Machine Learning Applications to Gamma-Ray Bursts

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భారతీయ సాంకేతిక విజ్ఞాన సంస్థ హైదరాబాద్
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Outline

- Galaxy Cluster Dataset- preprocessing
- Gaussian Process Regression
- GRB Dataset
- Error Propagation
- MCMC Analysis
- Regression relation

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Galaxy Cluster Dataset- preprocessing

Source:-

- Dataset Reference
- ➪ arxiv:astro-ph/0512349(Click here for Dataset)

- Dataset Description:-
  - ➪ cluster name
  - ➪ Redshift value
  - ➪ Angular diameter distance
  - ➪ error min and error max value.
- Dataset is consist of data related to 38 different galaxy cluster with redshift value in range of 0.14 to 0.89.
- Error is symmetrized for further calculation

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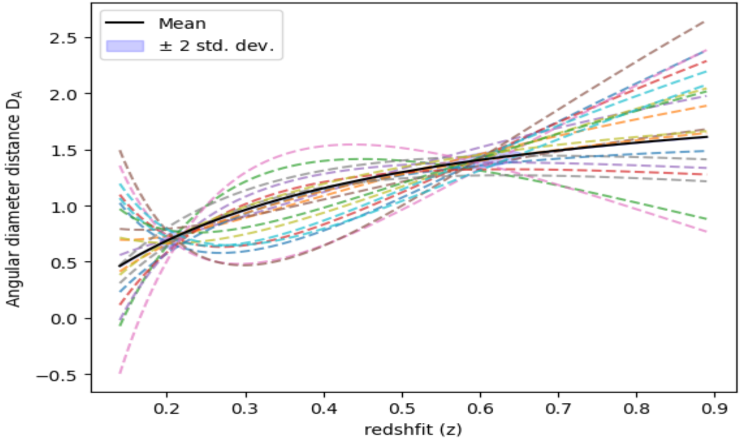
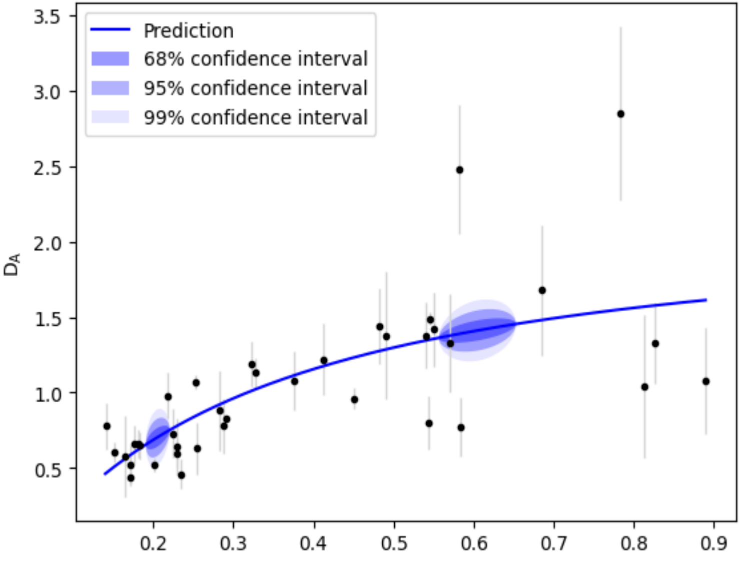
Gaussian Process Regression

- Using GPR finding the relation between the redshift z and Angular diameter distance D_A.



Gaussian Process Regression



Gamma Ray Burst(GRB) Dataset

Source:-

- Dataset Reference
- arxiv:1105.0046(Click here for Dataset)

- Dataset description:-
  - GRB
  - P_{bolo} and $P_{bolo}err$
  - S_{bolo} and $S_{bolo}err$
  - F_{beam} and $F_{beam}err$
  - T_{lag} and $T_{lag}err$
  - V and V_{err}
  - E and $E_{peak}err$
  - E and $E_{peak}err$
  - T_{RT} and $T_{RT}err$

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D_L calculation:-

- calculation of D_L is done for each GRB using the D_A and z relation obtained previously using Gaussian.

$$D_L = D_A \cdot (1+z)^2$$

L calculation:-

- calculation of L is done for each GRB

$$L = 4\pi (d_L)^2 P_{\text{bolo}}$$

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E_{ISO} calculation:-

- calculation of E_{ISO} is done for each GRB.

$$E_{\text{iso}} = \frac{4\pi(d_L)^2 s_{\text{bolo}}}{1+z}$$

E_r calculation:-

- calculation of E_r is done for each GRB

$$E_r = E_{\text{iso}} \cdot F_{\text{beam}}$$

Error Propagation

Error Propagation Derivation:-

- Error Propagation(Click here to see complete Error Propagation derivation)

- The general error propagation formula calculates the uncertainty (ΔQ) in a quantity Q that depends on several variables $x_1, x_2, \ldots, x_n$, each with their respective uncertainties ($\Delta x_1, \Delta x_2, \ldots, \Delta x_n$). The formula is given by:

$$\Delta Q = \sqrt{\left(\frac{\partial Q}{\partial x_1}\Delta x_1\right)^2 + \left(\frac{\partial Q}{\partial x_2}\Delta x_2\right)^2 + \ldots + \left(\frac{\partial Q}{\partial x_n}\Delta x_n\right)^2}$$

Here, $\frac{\partial Q}{\partial x_i}$ represents the partial derivatives of Q with respect to each variable x_i.

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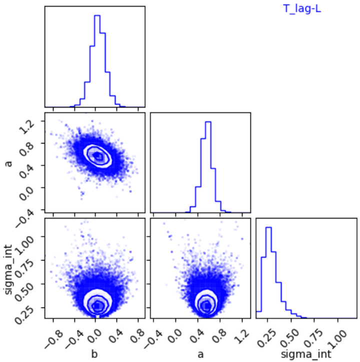
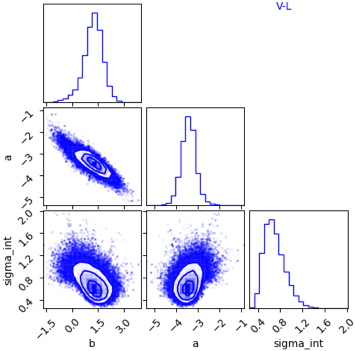
MCMC Analysis





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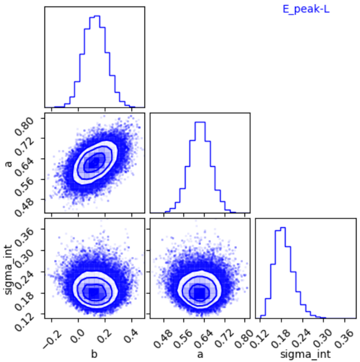

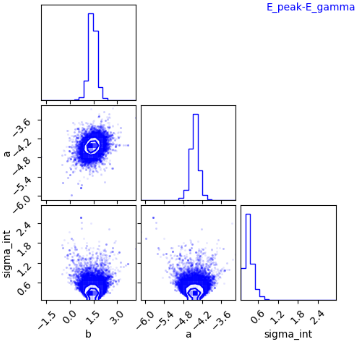

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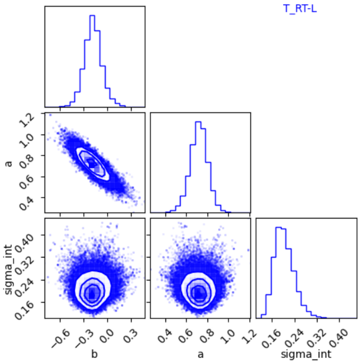

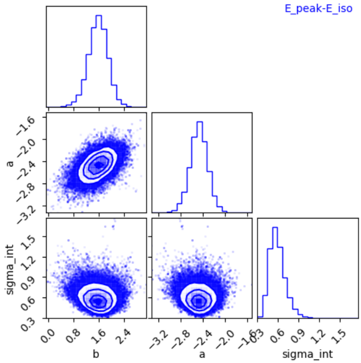

	a	a_err	b	b_err	sigma_int	sigma_int_err
('E_peak-E_gamma', 'GRB')	-4.44697	0.140672	1.43143	0.259921	0.335673	0.152011
('E_peak-E_iso', 'GRB')	-2.47432	0.161768	1.56583	0.317142	0.594658	0.120487
('E_peak-L', 'GRB')	0.623043	0.043082	0.126617	0.0854989	0.188655	0.0282104
('T_RT-L', 'GRB')	0.715671	0.0855066	-0.183487	0.114962	0.203865	0.0371049
('T_lag-L', 'GRB')	0.558511	0.106681	0.0473301	0.141298	0.300793	0.0884514
('V-L', 'GRB')	-3.42774	0.348096	1.20461	0.576007	0.701353	0.196112

Figure 4: Parameters values estimated using MCMC

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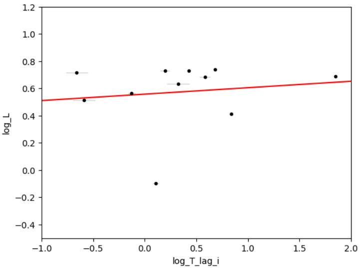
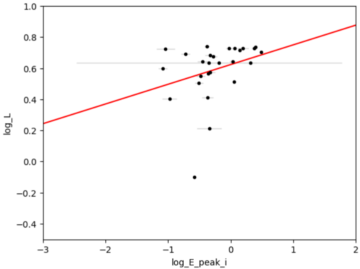
Regression relation





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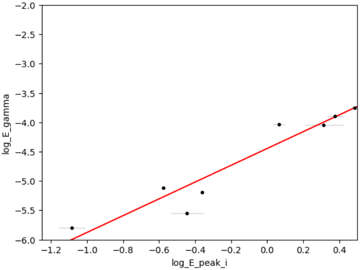

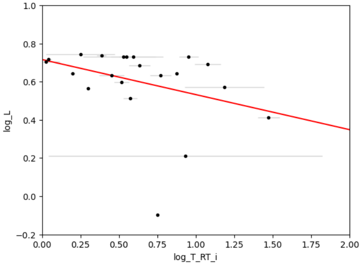

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