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SC20B152

Cosmology Assignment – 2

Introduction

The attached file **SCP_sn1a_data.txt** has data for observational data for Type Ia supernovae. We were instructed to estimate the cosmological parameters from this data.

The software I have used to perform this data analysis is python(particularly the jupyter notebook). I have made use of various packages such as **numpy**, **scipy**, **astropy** and **matplotlib**. For integration purposes I made use of the quad function. To access data from the file I had first converted the .txt file into .csv file for easier use. All these details will be displayed clearly in the python file which I will be attaching as well.

The parameters were estimated by fitting the curve.

Data Analysis

1. Flat Universe-
   We are well aware that for a flat universe the co-moving distance is equal to the proper distance. The proper distance is given by the following formula.

$$d_p(t_0) = \frac{c}{H_0} \int_0^z \left(\frac{dz'}{\sqrt{\Omega_{m,0}(1+z')^3 + \Omega_{\Lambda,0}}} \right)$$

   For a flat universe,

   r(comoving distance) = $d_p(t_o)$

   We have another quantity known as luminosity distance, which is given by the following formula.

$$d_L = r(1+z)$$

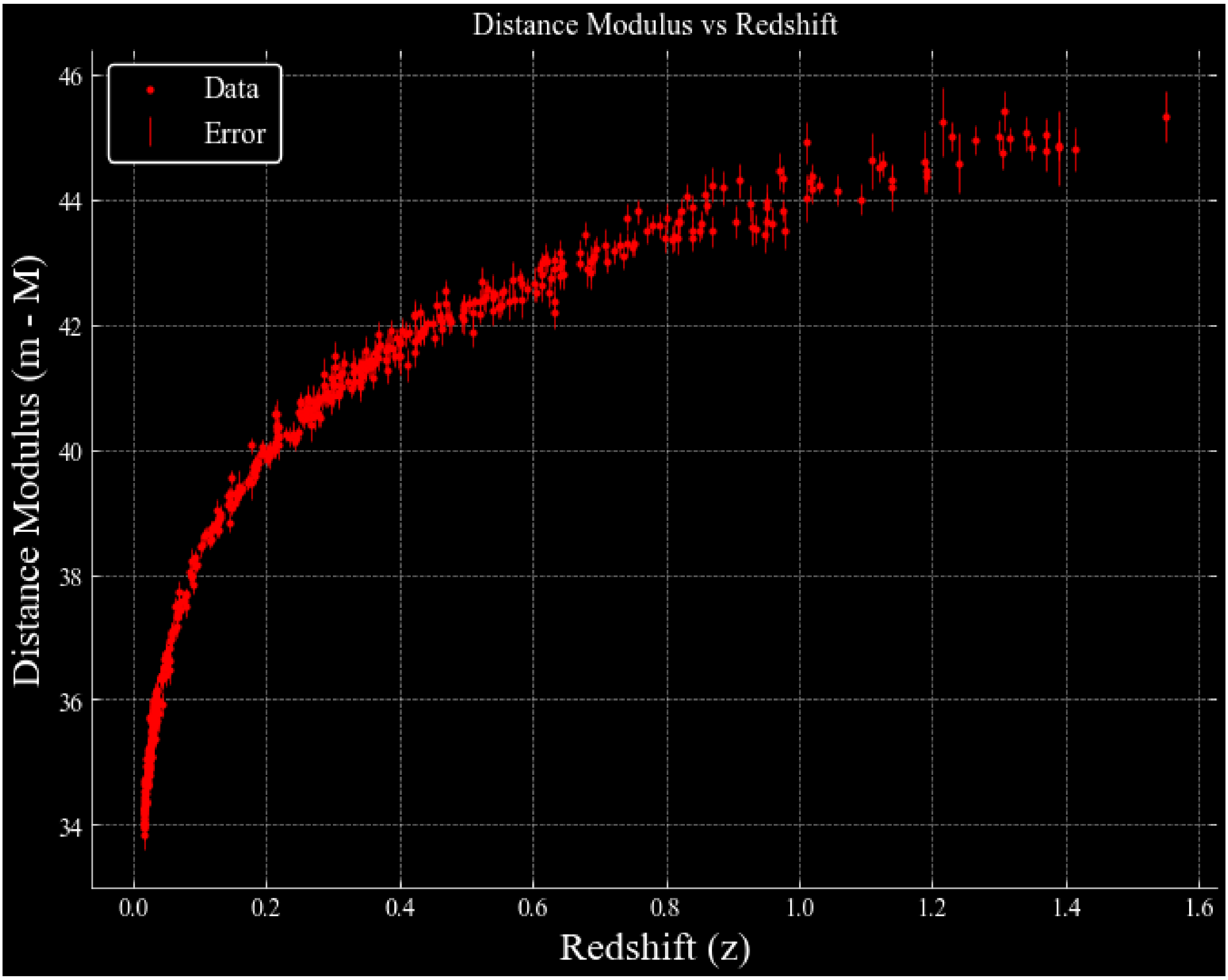
   Luminosity distance is obtained by comparing the apparent magnitude and the absolute magnitude. The following relation will make it easier to understand.

$$m - M = 5 \cdot log_{10}(d_L) + 25$$

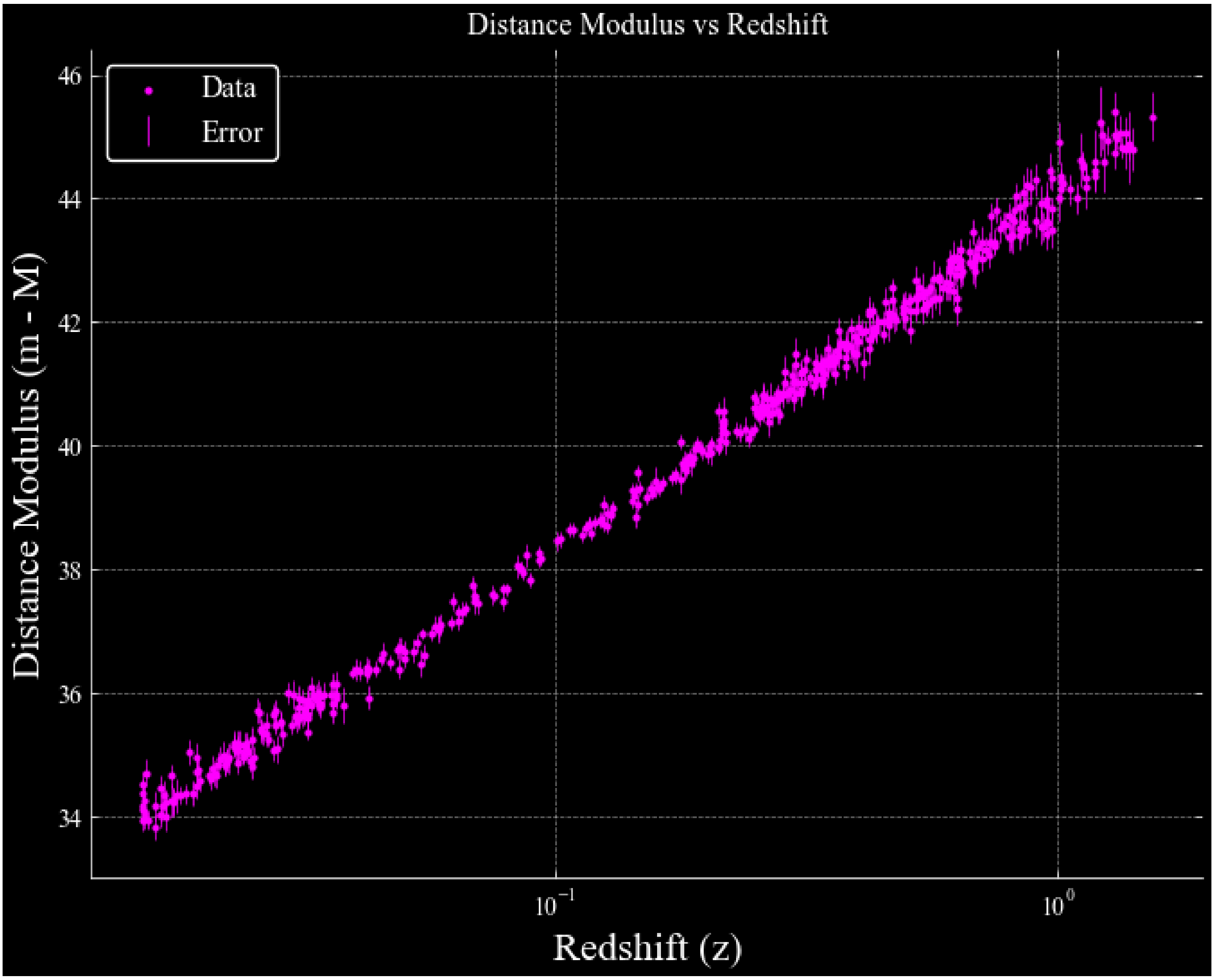
   Thus, a plot between the distance modulus(m-M) can be plotted against the redshift and we can obtain a best-fit of the data by varying the cosmological parameters. At some values of cosmological parameters, we obtain a best fit. Thus, we can estimate the parameters in this fashion.

Plots

These are the plots that I have obtained from my code.

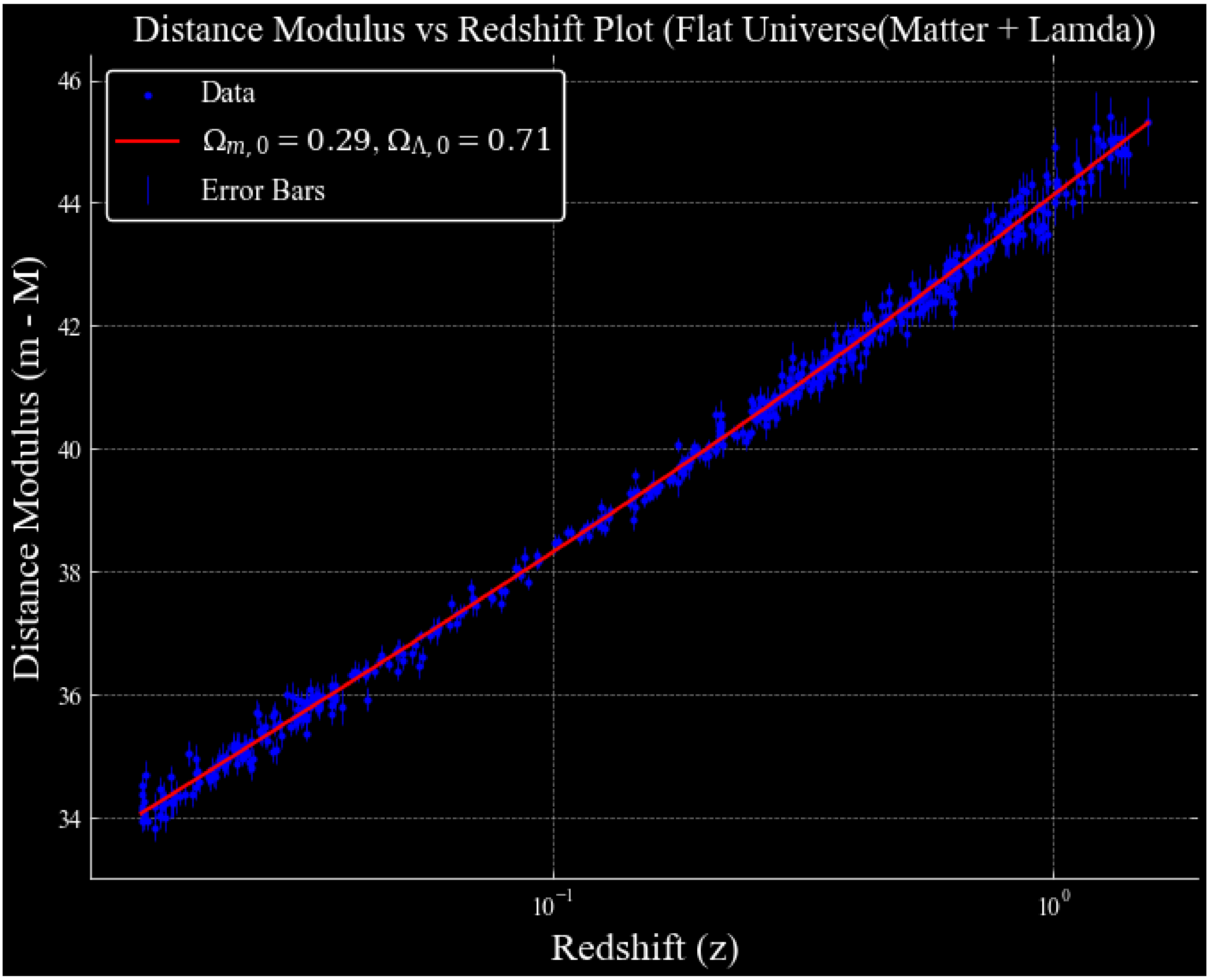


The plot between Distance Modulus vs Redshift with the error bars for each data point as well.



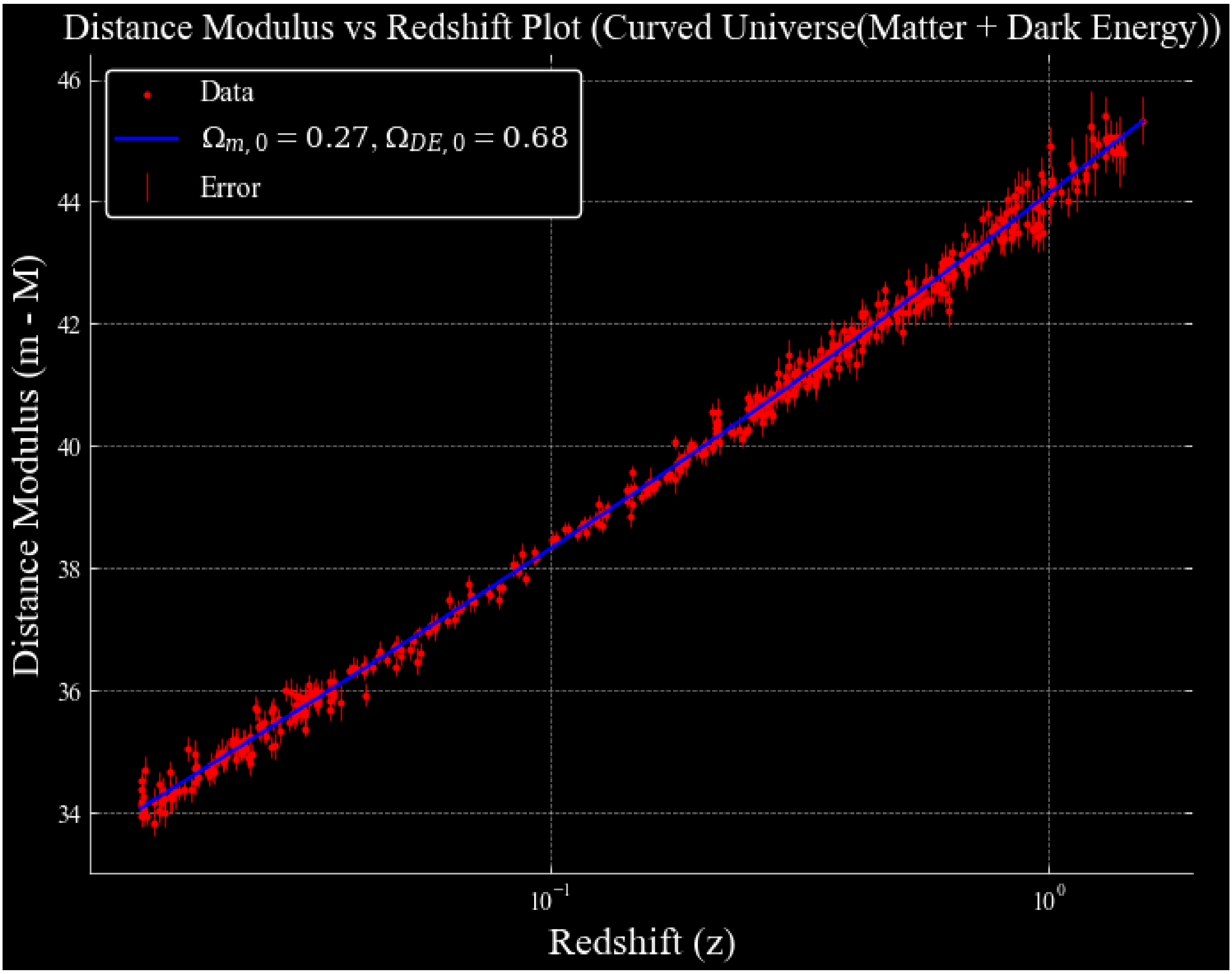
The plot between Distance Modulus vs Redshift with the error bars for each data point as well, plotted in log scale.

Other than these plots I have the plots where I have fitted the curve to estimate the cosmological parameters. The plots for that will be displayed on the next page.



This is the plot obtained for Flat Universe(Matter + Lamda). We can see that the red line fits the data effectively with the cosmological parameters as mentioned in the graph. The value of the hubble constant obtained for this model is,

$$H = 69.986 \text{ (km/s.Mpc)}$$



This is the plot obtained for Curved universe(Matter + Dark Energy). The blue line fits the data effectively as we can see. This was done through the LamdaCDM function avalaible in the astropy library of python. Te value of the cosmological parameters can be seen as shown in the figure. The value of the hubble constant turned out to be,

$$H = 69.907(\text{km/s.Mpc})$$

Results

These are the following values of cosmological parameters that I have obtained for both the models.

Universe Type	$\Omega_{m,o}$	$\Omega_{\Lambda,0} = 1 - \Omega_{m,o}$	H_o(km/s.Mpc)
Flat(Matter + Λ)	0.287 +/- 0.019	0.713+/- 0.019	69.986 +/- 0.003

Cosmological constants for a Flat Universe(Matter + Lamda)

Universe Type	$\Omega_{m,o}$	$\Omega_{\Lambda,0} = 1 - \Omega_{m,o}$	H_o(km/s.Mpc)
Flat(Matter + Dark Energy)	0.268 +/- 0.069	0.679 +/- 0.116	69.907 +/- 0.004

Cosmological constants for a Flat Universe(Matter + Dark Energy)