Problem Set #3 for G6010: Physical Cosmology

Fall Semester 2014

Problem #1

Reproduce the plot in Figure 1, which shows the state-of-the-art angular power spectrum measurements from the Planck satellite plotted along with theoretical angular power spectra curves for three different cosmological parameterizations. You should notice model #1 fits the data well, and the others do not suggesting model #1 describes our universe.

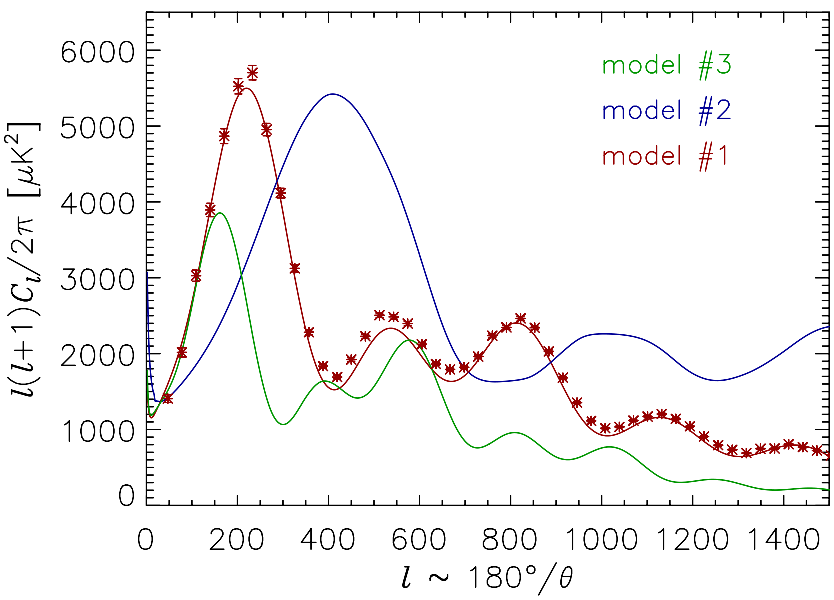

Figure 1: Angular power spectra for Problem #1.

You can download the data from

`http://cosmology.phys.columbia.edu/~bjohnson/g6010/planck_data.txt`

and you can generate the theoretical angular power spectra using this online Boltzmann equation solver

`http://lambda.gsfc.nasa.gov/toolbox/tb_camb_form.cfm`

When generating the theoretical curves, only vary Ω_{baryon}, Ω_{cdm} and Ω_Λ and use the following parameter values. Leave all of the other parameter values set to their default values.

	Ω_{baryon}	Ω_{cdm}	Ω_Λ
model #1	0.05	0.25	0.7
model #2	0.05	0.25	0
model #3	0.05	0.5	0.7

Problem #2

Reproduce the plot in Figure 2, which shows the distance modulus plotted versus redshift. You should determine the red curve by fitting the following model to the data

$$m - M = 5\log\left[cH_o^{-1}(z + \frac{1}{2}(1 - q_o)z^2)\right] + 25. \tag{1}$$

The free parameters in the fit are H_o and q_o, so you should get values for these parameters when you minimize χ^2. You should report your best-fit parameter values. The data points and associated error bars can be downloaded from the following link:

`http://cosmology.phys.columbia.edu/~bjohnson/g6010/supernova_data.txt`

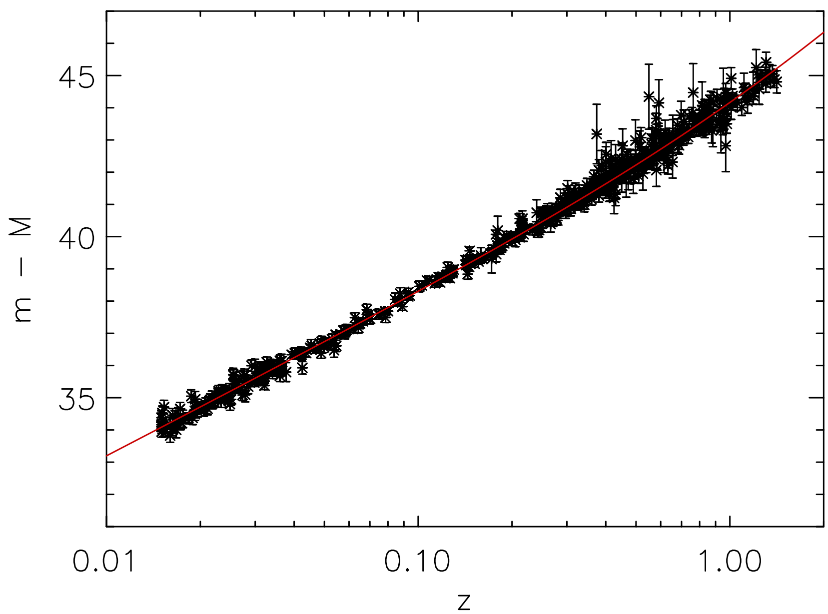

Figure 2: Distance modulus plot for Problem #2.

Problem #3

Analyze the data from a toy simulation experiment and reproduce the images in Panels (b) and (c) in Figure 3. The seminal simulated sky signal for this experiment is shown in Panel (a) of Figure 3, and this map was raster scanned to produce time-ordered data. Each time sample has an associated x and y position. The time-ordered data needed to recreate Panels (b) and (c) can be downloaded from this link

`http://cosmology.phys.columbia.edu/~bjohnson/g6010/data_3x2420.dat`

In this data file, you should find three columns of data. Column 1 is the x position, column 2 is the y position and column 3 is the signal value. Each row in this file is a time sample. Use Equation 2

$$\vec{m} = \left(\hat{A}^T\hat{A}\right)^{-1}\hat{A}^T\vec{d} \tag{2}$$

to produce the map in Panel (b) and Equation 3

$$\vec{m} = \left(\hat{A}^T \hat{N}^{-1} \hat{A}\right)^{-1} \hat{A}^T \hat{N}^{-1} \vec{d} \tag{3}$$

to produce the map in Panel (c). The inverse noise covariance matrix, $\hat{N}$, you need in Equation 3 can be downloaded from this link

`http://cosmology.phys.columbia.edu/~bjohnson/g6010/N_inv_2420x2420.dat`

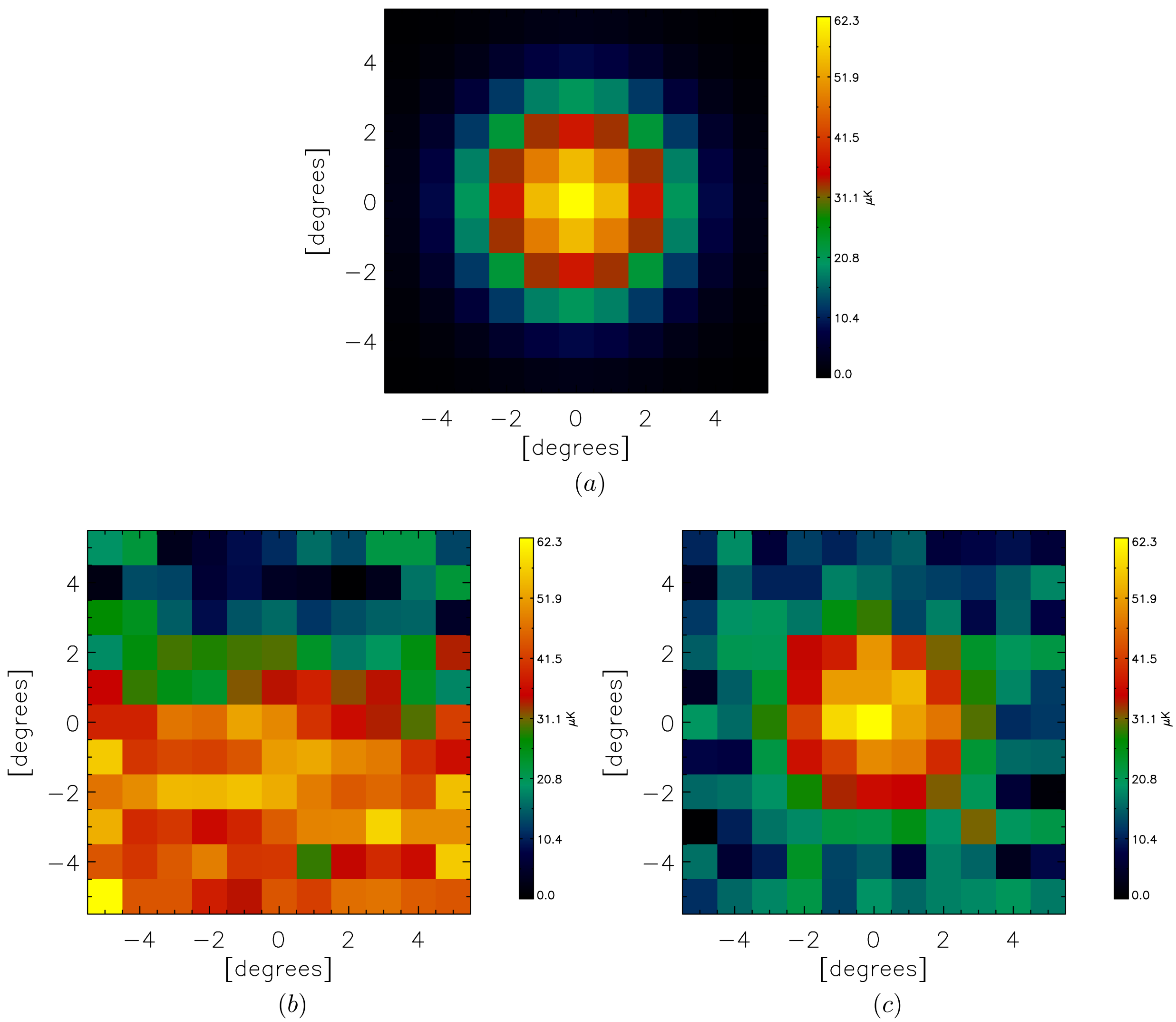

Figure 3: Maps for Problem #3.