Astronomy 802, Numerical Techniques

Homework # 3, Due Thursday, March. 4, 2004

Show All Your Work

This assignment is to use the F90 code to study the behavior of small and large amplitude pulses with both box and sinusoidal profiles. The periodic boundary conditions do not work yet correctly, so we will avoid interactions with the boundaries by making the grid large and only running each case until the wave hits the boundary. You should study the effects of varying the Courant factor and the numerical viscosity coefficients on the profiles for both small amplitude ($\sim$ 1.e-3) and large amplitude ($\sim$ 0.5-10) pulses.

The first thing to do is to change the dimension mx in cparam.inc from 101 to 1000. You also need to change the x-dimension in the shock.pro, shocktube.pro and wave.pro idl routines in subdirectory idl.

For each case you run the procedure is similar:

1. make the initial solution snapshot *.dat file using idl
2. edit job.in for the particular case you are running
   Adjust the length of the run using nstep and tstop so the wave just reaches the boundary at the end of the run.
3. run hd.x
4. analyze your results using idl
   Some useful routines are xmovie.pro, plot, oplot, plot2.pro.
   Print the most useful plots and discuss the significance of what you have found in terms of both numerical issues and shock properties.

Cases:

1. Shock Pulse
   The shock.pro procedure produces an initial hat profile pulse.

   Investigate how the propagation of this pulse depends on its amplitude and the values of the numerical viscosity coefficients nu1,nu2,nu3. For the numerical viscosity coefficients try both increasing and decreasing their values separately to see the effect of each. How is the profile of the hat distorted as it propagates?

2. Sinusoidal Pulse

   The wave.pro procedure now produces a sinusoidal wave train. Modify it so that it produces sinusoidal wave of two wavelengths only in the center of the computational domain.

   Investigate how the propagation of this short wave train depends on its amplitude and the values of the numerical viscosity coefficients nu1,nu2,nu3. For the numerical viscosity coefficients try both increasing and decreasing their values separately to see the effect of each. Also, investigate the effect of changing the wavelength of the wave from 10 grid zones to 200 grid zones. What is the linear behavior of the wave and the non-linear behavior of the wave?

3. Shock Tube

   The shocktube.pro procedure produces a shock tube.

   Shock tubes are not periodic, so there are in effect to shocks, one at the center and one at the boundary. Run this case until a little after these two waves first meet. What happens to the initial discontinuity as it evolves? What is the difference between the shock and the contact discontinuity? How do the two shocks interact? Again, investigate how the evolution of the profile depends on its amplitude and the values of the numerical viscosity coefficients nu1,nu2,nu3. For the numerical viscosity coefficients try both increasing and decreasing their values separately to see the effect of each.