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CODE THE COSMOS

Background Information

The universe is undergoing an accelerated expansion at current time. However, the expansion was not uniform throughout it's history and we have evidence that the expansion of the universe was decelerating till few billion years ago when it started to accelerate. The rate of expansion of the universe is quantified by the Hubble Parameter. Hubble Parameter varies with redshift(proxy for time) and the variation is given by

$$H(z) \; = \; H_0 \, [\, \Omega_m (1 \; + \; z)^3 \; + \; \Omega_k (1 \; + \; z)^2 \; + \; \Omega_\Lambda]^{1/2}$$

Where

Ω_m, Ω_k and Ω_Λ are current density parameter of matter(non-relativistic) , curvature and dark energy respectively while H_0 is the current value of Hubble Parameter and H(z) is the hubble parameter at redshift z.

$$\Omega_i \; = \; \frac{\rho_i}{\rho_{cr}}$$

ρ_{cr} is the critical density of the universe and is equal to $\frac{3H^2}{8\pi G}$ where H is the hubble parameter at the respective redshift and ρ_i is the density of ith component(i = matter, curvature etc).

Problem Statement

Given a dataset for Hubble parameter at various redshifts, constrain and find the best fit values for Ω_m, Ω_k and Ω_Λ and plot 1 and 2D marginalized probability distributions for all three parameters and report uncertainty corresponding to 1,2 and 3σ

- Take $H_0 = 73.04 \pm 1.04 \, km \, s^{-1} Mpc^{-1}$
- Note that the dataset contains associated errors for Hubble Parameter. Include those errors in your analysis

Data
The data can be found [here](#)

Useful Links
For more details about the Hubble parameter and it's evolution, one may look at the following links:

- https://ned.ipac.caltech.edu/level5/Peacock/Peacock3_2.html
- https://ned.ipac.caltech.edu/level5/Sept11/Freedman/Freedman2.html
- https://arxiv.org/pdf/2305.11950.pdf

Submission Format
The submission should contain the following things:
I. Documented Code file
II. Pdf file containing results and explaining the approach of your analysis

Judging Criteria
Submissions will be judged on following basis(weightage decreases downwards)
- Accuracy of final result
- Implementation
- Documentation

Restrictions and Plagiarism Policy
Participants are allowed to refer any sources. One team cannot collaborate with other teams and if they are found violating the rule, both the teams will be disqualified. **Implementation has to be done in Python only**. There is no restriction on the libraries that can be used.