ASTR4004/ASTR8004
Astronomical Computing
Assignment 2

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due Monday, August 19, 2019

1 Plotting and fitting with gnuplot

1. Plot the turbulent density PDF data file from http://www.mso.anu.edu.au/~chfeder/teaching/astr_4004_8004/material/mM4_10048_pdfs/EXTREME_hdf5_plt_cnt_0050_dens.pdf_ln_data using column 1 (as x-axis) and column 3 (as y-axis). You can use the gnuplot template from http://www.mso.anu.edu.au/~chfeder/teaching/astr_4004_8004/material/gnuplot.p. Now add a Gaussian fit. To make the fit, use the gnuplot 'fit' command with the Gaussian model function,

$$f(x) = \frac{1}{\sqrt{2\pi\sigma_x^2}} \exp\left[-\frac{(x-x_0)^2}{2\sigma_x^2}\right]. \tag{1}$$

2. Generate a script that does the fit and plots it on top of the data from $x_{\mathrm{min}} = -10$ to $x_{\mathrm{max}} = 10$. Plot the data as blue crosses and the Gaussian fit as a solid thin black line. Annotate the plot nicely (axis labels) and change the key (legend) text to give a reasonable description of what is plotted. Note that the data in columns 1 and 3 (which you should plot and fit) represent a probability distribution function (PDF) of the log-normalised gas density $s \equiv \ln(\rho/\rho_0)$ in a simulation of driven supersonic turbulence. Also change the key position, such that it is in the top right corner of the plot frame. Finally, let the script write out a postscript (.eps) file with the finished plot.

2 Plotting multiple datasets and data manipulation with gnuplot

Here we learn various ways of data manipulation and plotting techniques with gnuplot. Much more advanced methods are possible, but require some reading through the documentation and searching on the internet.

1. Make a copy of the previous script, but now instead of plotting only one data file, plot the times/files with (0020, 0030, 0040) contained in the tarball http:

//www.mso.anu.edu.au/~chfeder/teaching/astr_4004_8004/material/mM4_10048_pdfs/EXTREME_pdfs.tar.gz, all in one plot using different line styles or plot symbols and colours (so we can easily distinguish the three data sets from one another). Plot the data on a logarithmic y-axis from $y_{\min} = 10^{-5}$ to $y_{\max} = 2$. Use the x-axis range as in Section 1. Now shift the 0030 data up by a factor of 2 and the 0040 data up by a factor of 4. This should offset the curves, so they can be more easily distinguished.

2. Now make another copy of the script and plot x (column 1) versus $\exp(x) \times y$ (the exponential of column 1 times column 3) as the new ordinate of the 0050 data file from above. This will generate a mass-weighted (or density-weighted) PDF (P_M) instead of the previous volume-weighted PDF (P_V). Note that mass-weighted and volume-weighted PDFs are always related by $P_M = \rho P_V$ with the density $\rho = M/V$. To see this, consider that we have $s \propto \ln(\rho)$ and thus $\exp(s) \propto \rho$, hence the multiplication with $\exp(x)$ to obtain the mass-weighted PDF. In order to do this, you have to gain access to the data in column 1 of the data file and exponentiate it via '`(exp($1))`' within the gnuplot `using` construction.
3. Also fit the new mass-weighted PDF as in Section 1 and let the script print the mean and standard deviation of the fitted data to the gnuplot shell (the fitted mean should now be positive and has a value of 0.71 and the fitted standard deviation is 1.14).

3 Making movies of scientific data with `ffmpeg`

1. Make sure you went through the tutorial on plotting and making movies in http://www.mso.anu.edu.au/~chfeder/teaching/astr_4004_8004/05/05_Federrath_astro_computing_course_web_2019.pdf.
2. Create the gnuplot script to make the individual frames of the movie as in the tutorial, but add a fit as in Section 1 of this assignment to each frame.
3. Finally, generate the movie (`solution_3.mpeg`) as in the tutorial, but from the figure frames produced here (including the Gaussian-fitted PDF for each frame).

Please send 3 scripts in total – one for each section in this assignment (check that your scripts do not produce any errors or warnings when run, and add comments to each code line/block of the script), and a writeup (with the same numbering of sections as above).

Return of assignments is via Turnitin (see respective assignment link at course Wattle page). To upload the files, make a tarball named <YOUR_NAME>.tar.gz that contains all the submission files (3 scripts, writeup, and the resulting figure and movie files).