Coding in advance of the May 13, 2019 class

For this exercise, we will analyze the same data set as in exercises 13 and 14: the set is given as data15_1.txt on the website.

The file description15.txt, which is identical to description13.txt and description14.txt, describes the data.

Your task for this exercise will be to modify the affine-invariant MCMC code that I sent you to fit a broken power law plus Gaussian line model to the data (see guide.txt for specific things you can do). In this model, the flux is

$$\Phi = \Phi_0 (E_{\rm avg}/100\ {\rm GeV})^{-\gamma_1} \left[1 + (E_{\rm avg}/E_b)^{-(\gamma_1-\gamma_2)/\Delta}\right]^{-\Delta} + A e^{-(E_{\rm avg}-E_{\rm centroid})^2/(2\sigma_E^2)}\ . \qquad (1)$$

Here $\Delta = 0.1$ and the parameters in your model are Φ_0, γ_1, γ_2, E_b, and the amplitude A, the centroid energy $E_{\rm centroid}$, and the width σ_E of the Gaussian line. This is the money fit! If you determine that a line is needed, then it might indicate evidence for dark matter.

You should:

1. Compute the maximum log likelihood $\ln \mathcal{L}_{\rm max}$ using the model.
2. Output the values of Φ_0, γ_1, γ_2, E_b, A, $E_{\rm centroid}$, and σ_E that maximize the log likelihood.
3. Plot the best fit against the data. **This should be a plot of the $\log_{10}$ of the flux versus the $\log_{10}$ of the energy.**
4. Use Wilks' Theorem, $\ln \mathcal{L}_{\rm max}$ for this model, and the maximum log likelihood for last week's broken power law model, to determine whether the improvement to the fit is enough to justify the three extra parameters.
5. Use the output of the code, following the description in Lecture 14, to output one-dimensional posteriors for just the line parameters A, $E_{\rm centroid}$, and σ_E.

What do you think? Are you ready to sign up to this data indicating that we've detected dark matter?

Good luck!