Coding in advance of the April 15, 2019 class

For this assignment you will perform the second part of the analysis described in the April 8 and April 15 lectures, using the full baryonic Tully-Fisher data set on the website (which contains 118 points). For this analysis, you will continue to assume that the rotation speed $v_{\rm rot}$ is measured with zero uncertainty. To be self-contained, we will repeat the instructions from the April 8 coding exercise.

From the notes, the model you are fitting is

$$\log_{10} M_{\rm bary} = \tan\theta \log_{10} v_{\rm rot} + b \tag{1}$$

and thus the parameters are θ and b. For the ith rotation speed $v_{\rm rot,i}$, and for a given θ and b, the model prediction for $\log_{10} M_{\rm bary}$ is then

$$m_i = \tan\theta \log_{10} v_{\rm rot,i} + b \tag{2}$$

and the measurement is

$$d_i = \log_{10} M_{\rm bary,i} \ . \tag{3}$$

The uncertainty we are given in the table is

$$\sigma_i = \sigma_{\log_{10} M_{\rm bary}} \ , \tag{4}$$

and thus the total χ^2 for the data set is

$$\chi^2 = \sum_i \frac{(m_i - d_i)^2}{\sigma_i^2} \ . \tag{5}$$

Last time you found the minimum chi squared, over a reasonably fine grid in θ and b. Now, you are to do two additional computations:

1. Find the $\Delta\chi^2 < 2.3$ (or "1 sigma" for two parameters) region in $\theta - b$ space. To do this, (a) pick a value of b in your grid, (b) at that b, determine χ^2 for your full range of θ, (c) determine the values (if any) of θ that give a χ^2 equal to your minimum plus 2.3 (there will be 2, 1, or 0 such values of θ for each b), (d) do this for your full range of b, and finally (e) connect the (b, θ) points that give $\chi^2 = \chi^2_{\rm min} + 2.3$ to form and plot the contour. Note that because you are using a much larger data set than in the lecture notes, you will need to zoom in on the region rather than using a crude grid over all of b and θ.
2. Use your grid of b and θ to produce marginalized posterior densities $P(b)$ and $P(\theta)$, and plot them.

Note that you can test your codes by determining whether they give the same answers as the ones I plotted in the notes, for a reduced data set. What other tests can you use?