DS4S Group 2 Project Plan

Problem statement:

1) A reproduction of the Pantheon constraints shown in Fig. 18 of S18, both with and without inclusion of systematic errors.

2) Determine the posterior probability density of H_0 after adding a Gaussian prior on corrected supernova absolute magnitude of M =19.23 +/- 0.042. Make a figure.

Write your own MCMC code (do not use a publicly available code such as CosmoMC).

Grading is based on setup and presentation.

Additional stuff to maybe save for later assignment:

3) Tests for consistency:

A) A residual plot for the binned data similar to Fig. 11 of S18.

B) Evaluation of \chi^2 and calculation of PTE

C) Draw a handful of realizations from the noise covariance, and add to best-fit signal

D) Take the symmetric square root of the error covariance matrix. Transform the residuals r to r' = C^{-1/2}r and histogram. Compare with expectations. Note that <r' r'^T> = C^{-1/2}<r r^T> C^{-1/2} = the identity matrix. So the histogram should be consistent with a Gaussian with unit variance.

E) Break up binned supernova distances into several redshift ranges and test for stability of H_0 inference across these different subsets.

Repo Structure:

Modules are each of our first names
(parameters_adam, functionality_pritom, functionality_junying)
Separate directory (test) for tests
Simple “runme”-style file in root directory

Tasks:

Task 1)
Proposing parameter set in 3D: - Adam
Name: get_new_parameters()
Inputs: sigmas [sigma_h, sigma_m, sigma_v], previous parameters [H, omega_m, omega_v]
(Optional: distribution type {gaussian etc})
Outputs: List of 3 parameter values [H, omega_m, omega_v]

Task 2)
Compute likelihood : - Junying
Inputs: List of 3 parameter values [H, omega_m, omega_v]
Transients: least-squares errors np.lstsq(\vec{m_b}-\vec{mu})

Outputs: real number ; acceptance_probability

Task 3) - Pritom
Form Markov chain in ND:
Inputs: chain length, likelihood function, starting state
Outputs: T by N array

Task 4) -Pritom
Confirm convergence:
Inputs: TBD
Outputs: TBD

Task 5) - Adam
show_final_plot()
Visualization (isolate 1 variable, plot 2-d probability density) :

Schedule (Tentative):
Presentation Deadline: May 7th
Presentation Format: Google slides / libra

Task deadlines:
First drafts of all above tasks by Thursday, May 1, 5 PM
Final drafts by Saturday (synchronous meeting to work out kinks?)
Presentation draft by Monday (sections?)
Final presentation draft Tuesday night
Meet Wednesday for trial run
Present Thursday!

Questions (Answered 4/27/20 in office hours):

1. Should we use D_l(z) presented in https://iopscience.iop.org/article/10.3847/1538-4357/aab9bb/pdf#%FE%FF%00b%00m%00_%00a%00p%00j%00a%00a%00b%009%00b%00b%00e%00q%00n%003 P 16, or some other form? What is Ωk?
   Prof. Knox: https://en.wikipedia.org/wiki/Angular_diameter_distance
   Also see Adam's handwritten notes: w=-1, but Ωk satisfies Ωk+ Ωm+ Ωlambda = 1
2. What other systematic errors we need to consider besides d_mb ?
   Prof. Knox: Systematic errors! (having to do with smoothing!)
3. Do we care about "Nuisance" parameter M?

Prof. Knox: Yep, still counts--M is a 4th parameter (can constrain omegas via sum(omegas)=1).

M and H_0 influence the data the same way (H_0 can be absorbed into a constant sum)

4. Should we impose constraints on omega_m and omega_v ? Or we should consider them as independent ?
   (See above)
5. Should we also consider H0 dependent on omegas' ?
   H_0 should be varied independently.
6. Is our proposed likelihood valid or not ?
   No. Instead, use

$$P(m_0, m_1, ...m_{40}|\theta, M) \propto \exp\{-[m_i - (\mu(\theta, z_i) - M)](C^{-1})_{ij}[m_j - (\mu(\theta, z_j) - M)]/2\}$$

   Per slides #8.
7. What are the prior distributions for the parameters ?
   Uniform priors for everybody else.
8. Can we adaptively change sigma_h etc, or will this violate some assumption of Markov chain applicability? (Probably no?)
   Should be no need
9. P8 of slides: What's the purpose of the covariance matrix? (something with error?)
   See 2) above and slide 8 of the GroupProjectIntro.key

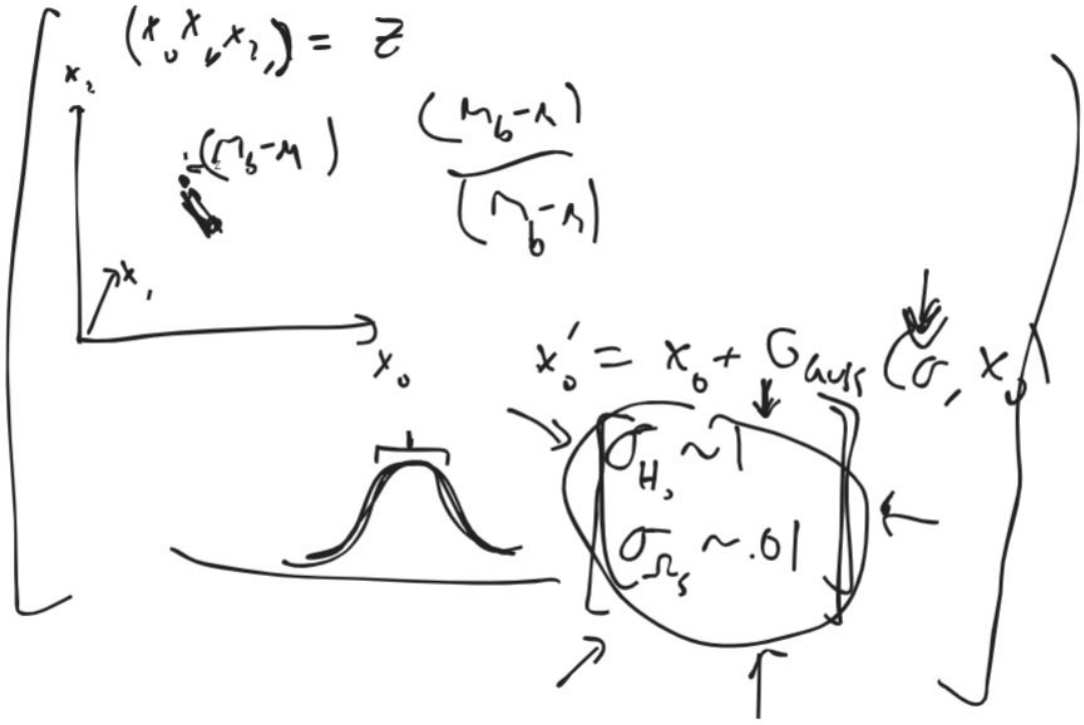
Useful Resources:

OBSERVATIONAL EVIDENCE FROM SUPERNOVAE FOR AN ACCELERATING UNIVERSE AND A COSMOLOGICAL CONSTANT

The Complete Light-curve Sample of Spectroscopically Confirmed SNe Ia from PanSTARRS1 and Cosmological Constraints from the Combined Pantheon Sample

Random doodle space:

Discussion of navigating 3-D parameter space and relevant sigmas:



To reproduce graphic: align an ellipse with semimajor and major axes pointing to maximize data capture while minimizing least-squares distance to nearest edge? Then scale the axes to get 68% of the data etc.