Astrostatistics: Sat 03 Mar 2017

https://github.com/CambridgeAstroStat/PartIII-Astrostatistics

- Lecture Demo Codes are online in directory lecture_codes/
- ExClass 3 TBC: Tue, 13 Mar, 4pm or **Thu, 15 Mar, 12pm**
- Last time: MCMC theory
- Today: MCMC in Practice
  - Tuning, Autocorrelation, G-R ratio, summarising posterior
- Begin Gaussian Processes in Astrophysics

Example Sheet 2, Problem 1

Generative Model:

$$\xi_i \sim N(\mu, \tau^2)$$

$$\eta_i|\xi_i \sim N(\alpha + \beta\xi_i, \sigma^2)$$

$$x_i|\xi_i \sim N(\xi_i, \sigma_x^2)$$

$$y_i|\eta_i \sim N(\eta_i, \sigma_y^2)$$

Likelihood function: $P(\boldsymbol{x}, \boldsymbol{y}|\, \alpha, \beta, \sigma^2, \mu, \tau^2) = \prod_{i=1}^{N} N(\boldsymbol{z}_i|\boldsymbol{\zeta}, \boldsymbol{V}_i)$

$$\boldsymbol{z}_i = \begin{pmatrix} y_i \\ z_i \end{pmatrix}$$

$$\boldsymbol{\zeta} = \begin{pmatrix} \alpha + \beta\mu \\ \mu \end{pmatrix}$$

$$\boldsymbol{V}_i = \begin{pmatrix} \beta^2\tau^2 + \sigma^2 + \sigma_{y,i}^2 & \beta\tau^2 \\ \beta\tau^2 & \tau^2 + \sigma_{x,i}^2 \end{pmatrix}$$

Example Sheet 2, Problem 1

"Noninformative Priors"

$$P(\sigma) \propto 1, \sigma > 0$$

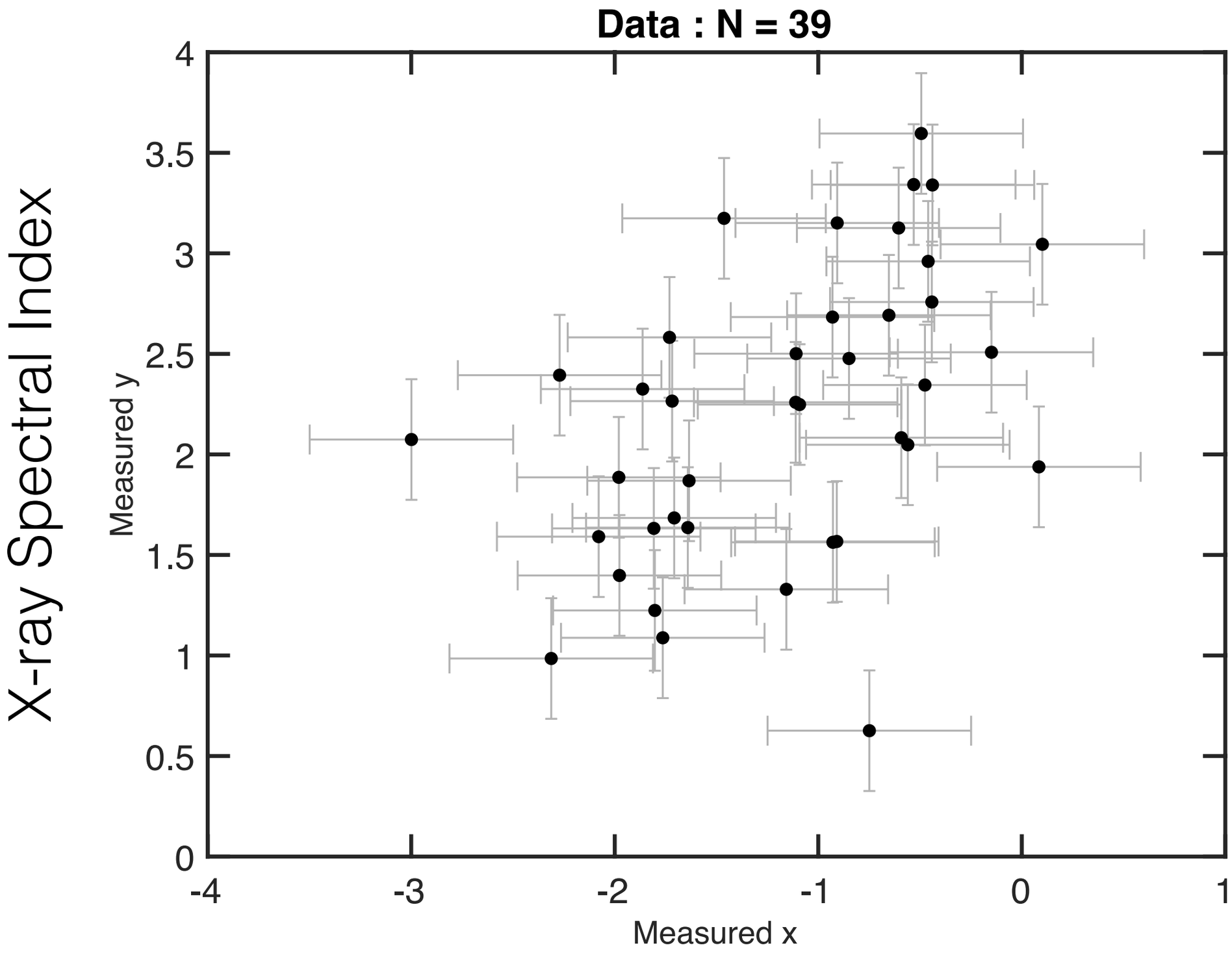
$$P(\alpha) = P(\beta) = P(\mu) \propto 1$$

$$P(\tau) \propto 1, \tau > 0$$

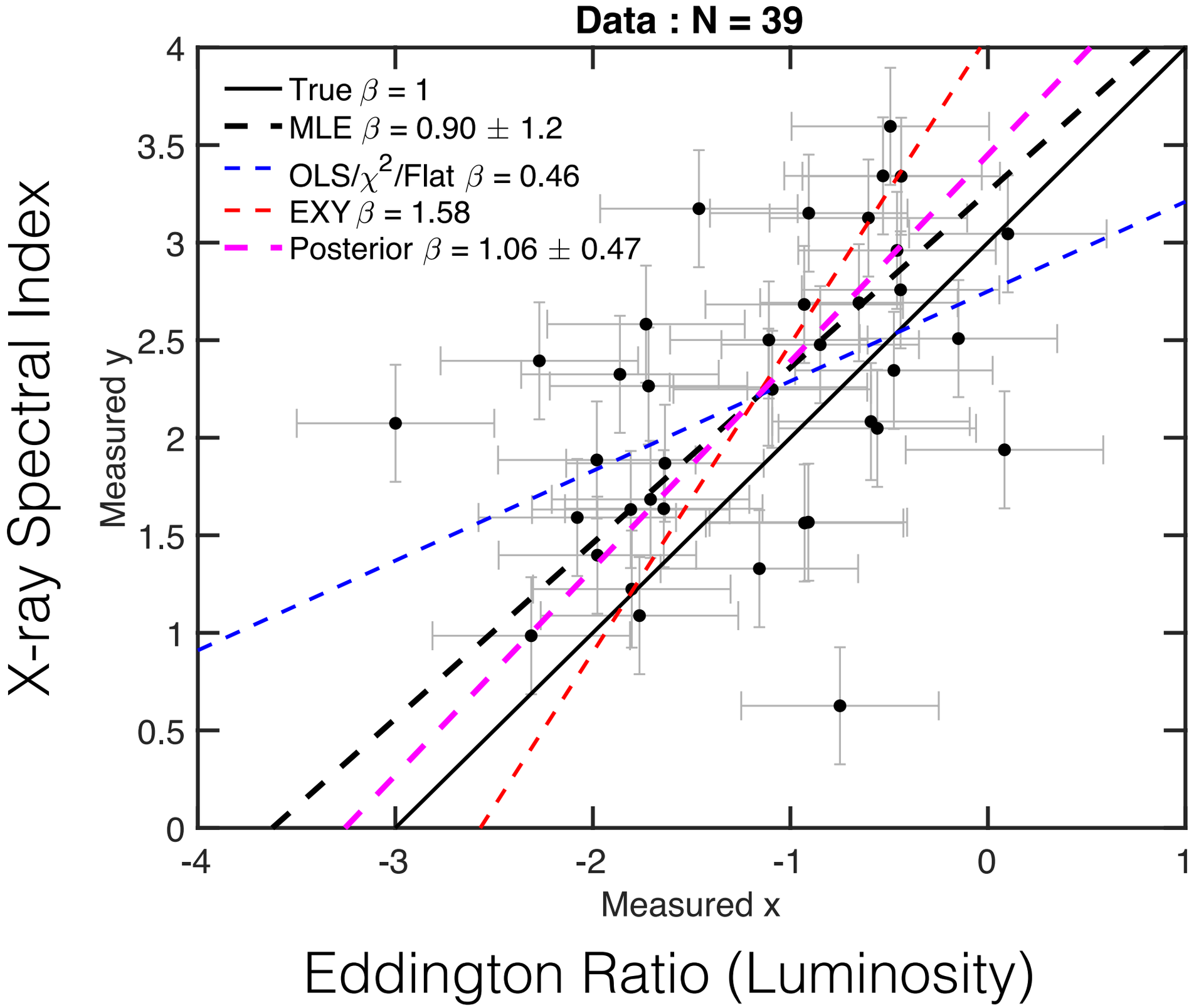
Posterior Probability Density:

$$P(\alpha, \beta, \sigma^2, \mu, \tau^2 | \boldsymbol{x}, \boldsymbol{y}) \propto P(\boldsymbol{x}, \boldsymbol{y} | \alpha, \beta, \sigma^2, \mu, \tau^2) P(\alpha, \beta, \sigma^2, \mu, \tau^2)$$

Example Sheet 2, Problem 1



Example Sheet 2, Solutions 1



Code Demo

Human Learning of Gaussian Processes

- Classic Text: Rasmussen & Williams (2006)
  - “Gaussian Processes for Machine Learning”,Ch 1-2,4-5
  - Free Online: http://www.gaussianprocess.org/gpml/
- Gelman, Bayesian Data Analysis 3rd Ed., Chapter 21
- Ivezic, Sec 8.10 GP Regression, (Ch 8 is Regression)
- Bishop: Pattern Recognition & Machine Learning, Ch 6
- “Practical Introduction to GPs for Astronomy” - D. Foreman-Mackey
  - http://hea-www.harvard.edu/AstroStat/aas231_2018/DForeman-Mackey_20180110_aas231.pdf