# Relativistic Hydrocode

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# 1 Reconstruction Techniques

I reconstructed the left and right states using a TVD generalized minmod slope limiter. This is accurate to second order in space for problems with no shocks or discontinuities.

# 2 Numerical Flux

Once I have computed the physical fluxes, I can solve the riemann problem at each of the boundaries using a high resolution shock capturing approximate riemann solver. In this case, I used the HLL approximate riemann solver for special relativistic hydrodynamical simulations.

# 3 Physical Fluxes

In order to compute the FHLL fluxes at each of the boundaries, I need to compute the physical fluxes for each of the time averaged conserved quantities in each cell, as prescribed by the euler equations. Then I can use these physical fluxes to compute the fluxes of the left and right states and then compute the FHLL flux at each boundary.

# 4 Ghost cells

In order to reconstruct the states to the left and right of the first and last interface, I needed to use imaginary ghost cells in which I fill the values of the conserved quantities as specified by the boundary conditions each iteration. I then could use these values of the ghost cells in order to compute the left and right states during reconstruction. For first order in space, I only needed one ghost cell, whereas for second order in space, when I did the TVD minmod reconstruction, I needed two ghost cells on either side.

# 5 Retrieving the Primitives from the Conserved Variables

In order to compute the numerical FHLL flux, I needed to recover the primitive variables from the conserved ones at least once per iteration. For the nonrelativistic case, this was easy because the expressions for recovering the primitive variables can be derived in a straightforward manner from the euler equations. Conversely, for the relativistic case, retrieving the primitives becomes slightly more complicated, as it involved iterating over a nonlinear root-finding algorithm in order to retrieve one of the primitives, which I then used to compute the remaining missing ones.