Final Project Progress Report #1

Our project is to develop a 1D hydrocode that functions to model a high-mass (10 $M_\odot$) star that has undergone a core-collapse event and subsequent shock that ejects its outermost layers. We are effectively following the numerical method given in Arnett (1966) to calculate temperatures, pressures, densities, etc. using equations of mass conservation, momentum conservation, and energy conservation, as well as an equation of state.

So far, we have set up the code to handle most of the hydrodynamical functionality. This means writing all the difference equations for all of the mechanical properties (zone velocities, specific volumes, etc.) as well as some others (e.g. temperature).

Some functionalities still needed are those that are related to the equation of state (pressure and energy). This is a bit more difficult to decide on due to the nature of the project, but after looking through and understanding the paper more, we may assume that the pressure can be split into that due to nucleons (as free Fermi particles), electrons (relativistic Fermi particles), and radiation. Using the pressure and energy equations of state from Arnett (1966), most of what is left in the code is to actually calculate the pressure and evalutate $\partial E/\partial T$ and $\partial E/\partial V$, which is still a bit unclear for now. If this proves too time-consuming or difficult, more simplistic equations of state could also be used (e.g. just the relativistic degenerate Fermi gas).

There are also the radiative terms to calculate, such as energy generation rate ($\dot{s}$ due to neutrino emission, etc.) and opacities. This will require a lot more looking into.

After these have all been established, boundary conditions must be set. The boundary conditions we still need to apply are the initial temperature, pressure, and density profiles. These profiles will possibly just be some power-law relation with an initial core value.

Ultimately, the project is going well in terms of writing the code. However, on my end I am a bit stuck with some of the physical mechanisms involved in a core-collapse event, and what I should actually be including in the code. Unfortunately I do not yet have plots to show, however to make things more clear when writing this code, my next step will probably be to set it up to run and actually generate plots, regardless of what the plots look like.

Our current progress may be found at the following GitHub link: `https://github.com/anthonyburrow/Hydro1D`

References

Arnett, W. D. 1966, Can. J. Phys., 44, 2553, doi: `10.1139/p66-210`