OBSERVATIONAL COSMOLOGY

Problem sheet 2 - 04/05/2017

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.

1) We want to design a new experiment to measure a and b with great accuracy. For simplicity, let us assume that we can compress the supernova data in a set of bins which are spaced by $\Delta m_{15} = 1$ (using some specific units). We expect statistical errors on M_{max} of $\sigma_M = 0.1$, which are Gaussian distributed and independent. Using the Fisher matrix method, determine the **number of bins** we need to consider to get marginal errors $\sigma_a = 0.01$ and $\sigma_b = 0.01$ on the linear fit parameters a and b.

Hints:

$$\sum_{n=1}^{k} n = \frac{k(k+1)}{2}$$

$$\sum_{n=1}^{k} n^2 = \frac{k(k+1)(2k+1)}{6}$$

2) Current experiments are less accurate and give $\sigma_M = 0.7$. We collected data in five bins, ranging from $m_{15} = 1$ to 5 and the results are: -17.3, -15.5, -15.6, -12.0, -10.1. Using the MCMC method, plot the 68% credibility interval in parameter space (both in the joint and in the marginalized cases).