The *rocketbox* library uses a MacCormack scheme to integrate the compressible quasi-one-dimensional Navier Stokes equations.

The code is tested on the geometry configuration is a parabolic convergent/divergent nozzle, similar to that used by Anderson.

Chart, line chart

Description automatically generated

Figure 1. Parabolic geometry used for validation (used as example in Anderson)

The solver is tested for grid dependency assuming no heat flux and no friction with a grid size ranging from 21 points to 251 points. For each configuration, the solution assuming an isentropic flow is also computed and considered as reference. For each property of interest: Mach number, mass flow, density, velocity, and internal energy, the residual, , is computed as such:

Where f is a property of interest and N is the number of points in the grid. Over this range, the solver shows clear decrease of residual of all properties with number of points down to 151 points where residuals hits a minimum and then increases slightly until 201 points where it starts decreasing again.

Chart, line chart

Description automatically generated

Figure 2. Evolution of the residuals on Mach number at the throat, total mass flow, density, internal energy and velocity as a function of number of grid points. CFL is 0.4

On a laptop equipped with an Intel i7-10875H running at 2.3 GHz, the solver takes about 151 67 s for 151 points and a CFL of 0.4.

The residual shows limited sensitivity to the CFL number if kept below 0.9.