OBSERVATIONAL COSMOLOGY

Problem sheet 4 – Due 07/05/2019

1. Write a code that performs MCMC simulations using the Metropolis-Hastings algorithm for a given target probability density function.

2. Supernovae Ia are used to derive the Hubble diagram and provide strong evidence for the acceleration of cosmic expansion. The key fact is that they are *standardizable candles*. In fact, observing their light curves (i.e. the evolution of light intensity as a function of time) an empirical relationship was found between the maximum luminosity and the width of the curve itself. It can be expressed as

   $$M_{max} = a \cdot m_{15} + b \,,$$

   where M_{max} is the peak magnitude and m_{15} is the decline of the magnitude 15 days after it has reached its peak.

   We built an experiment similar to one we had designed as part of the previous problem sheet, and collected supernova data in five equally spaced bins, ranging from $m_{15} = 1$ to 5. The results are: -17.3, -15.5, -15.6, -12.0, -10.1, with the statistical errors on M_{max}, σ_M, being equal to 0.7 which by assumption are Gaussian distributed and independent. Using the Markov Chain Monte Carlo method, plot the joint posterior distribution for a and b by highlighting the 68.3 and 95.4 per cent credibility intervals. Moreover, plot the marginalized posterior distribution for each of the parameters and measure the corresponding 68.3 per cent marginalized credibility interval.

Instructions: If you did not manage to solve problem 1, you can use a public package to solve problem 2. In both cases, please submit the final plots AND the source code for running the MCMC chains. If you use Python, submit a single jupyter-notebook file.