From Data to Insights - Exercise sheet 8

discussed June 13 and June 14

June 7, 2024

Building upon the first problem in exercise sheet 3, we'll explore some more advanced concepts in this week's tutorials. You are encouraged to use the common python packages `emcee`, `corner`, and `multinest`, but you can use other tools or write your own as well in case you prefer.

1 Preparation

For this, download the data `xi_measurement_tutorial8.dat` from the exercises cloud folder. It contains a measurement of a quantity ξ_+ at a set of angular distances θ, with uncorrelated Gaussian errors of given size σ.

A full model for the data is given by

$$\xi_+(\theta) = A\theta^{0.5} + B\theta^{\alpha_B} \ , \tag{1}$$

with a parameter of physical interest A and a nuisance effect described by B, α_B. From geometric considerations we know that $0 \leq \alpha_B \leq 0.4$. Compared to our current knowledge, an agnostic prior on A and B is that each of their absolute values does not exceed 10.

Plot the data, and overplot models for a few different values of A, B, and α_B you choose.

2 Sampling a chain with a nuisance model

Sample the joint posterior of A, B, and α_B based on the model and prior described in the previous section. You could (but do not have to) follow this tutorial, mutatis mutandis:

https://emcee.readthedocs.io/en/stable/tutorials/line/

(a) Report:

- The length of the chain you have sampled, and the length of the "burn-in" phase you have thrown away
- The joint posterior in the form of a contour plot (e.g. with `corner`)
- Your 68% confidence interval on each of the three parameters
- A plot of data with model, for some values of the model parameters you find interesting based on the posterior (e.g. the mean of the model parameters among the chain).

(b) Could anything possibly have gone wrong? Your collaborator refuses to believe the results since the parameter constraints are affected by the prior on α_B. Expand the prior range to satisfy this concern.

3 Marginalizing over the nuisance with a covariance

Repeat the analysis, but with a model that only includes the first term, $\xi_+(\theta) = A\theta^{0.5}$.

To account for the nuisance effect, add a term to the covariance that corresponds to variations of the nuisance effect according to the uniform priors on B and α_B described in the preparation section.

4 Bonus exercise: Evidence ratios

Use `multinest` or another nested sampling tool to measure the evidence of the model of exercise 2 with and without inclusion of the B term. Is modeling the nuisance preferred by the data?