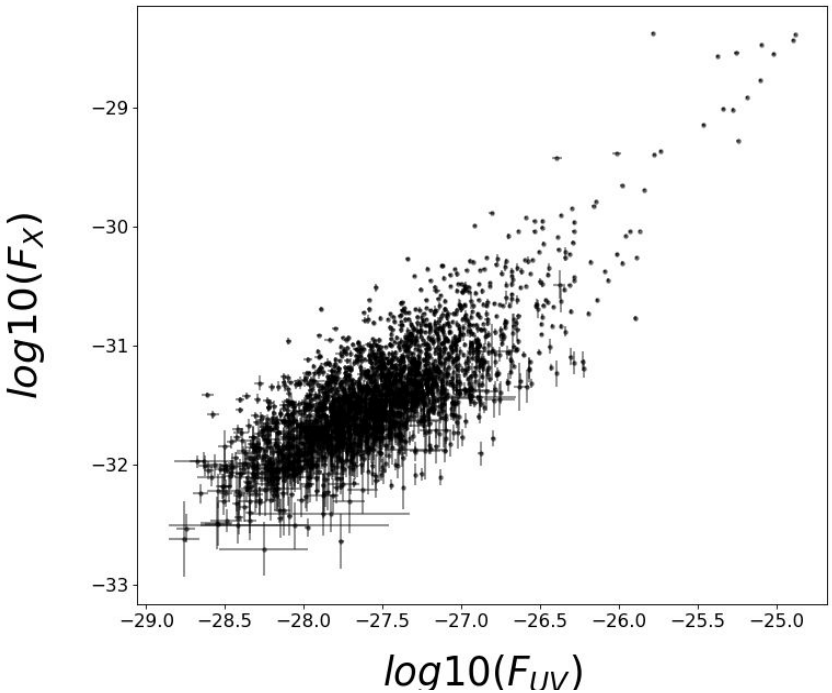
Reconstruction and study of Hubble diagram of quasars

Ranbir Sharma

Collaborator: Yong-Seon Song

Korea Astronomy and Space Science Institute (KASI)

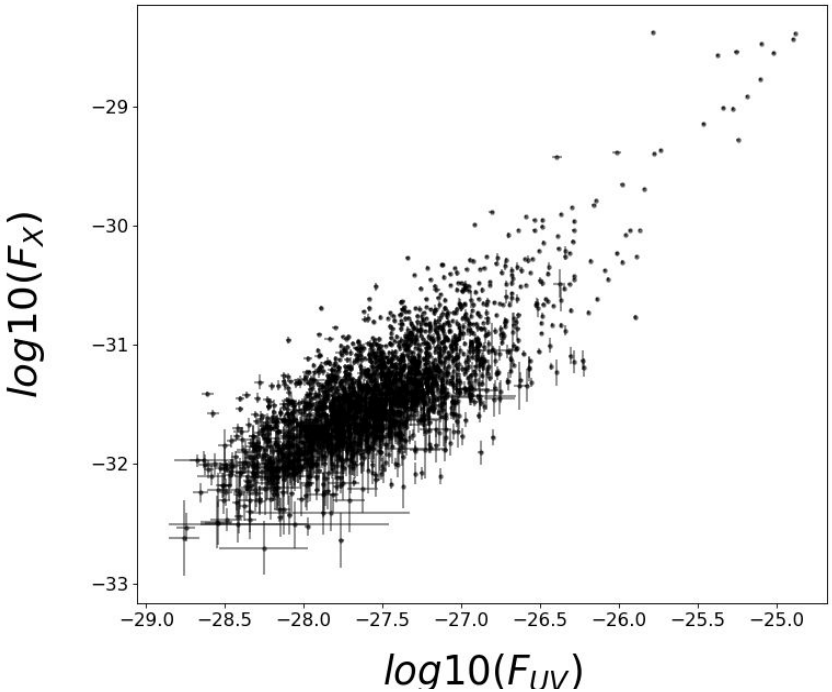
Quasar data-set:

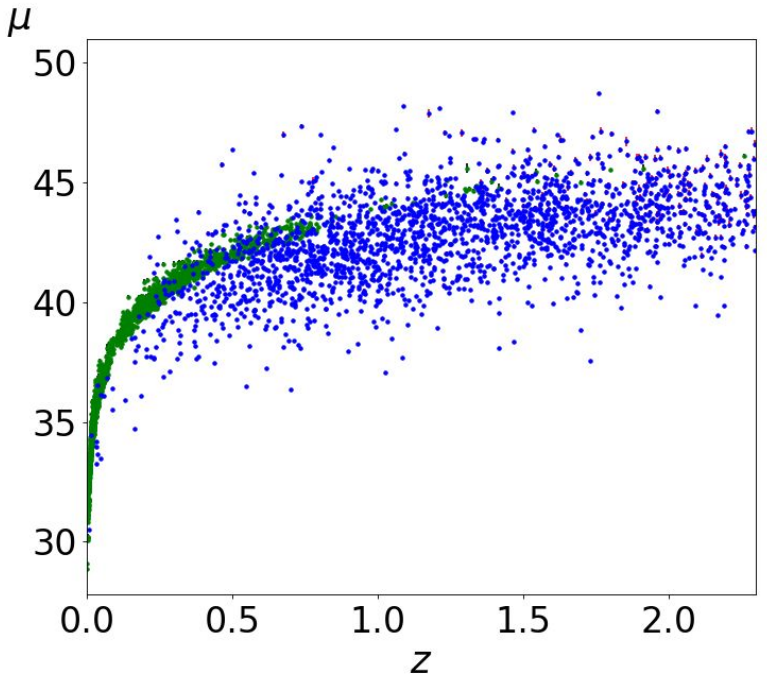


- ★ **Eddington Bias:** Accepting sources with deep enough X-ray observation to be detected.
- ★ **X-ray spectrum:** Fixing threshold for X-ray photon index.
- ★ **Optical Spectrum:** Selection of relatively blue objects to remove objects with a significant dust extinction.

Footnote: Lusso et. al. 2020, Risaliti 2022 >> (Paris et.al. 2018) + (Webb et. al. 2020 & Evans et. al 2010)

Quasar data-set:





Footnote: Lusso et. al. 2020, Risaliti 2022 >> (Paris et.al. 2018) + (Webb et. al. 2020 & Evans et. al 2010)

RL relation:

The non-linear relation of the fluxes must be the manifestation of the physical mechanism responsible for the energy flow from the accretion disk to corona.

$$log10(\mathcal{L}_X) = \alpha * log10(\mathcal{L}_{UV}) + \beta$$

$$log10(\mathcal{F}_X) \approx \beta^*(z) + \alpha \times log10(\mathcal{F}_{UV})$$

$$\beta^* = \beta + (\alpha - 1)log10(4\pi) + 2(\alpha - 1)log10(d_L)$$

Lusso relation:

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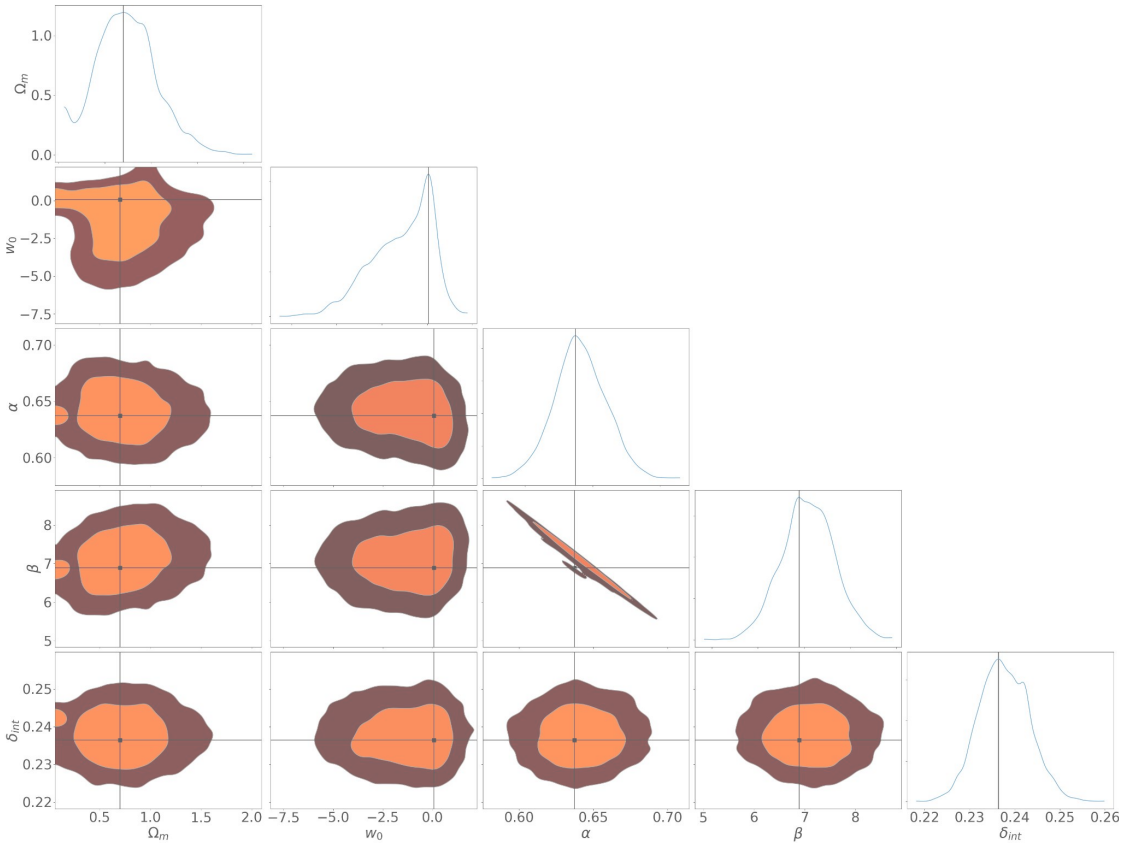
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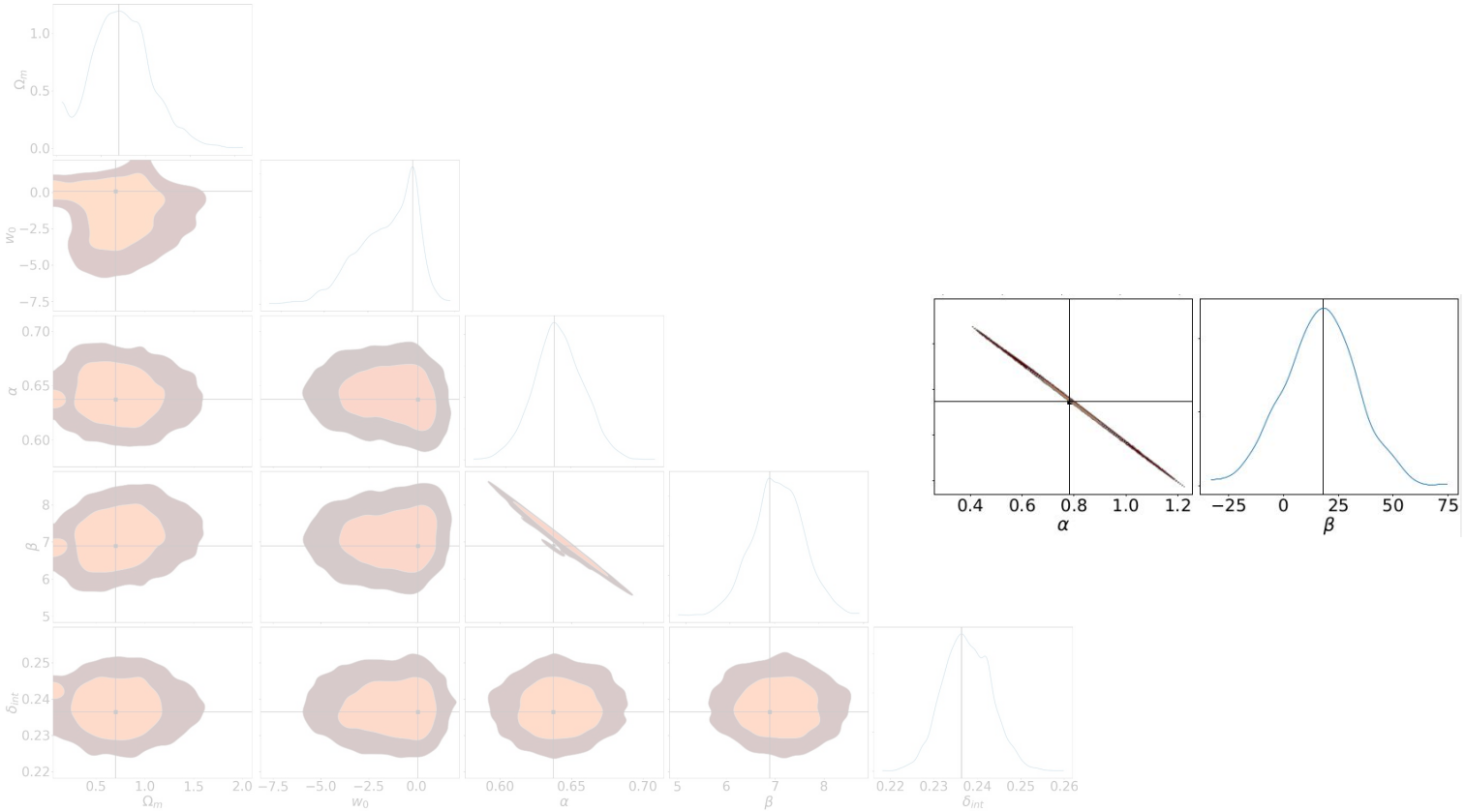
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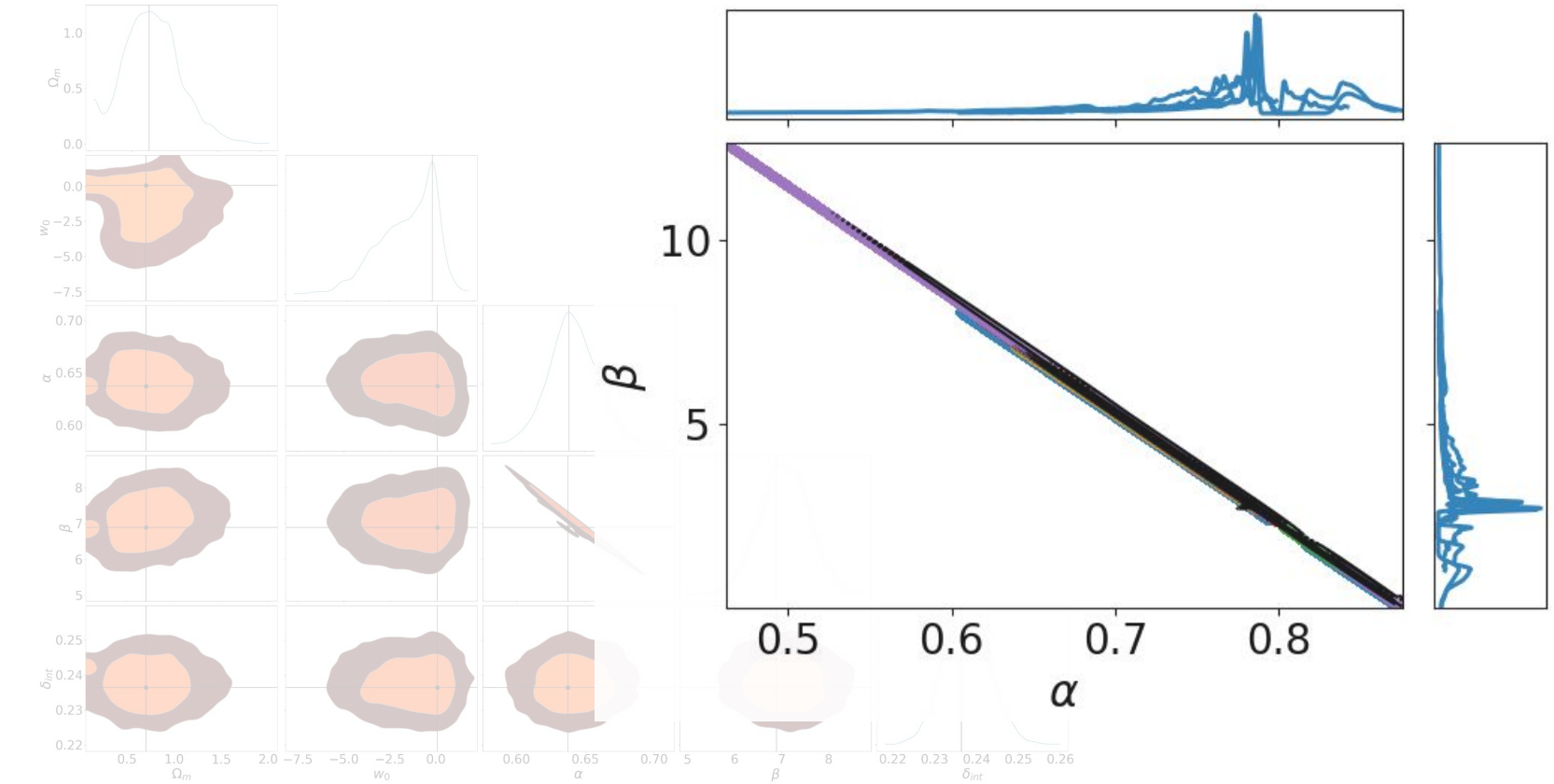
Strong Correlation of two quasar parameters



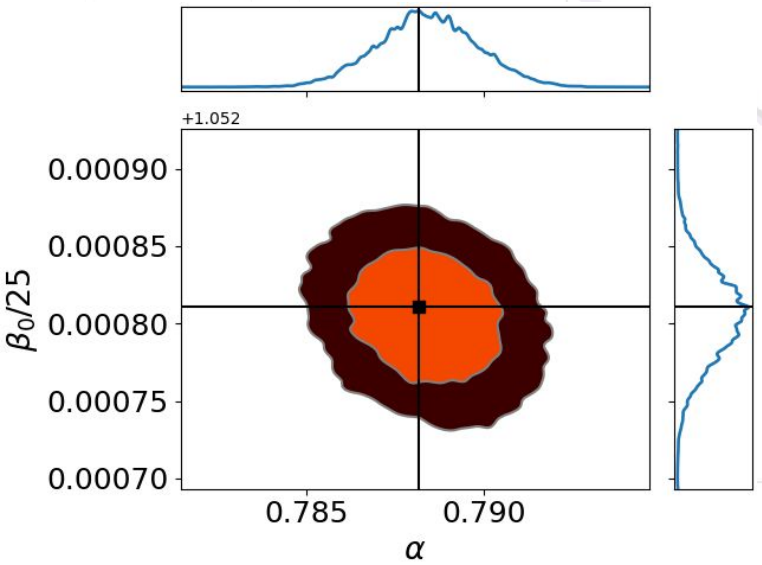
Strong Correlation of two parameters



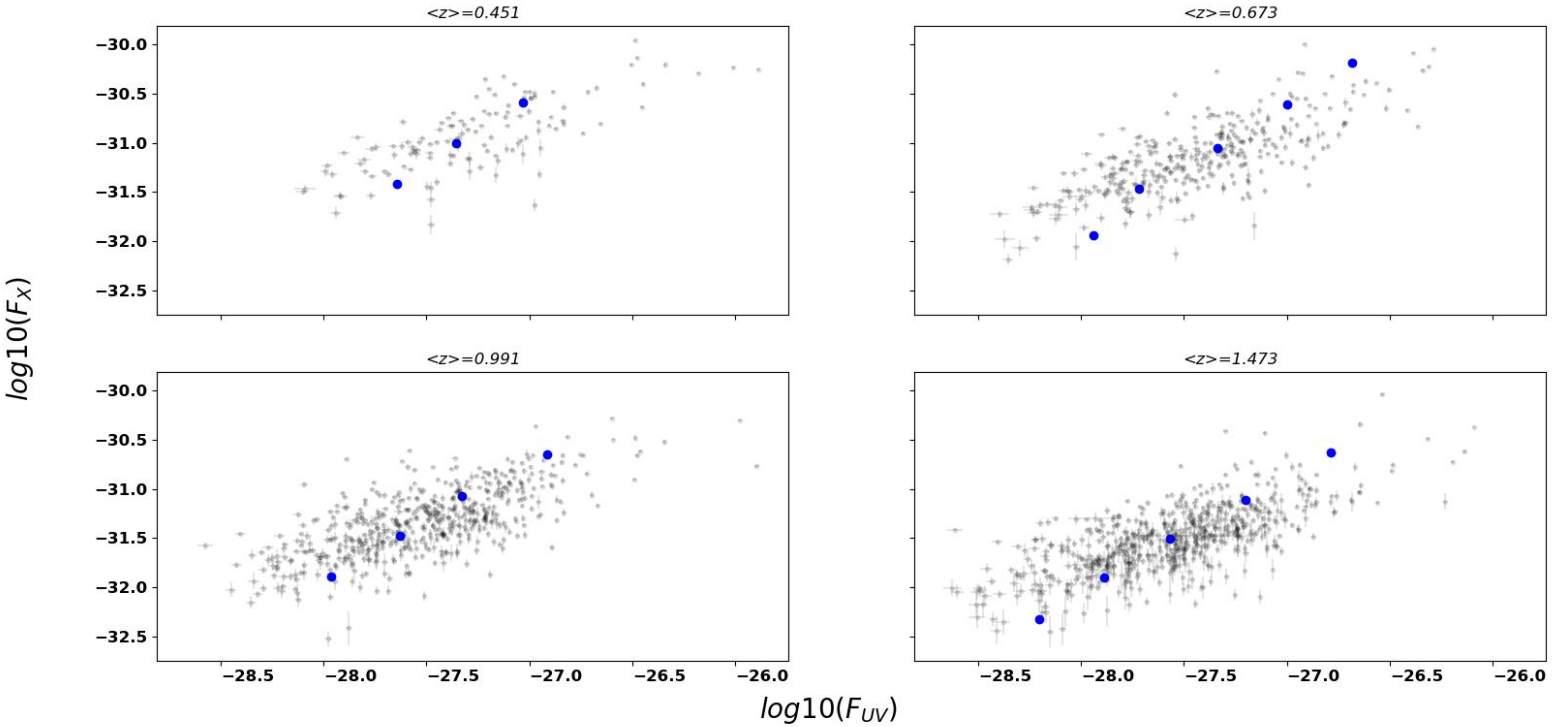
Strong Correlation of two parameters



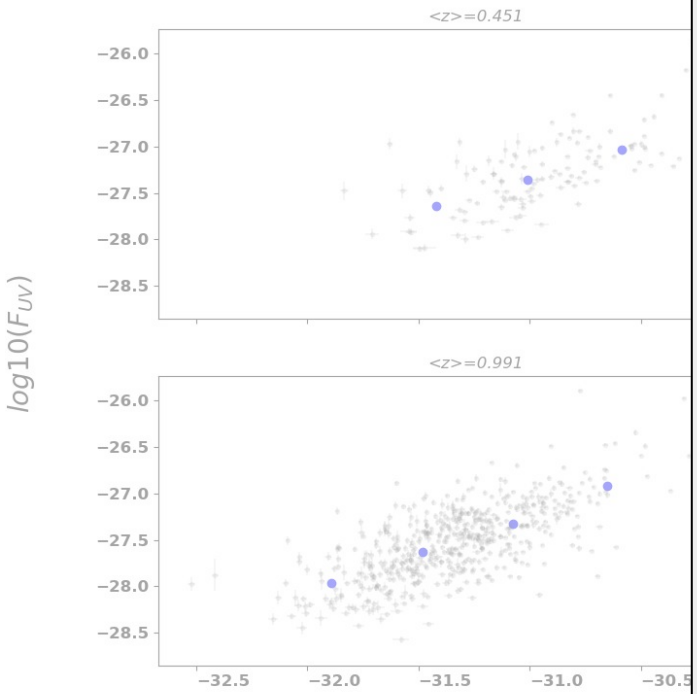
Breaking of the Correlation of two parameters



Lusso relation in binned space:

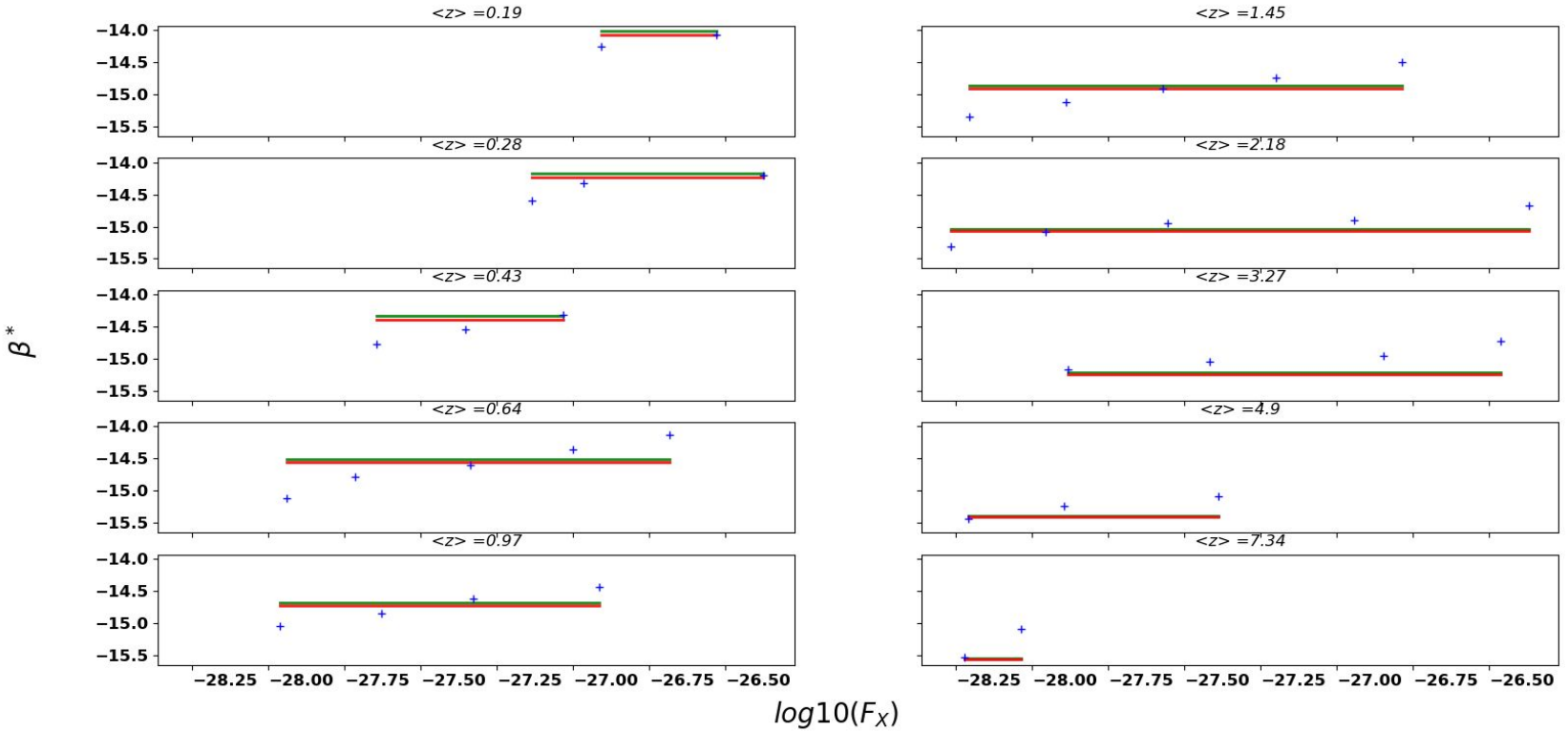


Lusso relation in binned space:

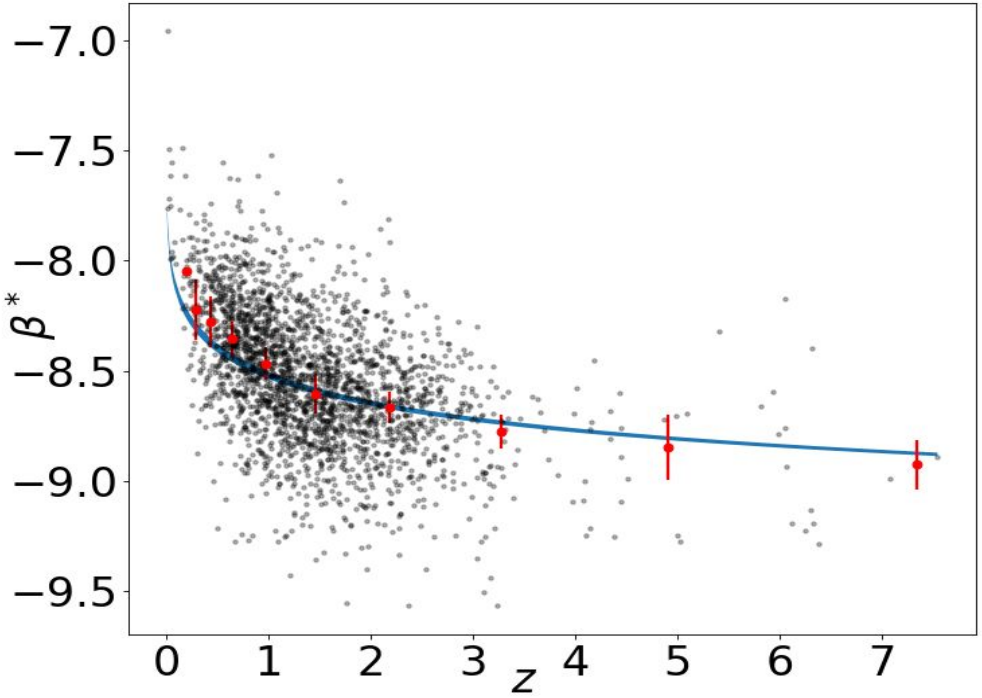


- The flux bins has been created for each of the redshift bins.
- For each flux bin at least **five quasar points** are there.
- Number of the redshift bin is determined by the **dispersion of the data**.
- The flux value of the bin points are created by taking the **weighted mean** over the flux values.

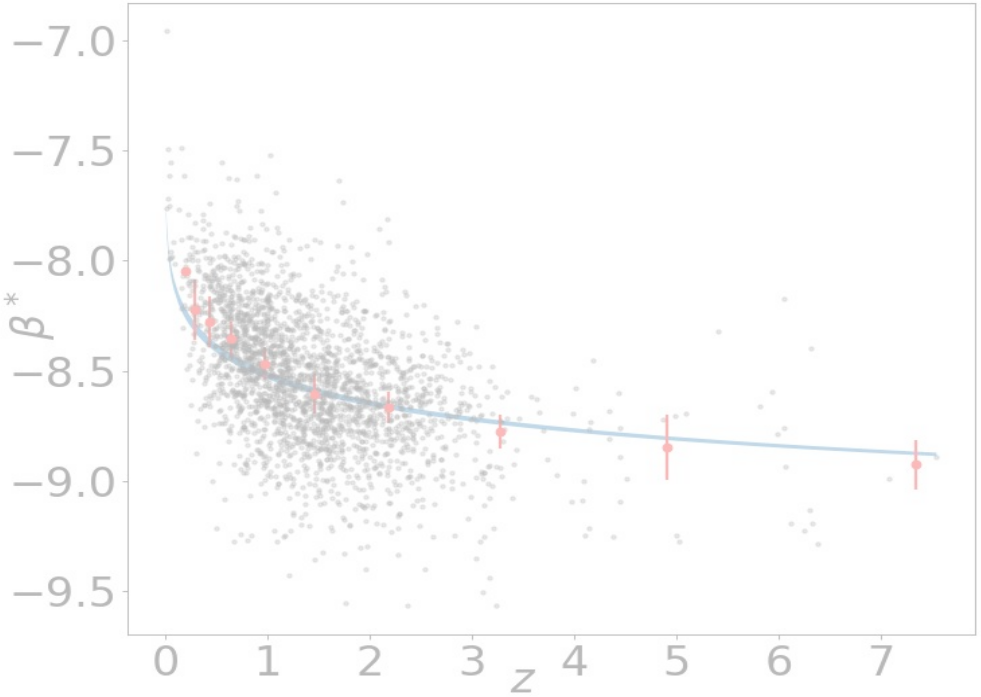
The complete binned space

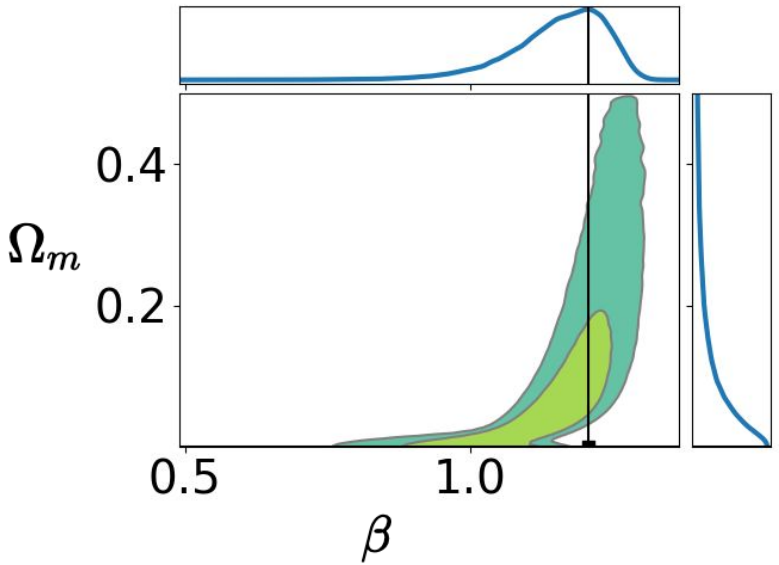


Quasars and LCDM



Quasars and LCDM

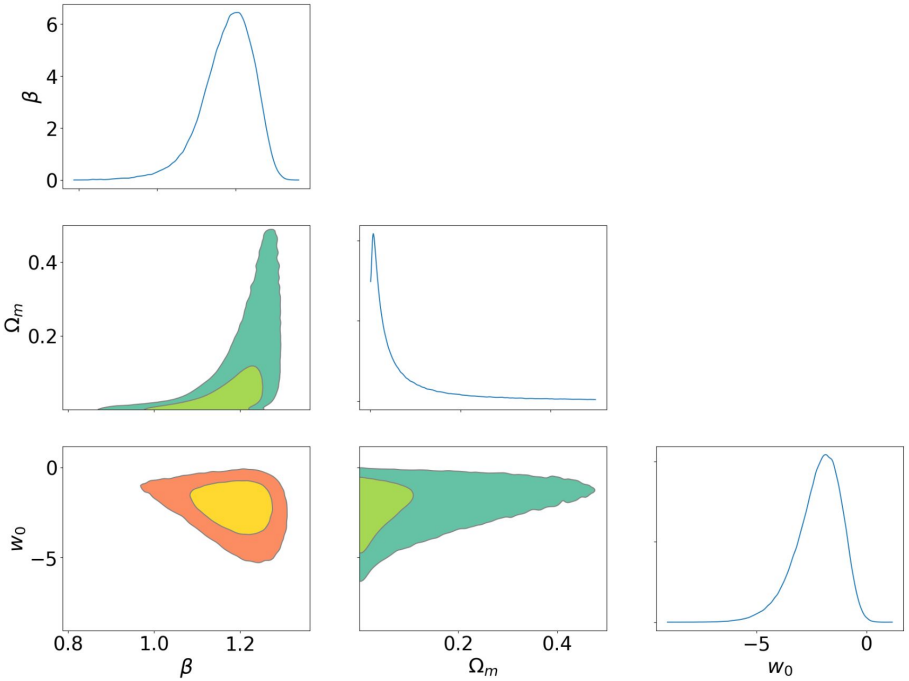




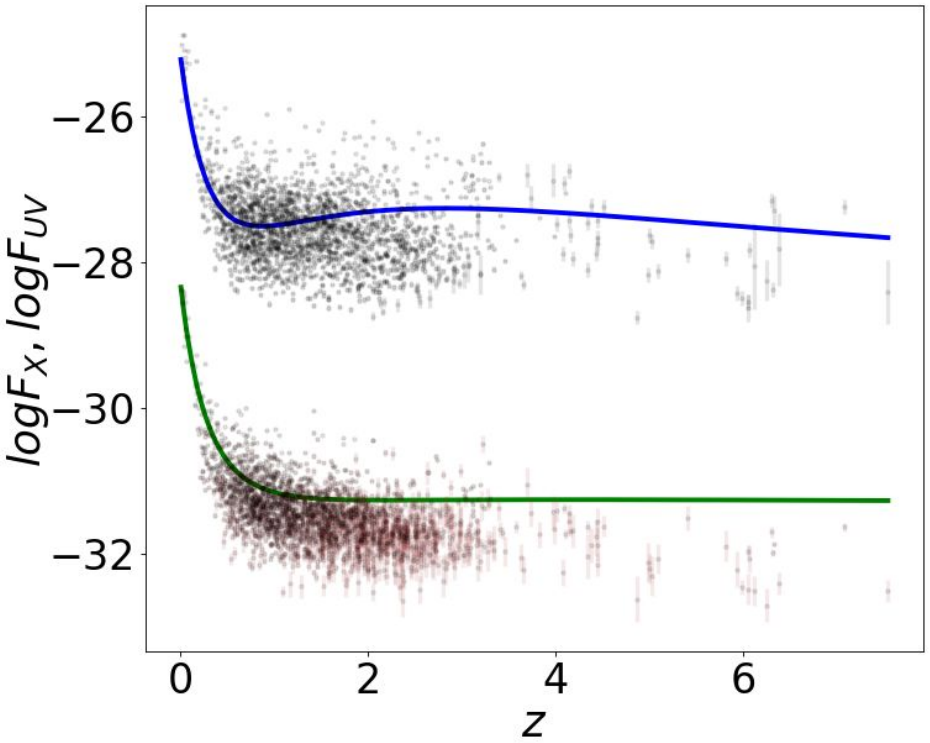
Future direction

- We are finding a efficient way to negate the outliers in the case of SDSS dataset.
- With the improvement of the QSO dataset we can verify the RL relation with higher precision with higher redshift bin & with it we can constrain the cosmological parameters in a better way.
- As the core of the PCA + CCC + NUTS calculation is the data-set in hand, with the improve of the quasar data-set there is a possibility of using the quasars as the constrained purpose.

Constrained parameters from binned data



PCA reconstruction Flux

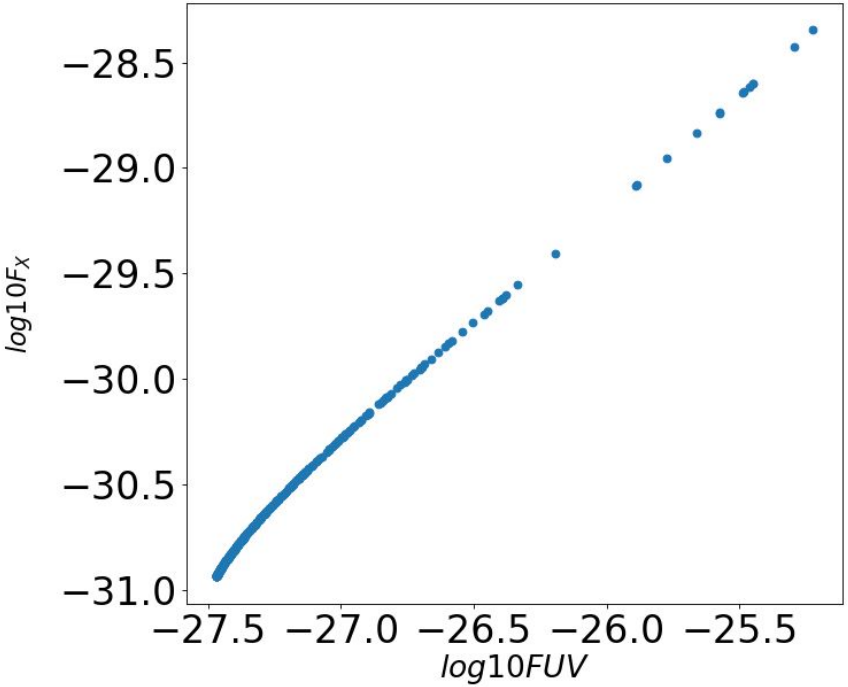


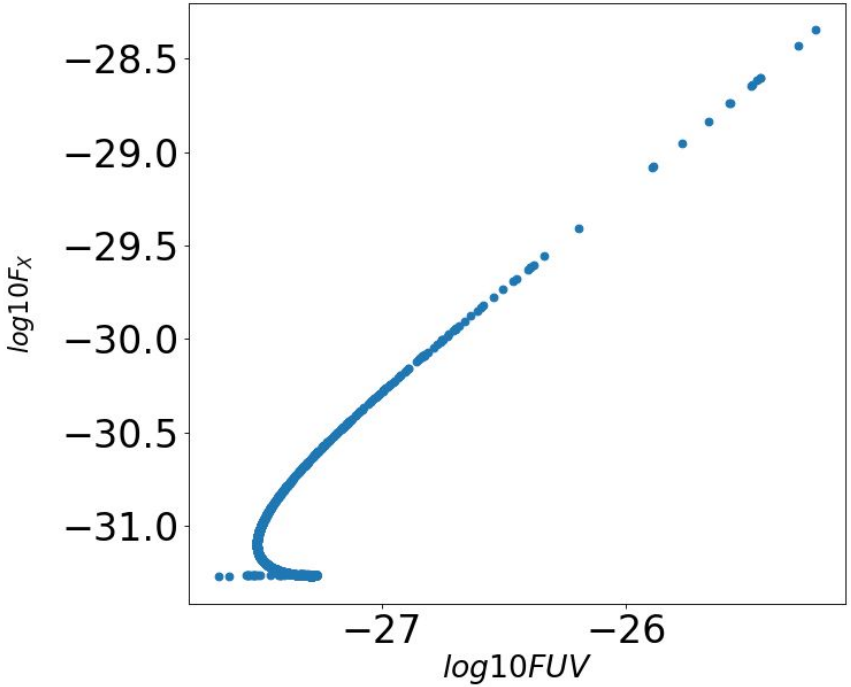
- We apply the combined algorithm of PCA and Correlation Coefficient Calculation (CCC) to reconstruct the functional form of the observables.

arxiv:2004.01393

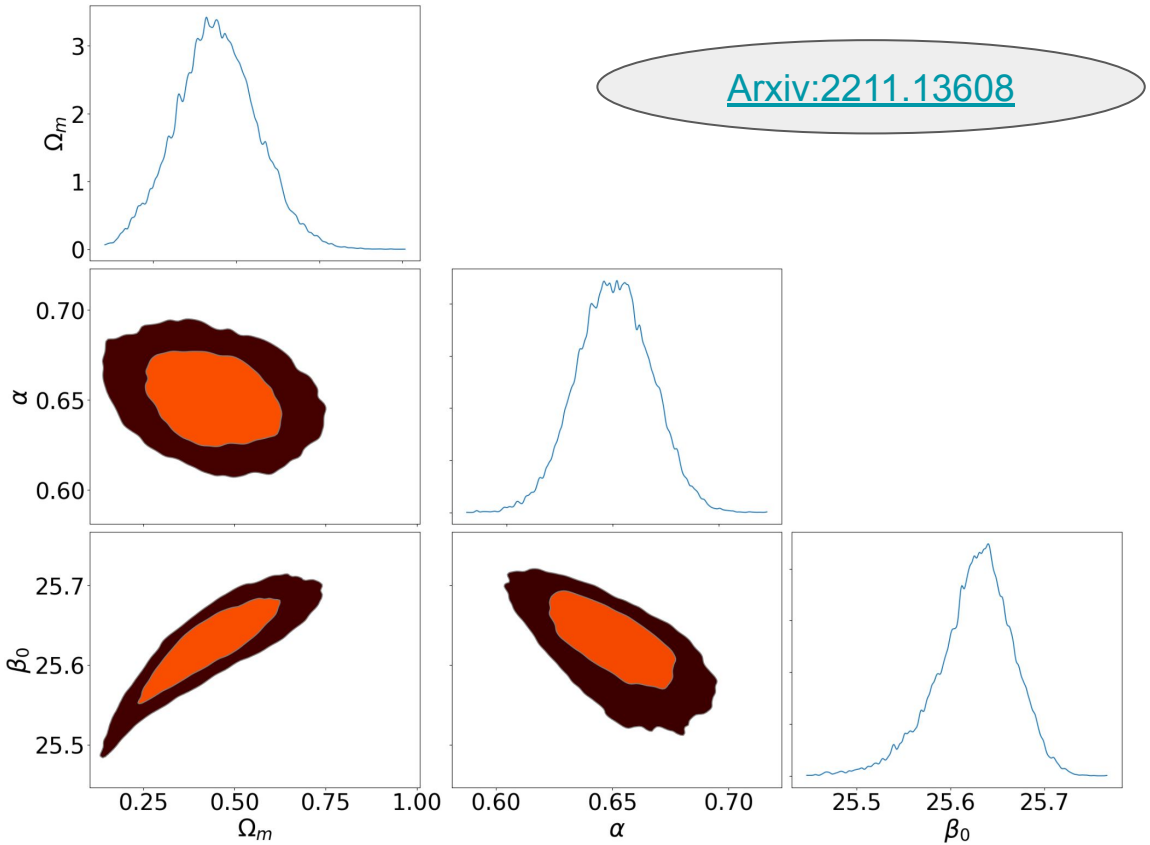
- Only input in the data-set is the redshift-flux binned data.

Validity of the RL relation from PCA





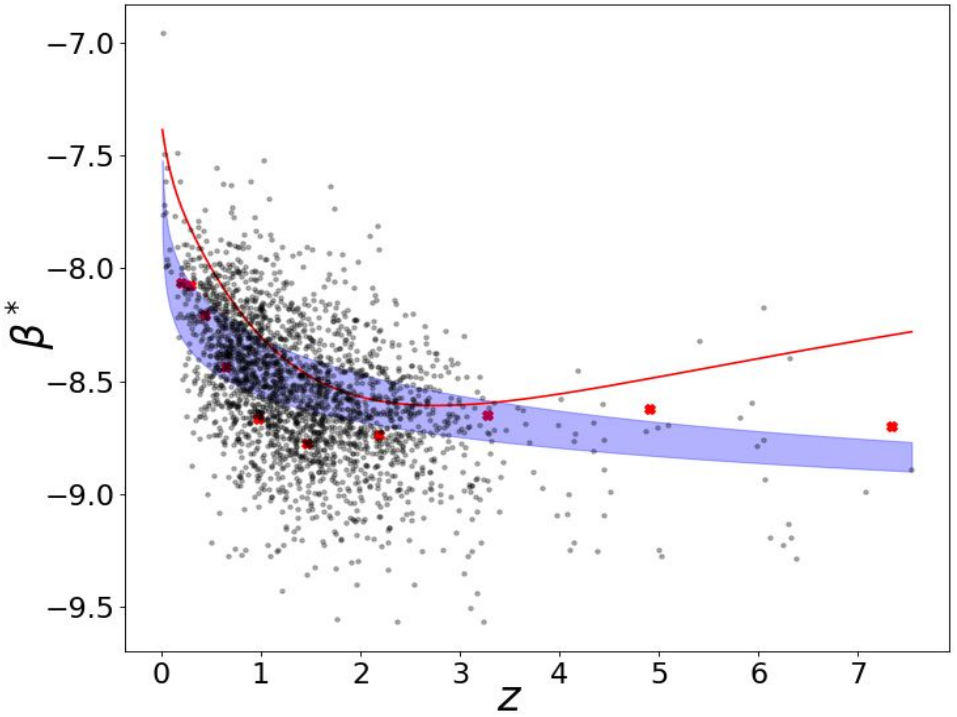
Parameter constraints for allowed data-points



Arxiv:2211.13608

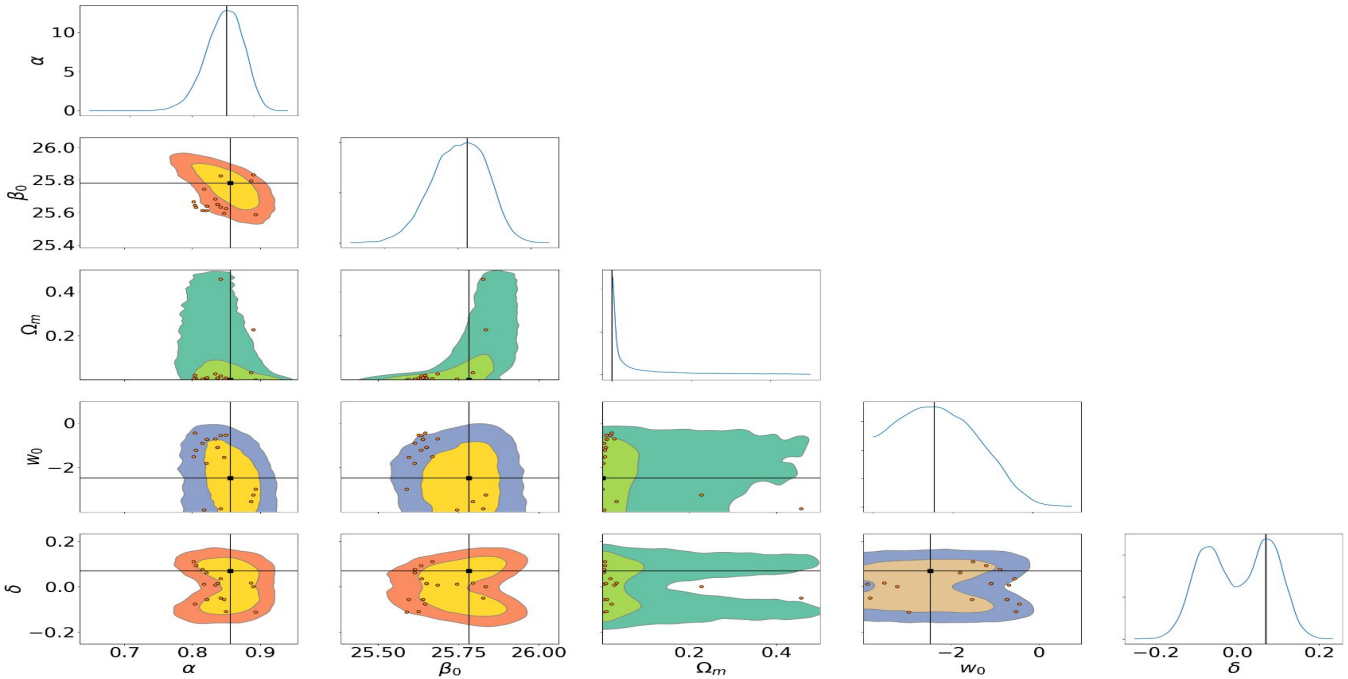
1) MCMC sampler: NUTS
2) Number of sample points: 20000
3) Independent Variable in PCA reconstruction: z/(1 + z)
4) Value of Sample points: 10000

Lusso relation in binned space:

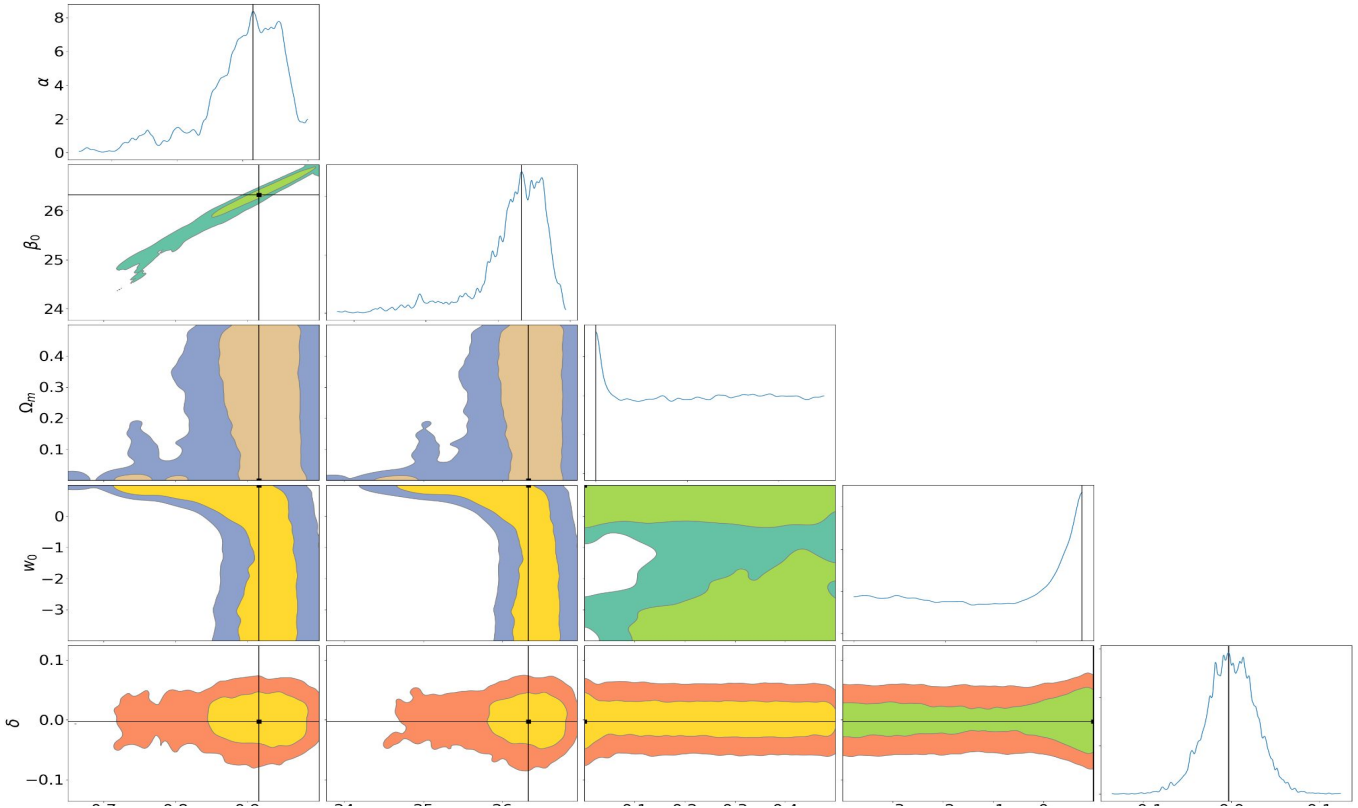


Strong discrepancy with the PCA reconstruction and LCDM predicted points.

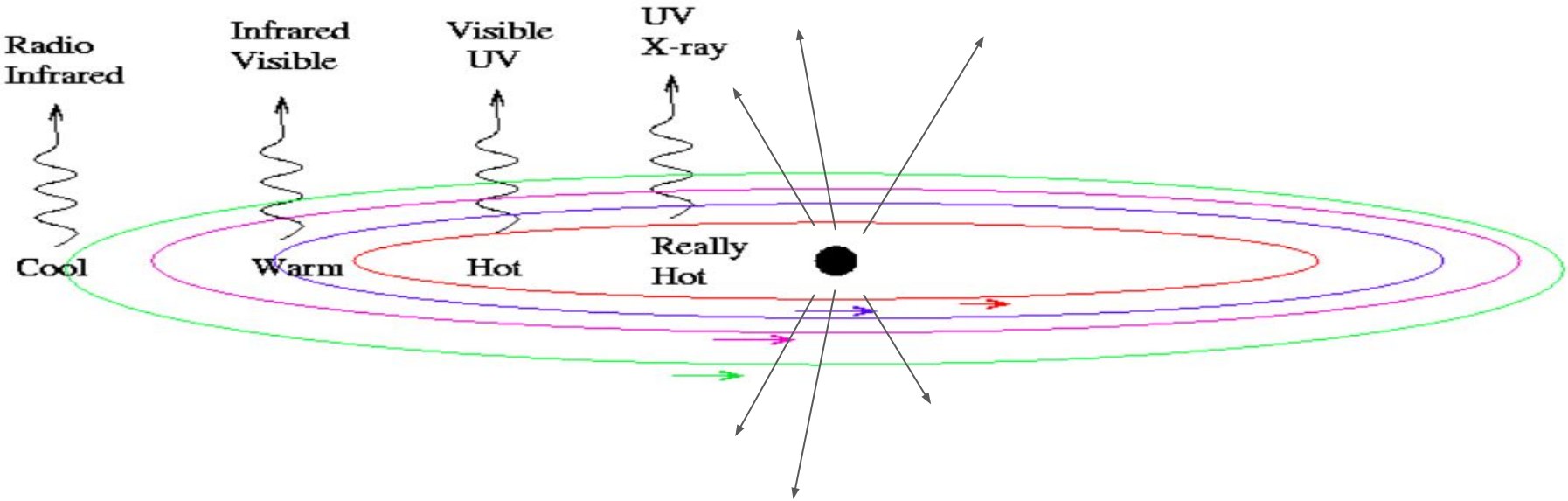
Constrained parameters from unbinned data (extra)



Constrained From PCA + CCC + MCMC (extra)



Quasar radiation:



1) Quasars are numerous in number
2) Quasars can be observed to a higher redshift
3) Quasars can be a tool to infer cosmology in between the CMB and SNIa