A Few Comments on Time Series Representations

Jeff Scargle

Parametric vs. Non-Parametric

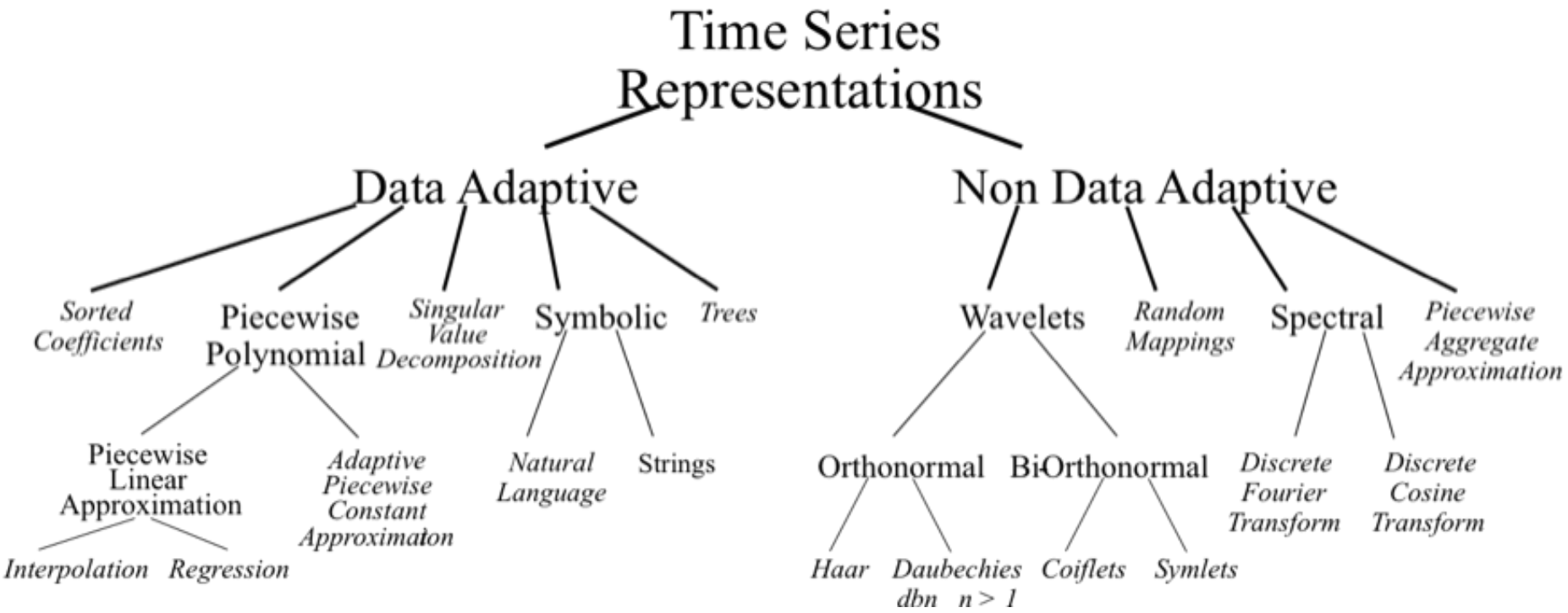
Classification

Symbolic Aggregate approXimation (SAX)
Eamonn Keogh and Jessica Lin in 2002
http://www.cs.ucr.edu/~eamonn/SAX.htm

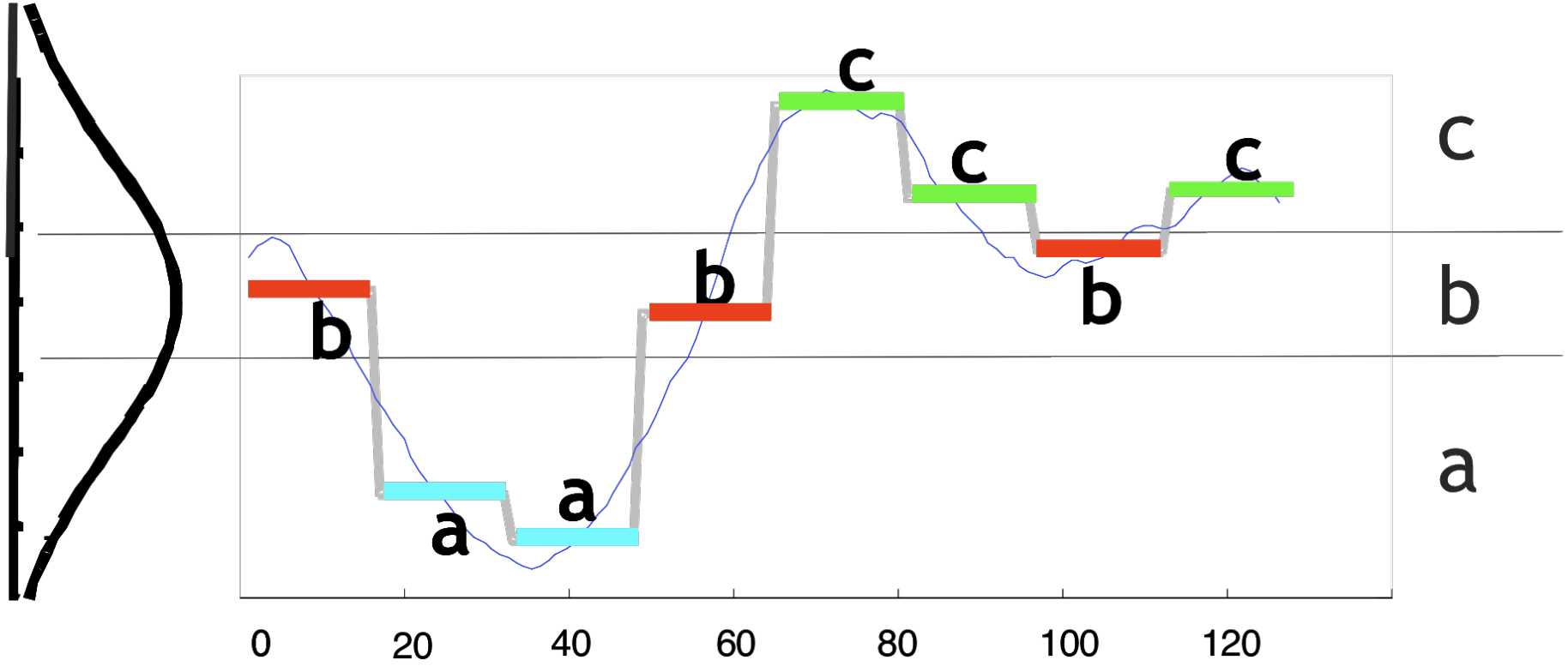
indexable Symbolic Aggregate approXimation (iSAX)
iSAX: Indexing and Mining Terabyte Sized Time Series, by Jin Shieh and Eamonn Keogh
http://www.cs.ucr.edu/~eamonn/iSAX/iSAX.html

Dynamical Systems

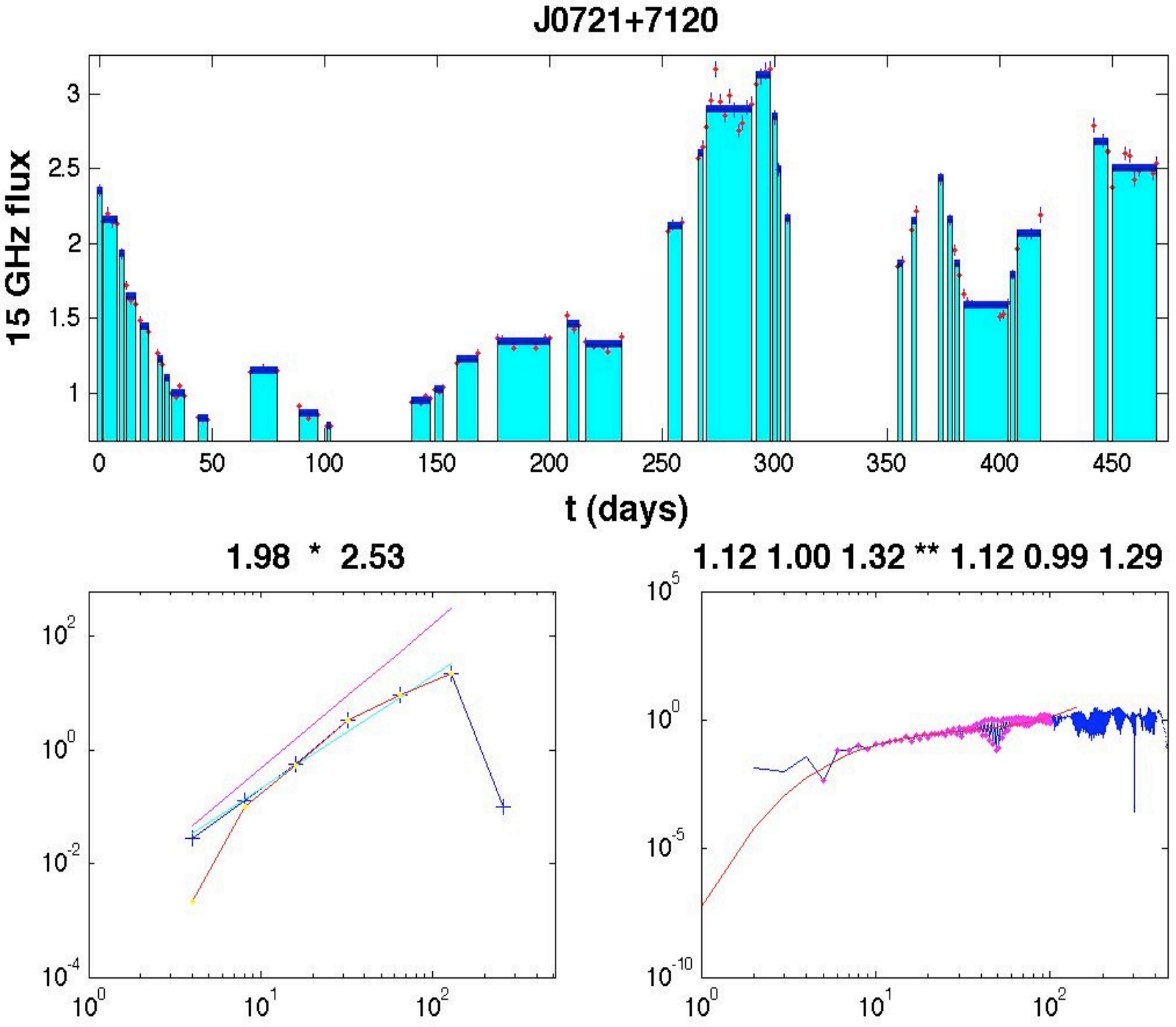
Symbolic Dynamics
Dynamics of Learning
Learning Dynamics (from time series)
http://tuvalu.santafe.edu/~cmg/compmech/pubs.htm


Time Series Representations
Data Adaptive
Non Data Adaptive
Sorted Coefficients
Piecewise Polynomial
Singular Value Decomposition
Symbolic
Trees
Wavelets
Random Mappings
Spectral
Piecewise Aggregate Approximation
Piecewise Linear Approximation
Adaptive Piecewise Constant Approximaton
Natural Language
Strings
Orthonormal
BiOrthonormal
Discrete Fourier Transform
Discrete Cosine Transform
Interpolation
Regression
Haar
Daubechies dbn n > 1
Coiflets
Symlets

http://www.cs.ucr.edu/~eamonn/SAX.htm
Eamonn Keogh and Jessica Lin in 2002



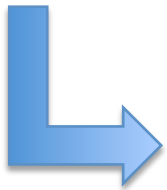
A time series is discretized by first obtaining a piecewise aggregate approximation (PAA) and then using predetermined breakpoints to map the PAA coefficients into Symbolic Aggregate approXimation (SAX) symbols. In the above example, with n = 128, w = 8 and a=3, the time series is mapped to the word baabccbc.


J0721+7120
15 GHz flux
t (days)
1.98 * 2.53
1.12 1.00 1.32 ** 1.12 0.99 1.29

Backup slides

Data Mode

- Photon events
- Time-to-Spill
- Counts in bins
- Flux measurements
- Any Mode/Sampling!



Universal Time Series Analysis Machine

Auto-

- Correlation Function
- Fourier Power Spectrum
- Fourier Phase Spectrum
- Wavelet scalgram
- Wavelet scaleogram
- Structure Function
- Time-Frequency Distribution
- Time-Scale Distribution
- …

Extension of Edelson & Krolik Algorithm for Correlation Function of Unevenly Sampled Data

Jeff Scargle

Data Mode

- Photon events
- Time-to-Spill
- Counts in bins
- Flux measurements
- Any Mode/Sampling!

- Photon events
- Time-to-Spill
- Counts in bins
- Flux measurements
- Any Mode/Sampling!

Universal Time Series Analysis Machine

Extension of Edelson & Krolik Algorithm for Correlation Function of Unevenly Sampled Data

Cross-

- Correlation Function
- Fourier Power Spectrum
- Fourier Phase Spectrum
- Wavelet scalgram
- Wavelet scaleogram
- Structure Function
- Time-Frequency Distribution
- Time-Scale Distribution
- …

Jeff Scargle

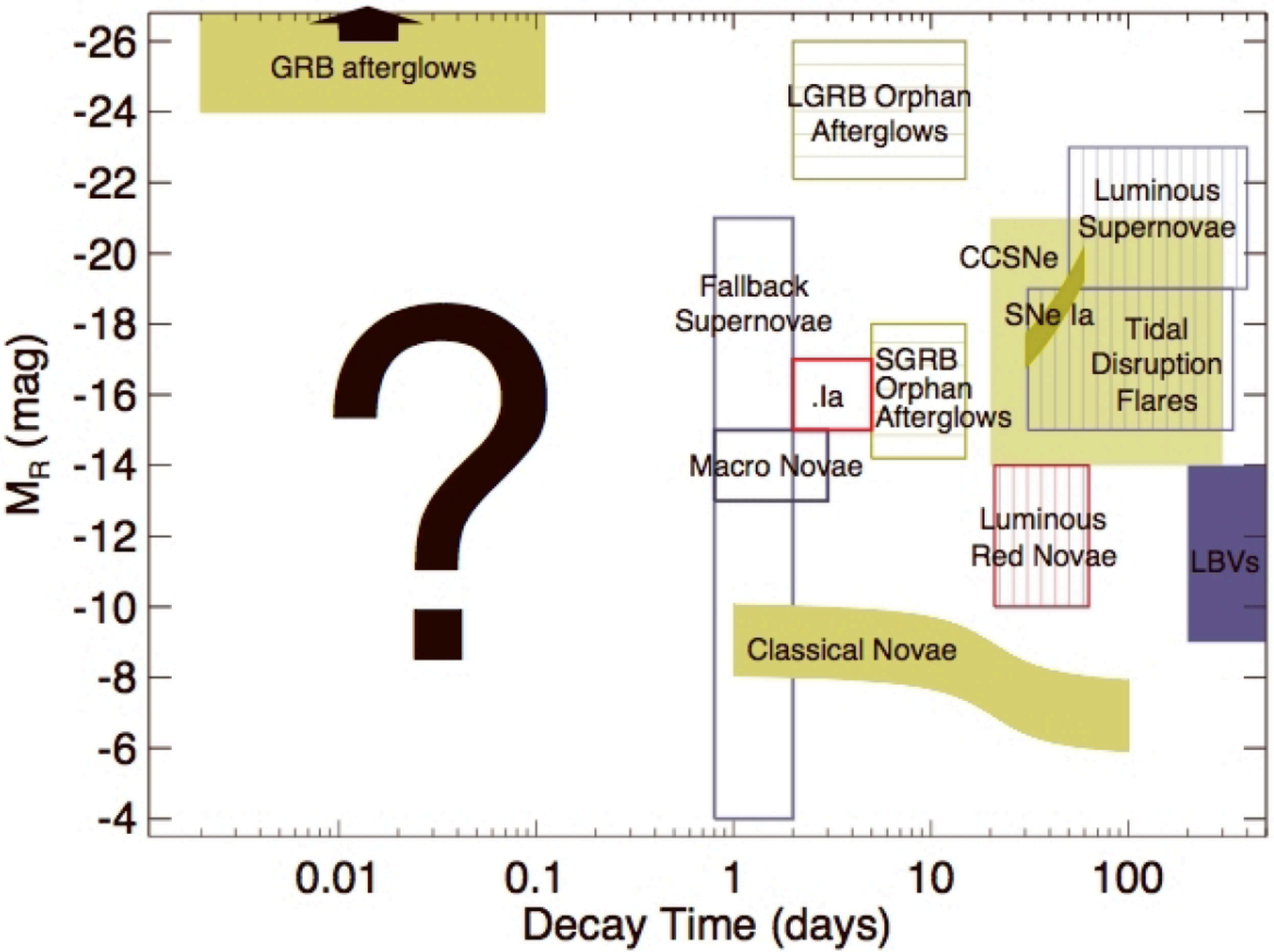
Time-Frequency/Time-Scale Analysis

Transform to a new view of the time series information.

- A Reality in joint time & frequency (or scale) representation
- Atomic decomposition
  - Time-frequency atoms
  - Over-complete representations
  - Optimal Basis Pursuit (Mallat), etc.
- Uncertainty Principle: T-F resolution tradeoff
- Non-stationary processes
  - Flares
  - Trends and Modulations
  - Statistical change-points
- Instantaneous Frequency
- Local vs. Global structure
- Interference (cross-terms in bi-linear representation)

Time-Frequency/Time-Scale Analysis (Temps-Fréquence) Patrick Flandrin http://perso.ens-lyon.fr/patrick.flandrin/publis.html; A Wavelet tour of Signal Processing (Une Exploration des Signaux en Ondelettes) Stéphane Mallat

Function	Domain	Range	Auto-	Cross-	Physical Interp
Bayesian blk. Light Curve	Time	Flux	✔	✔ multivar. BB	Flares, events etc.
Scatter Plot	Flux 1	Flux 2		✔	Dependency (not just cor.)
Correlation	Lag	$<X^2>$ <XY>	✔	✔	Correlated behavior/lags
Spectrum	Frequency	Power	✔	✔	Periodicity 1/f noise …
		Phase	✔	✔	Shifts, lags
Structure	Lag	$<X^2>$ <XY>	✔	✔	Correlated behavior/lags
Scalogram	Scale/Time	Power	✔	✔	Dynamic behavior
Scalegram	Scale	Power	✔	✔	1/f noise QPOs
Distribution	Time/scale/ frequency	Power	✔	✔	Dynamic behavior


GRB afterglows
LGRB Orphan Afterglows
Luminous Supernovae
CCSNe
Fallback Supernovae
SNe Ia
Tidal Disruption Flares
SGRB Orphan Afterglows
.Ia
Macro Novae
Luminous Red Novae
LBVs
Classical Novae
?
-26
-24
-22
-20
-18
-16
-14
-12
-10
-8
-6
-4
M_R (mag)
0.01
0.1
1
10
100
Decay Time (days)