider in turn again a donor main sequence, a donor red giant and a donor white dwarf star respectively.

References

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