AMATH574 - Project Proposal

Alex Le, Christopher Uyeda

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We propose to simulate nozzle flows in 1-D and 2-D, if time permits, for subsonic and supersonic applications by solving the Euler equations. We will choose a nozzle curvature which will be kept consistent for all simulations and be incorporated in 1-D as a source term. The problem will initially be run as unsteady and tested to see if it converges to a steady state. The location of the shock when the simulation has reached steady state will then be compared to the quasi 1-D nozzle solution.

These simulations will be conducted with the use of the Clawpack finite volume methods, specifically the wave-propagation methods. Each method will be tested for convergence to the steady solution at which point the steady state solution will be compared theory using the quasi 1-D nozzle solution. Each method will also be tested under different test conditions, such as purely subsonic, choked subsonic, and pure supersonic flow, to test for convergence.

The two different types of flow, subsonic and supersonic flows, will pose a challenge because in the subsonic case, the Euler equations become elliptic. This means that hyperbolic finite volume methods may no longer converge in the subsonic case. Also, the boundary conditions in the two cases will differ because of how the characteristics move in two different directions in the subsonic case while in the supersonic case they move in the same direction.

As mentioned, if time permits and the 1-D analysis has been completed, the 2-D case will be explored. The 2-D nozzle will require the use of a function to map the rectangular, block structured grid into our specified nozzle curvature. The simulation will then be performed for an axi-symmetric case to essentially simulate a 3-D nozzle. The same analysis from the 1-D case will then be applied here by exploring the convergence of different finite volume methods under different flow conditions.