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A DEMO ON

TIME SERIES

LSST WORKSHOP - JUNE 20 MMXVIII

IN BRIEF...

- ▶ What we're going to do? Variability period estimation
- ▶ How? Through parametric and non-parametric methods (not autoregressive)
- ▶ Additionally, we're going to explore Gaussian Process Regression, and Cross Validation
- ▶ Afterwards, play with more data

AUTOCORRELATION FUNCTION

- ▶ Non-parametric estimator
- ▶ Works well with sparse data
- ▶ Fast and easy to implement
- ▶ Stable

$$\rho_k = \frac{\sum_{t=1}^{N-k} (x_t - \bar{x})(x_{t+k} - \bar{x})}{\sum_{t=1}^N (x_t - \bar{x})^2}$$

LOMB SCARGLE

- ▶ Generalization of FFT to sparse data (or Least Squares)
- ▶ Multiband option
- ▶ Fast and stable

$$P_{LS}(\nu) = \frac{1}{2\sigma^2} \left[\frac{(\sum_{i=1}^N x_i \cos(2\pi\nu t_i))^2}{\sum_{i=1}^N \cos^2(2\pi\nu(t_i - \tau(\nu)))} + \frac{(\sum_{i=1}^N x_i \sin(2\pi\nu t_i))^2}{\sum_{i=1}^N \sin^2(2\pi\nu(t_i - \tau(\nu)))} \right]$$

$$\tan(4\pi\nu\tau) = \frac{\sum_{i=1}^N \sin(4\pi\nu t_i)}{\sum_{i=1}^N \cos(4\pi\nu t_i)}$$

WAVELET

- ▶ Multi-scale analysis
- ▶ Good for non-stationary phenomena
- ▶ Dependent on mother wavelet
- ▶ Convolution with orthonormal basis function

$$W[x](\tau, s) = \frac{1}{\sqrt{s}} \int_{-\infty}^{\infty} x_t \Psi^* \left(\frac{t - \tau}{s} \right) dt$$

GAUSSIAN PROCESS REGRESSION

- ▶ Useful for construct flexible models
- ▶ Used as prior in Bayes
- ▶ Maximizes likelihood, maximizes covariance
- ▶ Distance-dependent process, easy to setup

CROSS VALIDATION

- ▶ How to train a model? (when we don't have data to give away)
- ▶ Useful to choose the right hyperparameters
- ▶ Helps detect stable solutions

REQUIREMENTS

- ▶ If running locally, first get the Github repo. On a terminal type:
`git clone https://github.com/paztronomer/time_series_demo.git`
- ▶ Then, you should also have the following (5) packages
numpy, pandas, matplotlib, scipy
 - statsmodels: `pip install -U statsmodels` ||
`conda install -c conda-forge statsmodels`
 - sklearn: `pip install -U scikit-learn` || `conda install scikit-learn`
 - gatspy: `pip install gatspy`
 - pywt: `pip install PyWavelets` || `conda install pywavelets`
 - vaex: `pip install --pre vaex` || `conda install -c conda-forge vaex`