Astronomy 401

Stars

Homework # 4, Due Thursday, November 1, 2001

Name: ______________________________

Student number: ______________________

The purpose of this homework is to explore the effects of: (1) the courant factor, $\Delta t/c\Delta x$, where Δt is the time step in the numerical integration of the conservation equations, c is the speed of sound, and Δx is the size of the spatial grid zones. (2) the numerical viscosity, nu. You will do this using the experimentarium developed by my colleague Åke Nordlund from Denmark. The experimentarium implements the computer code you will use to study convection (in a slightly simplified version) together with idl to display what is happening as the system evolves.

1. Go through the pocedure to allow kepler to open a window on your local computer, logon to kepler, change directories to the experimentarium directory, start idl, start the widgets idl procedure:

   - Allow kepler to open a window
     On your local unix or linux computer, type
     `xhost kepler.pa.msu.edu`
     On your local windows PC,
     start X-Win32 (look for icon or use Find)
   - Log onto kepler
     If using telnet (ok for unix or linux)
     `telnet kepler.pa.msu.edu`
     Tell kepler where to display graphics by typing
     `setenv DISPLAY your_local_computers_name:0`
     If using ssh (must on windows, ok on unix or linux) (automatically sets window permissions)
     `ssh kepler.pa.msu.edu` (unix or linux)
     `start ssh` on windows
   - Change to the experimentarium directory
     `cd /home/web/documents/courses/ast401/experimentarium`

- Initialize idl
  `source /h0/steinr/idl/bin/idl_setup`
  Set idl path so it can find the procedures
  `setenv IDL_PATH \+/home/web/documents/courses/ast401/convect/idl:\`
  `+$IDL_DIR/lib:\+$IDL_DIR/examples`

- Start idl
  `idl`
- Set the x-window device properties. At the idl prompt `IDL>` type
  `device, pseudo_color=8`
- Start the experimentarium. At the idl prompt `IDL>` type
  `widgets`

2. In the experimentartium, choose the case you are going to run

   - Click on the `Sound waves` button
   - Click on the `2 waves` button
   - Set the ampl1 slider to `-1`
   - Set the ampl2 slider to `-6`
   - Set both k1 and k2 sliders to `2`
   - Set the tanh slider to `0`

   You should now see graphs of $\Delta\rho/\rho$, U_x/c_s, and $\Delta P/P$ on the right side of the experimentarium window.

3. Run the simulation with the default parameters: nu = 0.03, Cdt = 0.5 and record the results.

   - To start the simulation, click on the `Evolve` button.
   - To record the results, grab the three graphs on the right.

4. Rerun for the following cases with different viscosity coefficients, nu, courant factors, Cdt, and wave shape, tanh. The variables nu and Cdt are found by clicking on the `Numerical Parameters` button. Grab the graphs of the initial states for both tanh=0 and tanh=20. For each case grab the graphs of the results.

tanh	nu	Cdt	
0	0.03	0.5	(default)
0	0.01	0.5	
0	0.0	0.5	
0	0.1	0.5	
0	0.029	0.702	
20	0.03	0.5	
20	0.00	0.5	
20	0.1	0.5	
20	0.03	0.604	
20	0.01	0.604	
20	0.03	0.241	
20	0.01	0.241	
20	0.0	0.241	

5. Grab the graphics windows:

   - On unix or linux computers, in another window (not running idl)
     `xwd -out filename.xwd`
     Then click on the window you want to grab. This produces a file filename.xwd, which you can then display with the command
     `display filename.xwd`
     Print the graph:
     Left mouse button opens command window, select
     Transform → crop
     With left mouse button select just graphics area you want to print
     A new crop menu will open, select crop, the window will be cropped to what you selected.
     Then File → Save → Format → ps → Select
     Postscript geometry → letter → Select
     Print from another window (not running display or idl)
     `lp -drm316 name_of_postscript_file`
   - On windows PCs, `ALT+PrintScreen` will copy the active window to the clipboard which you can paste into a new file using a graphics editor.

6. If you can not grab the graphics as presented by the *experimentarium* you can get the individual variables and plot your own graphs and save them as postscript files as follows:

   - To save any files on kepler itself you need to work in a directory where you have write permission. This should be a subdirectory of your home directory, call it for instance "experimentarium". You need to create this directory if it does not already exist, cd to it, link the experimentarium files into it, source the idl_setup file, setenv the IDL_PATH and then start idl and the experimentarium.
     - `cd` (change to your home directory)

  - `mkdir experimentarium` (make the directory)
  - `cd ./experimentarium` (change to this directory)
  - `ln -s /home/web/documents/courses/ast401/experimentarium/* .` (link the experimentarium files)
  - `source /h0/steinr/idl_5.3/bin/idl_setup` (set up idl)
  - `setenv IDL_PATH \+/home/web/documents/courses/ast401/convect/idl:`
    `\+$IDL_DIR/lib:\+$IDL_DIR/examples` (type without line break)
    (set the idl path so idl can find the procedures)
  - `idl` (start idl)
  - `device, pseudo_color=8` (set x-window properties)

- Run widgets with an argument, e.g. p1
  `widgets,p1`
- Evolve the experiment
- Open a window
  `window,0`
- load the resulting variables
  `*p1->get,v=v1 & f1=*v1`
  f1(*,0)=density
  f1(*,1)=x-momentum
  f1(*,2)=y-momentum
  f1(*,3)=z-momentum
  f1(*,4)=energy per unit volume
  f1(*,1)/f1(*,0)=x-velocity
  f1(*,4)/f1(*,0)=energy per unit mass $\propto$ temperature

- Plot a variable
  TO GET HELP IN IDL, at the prompt IDL¿ type a question mark
  `?`
  Also read the convection project notes, which has some examples of using idl
  `plot,name_of_variable`
  To plot 2 variables on the same plot use the `oplot` command.
  To plot several plots in the same window, use the `!p.multi` variable.

- To make the plots into a postscript file, first set the plot device to postscript,
  `ps`
  If using p.multi to put several plots on one page use psv instead
  `psv`
  Then repeat the plotting commands (not the calculation of the variables)
  After making all the plots (you wont see any changes on the screen), close the postscript file (called idl.ps) and set the plot device to x-windows.

```
psend
x
```

- Outside of idl, move the idl.ps file to another name, else idl will overwrite it with the next postscript plot you make
  `mv idl.ps name.ps`

Based on a comparison of the results from these different cases, discuss what you can conclude about the role of viscosity and the courant factor in numerical simulations of fluid dynamics problems. Include figures as needed to illustrate your conclusions.