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.*

Structure:

Modules are each of our first names

(parameters\_adam, functionality\_pritom, functionality\_junying)

Desired functionalities:

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 3D:

Task 4) -Pritom

Confirm convergence:

Task 5) - Adam

show\_final\_plot()

Visualization (isolate 1 variable, plot 2-d probability density) :

Presentation planning:

Deadline: May 7th

Google slides / libra

Questions need to answer:

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](https://iopscience.iop.org/article/10.3847/1538-4357/aab9bb/pdf#%EF%BF%BD%EF%BF%BD) P 16, or some other form? What is Ωk?

Prof. Knox: <https://en.wikipedia.org/wiki/Angular_diameter_distance>

Also see handwritten notes

1. What other systematic errors we need to consider besides d\_mb ?

Prof. Knox: Systematic errors! (having to do with smoothing!)

1. 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)

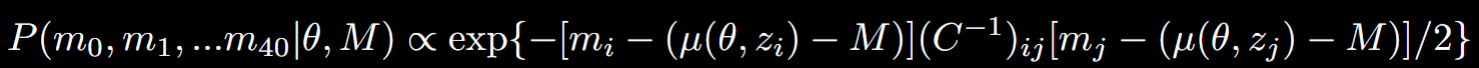
1. Should we impose constraints on omega\_m and omega\_v ? Or we should consider them as independent ?

(See above)

1. Should we also consider H0 dependent on omegas’ ?

H\_0 should be varied independently.

1. Is our proposed likelihood valid or not ?

No. Instead, use 

Per slides #8.

1. What are the prior distributions for the parameters ?

Uniform priors for everybody else.

1. Can we adaptively change sigma\_h etc, or will this violate some assumption of Markov chain applicability? (Probably no?)

Should be no need

1. P8 of slides: What’s the purpose of the covariance matrix? (something with error?)

See 2) above and slide 8 of the GroupProjectIntro.key

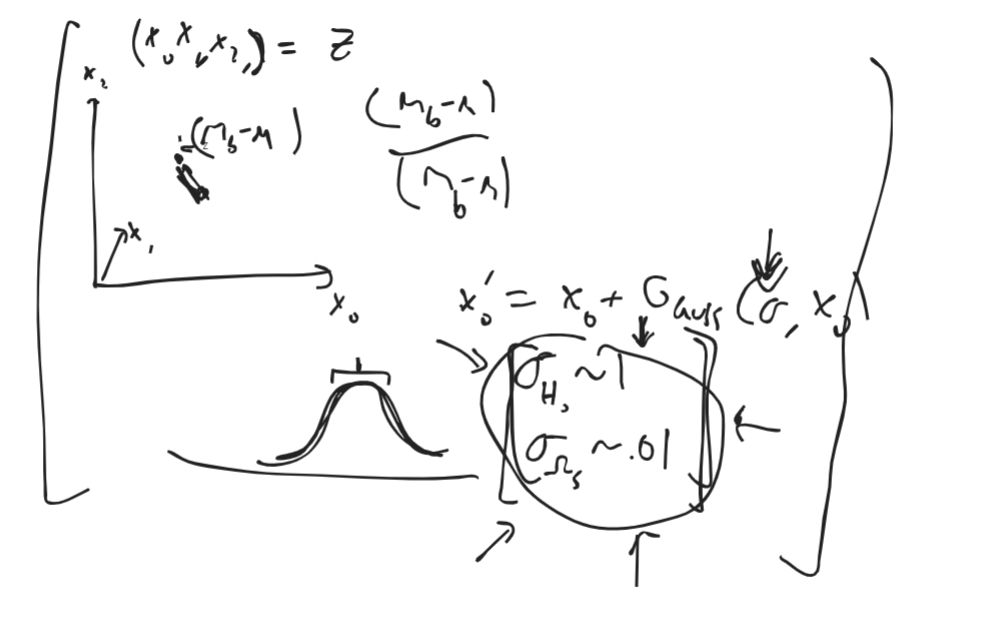
Useful Resources:

[OBSERVATIONAL EVIDENCE FROM SUPERNOVAE FOR AN ACCELERATING UNIVERSE AND A COSMOLOGICAL CONSTANT](https://iopscience.iop.org/article/10.1086/300499/pdf)

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

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.