Stellar Lighthouses: Characterizing and Detecting Non-Astrophysical Sources of Stellar Variability in Time Domain Surveys

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The Idea:
ET may Signal by Perturbing a Variable Star

The Cepheid galactic internet

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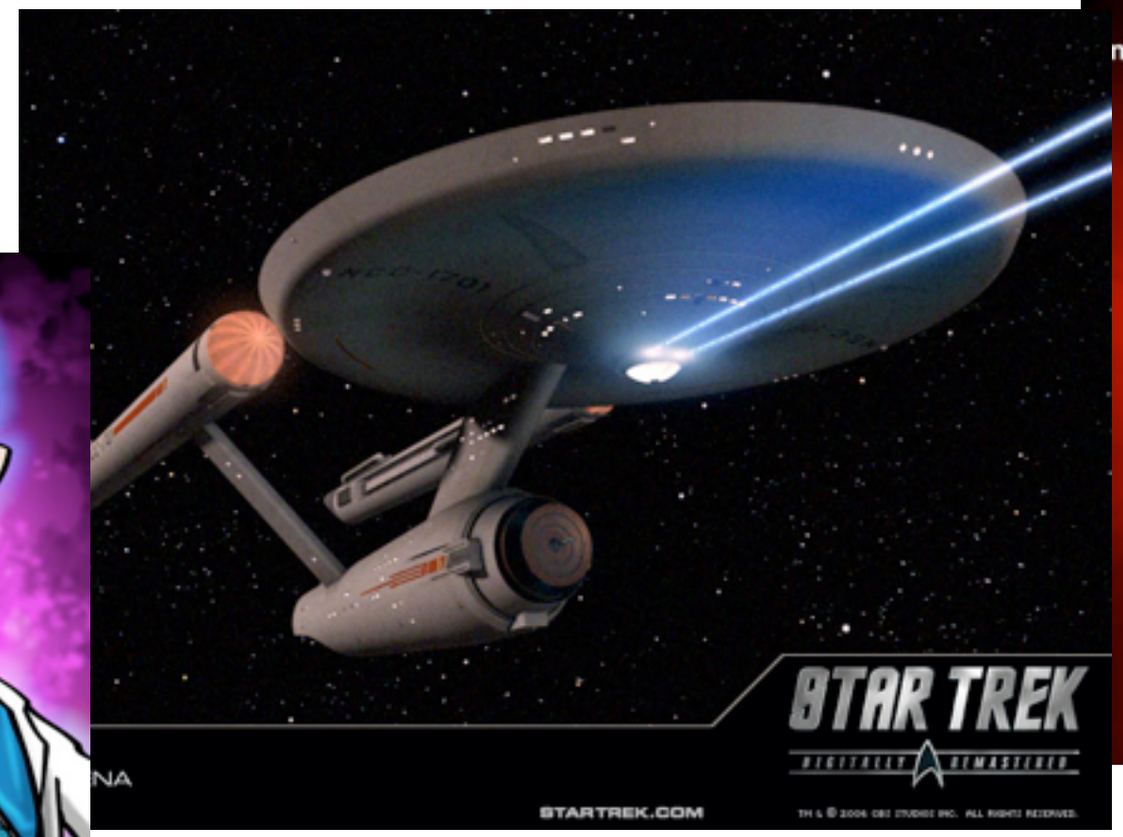
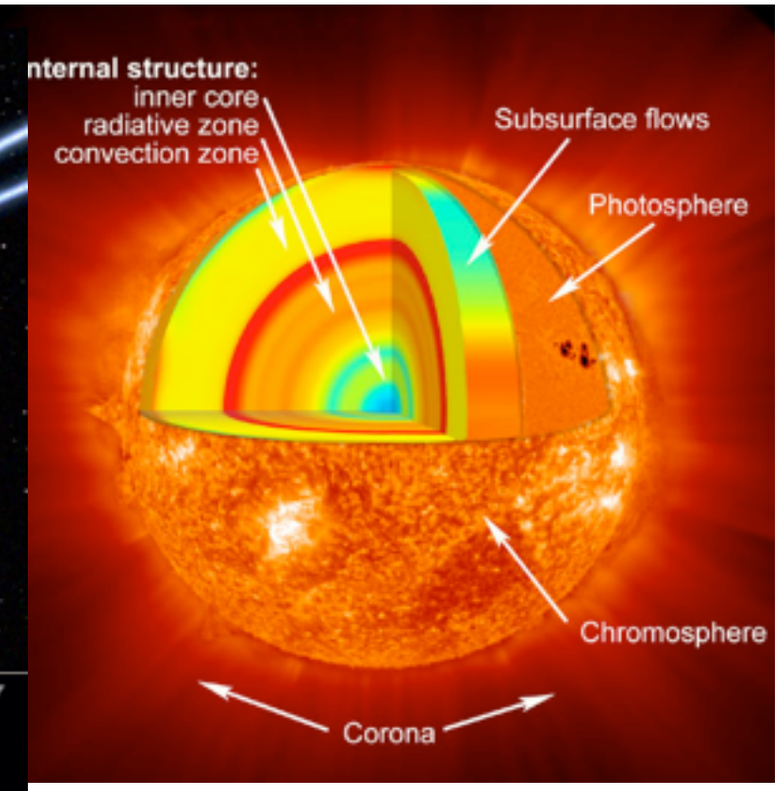
We propose that a sufficiently advanced civilisation may employ Cepheid variable stars as beacons to transmit all-call information throughout the galaxy and beyond. They might employ a pulsed neutrino beam to trigger the expansion of a Cepheid at an earlier than normal time, generating a binary signature of normal period or artificially shortened period. One can construct many scenarios wherein it would be desirable for such a civilisation of star ticklers to transmit data to anyone else within viewing range. The beauty of employing Cepheids is that these stars can be seen from afar (we monitor them out through the Virgo cluster), and any developing technological society would seem to be likely to closely observe them as distance markers. Records exist of Cepheids for well over 100 years. We propose that these (and other regularly variable types of stars) be searched for signs of phase modulation (in the regime of short pulse duration) and patterns, which could be indicative of intentional signalling.

Keywords: Cepheids; phase modulation; patterns; intentional signalling

A neutrino beam is a good way to perturb the marginally unstable core of a variable star -- but may not be the most efficient choice overall.

These cartoons convey the basic idea of tapping the radiant output of a star to send a message, thus solving the problem of producing a hugely powerful signal.





The Kepler Data:

168,418 Quarter14 light curves

Carry out Automated Time Series Analysis:

Bayesian Blocks (time domain)

Fourier Transform Power Spectrum
(based on Edelson and Krolik ACF)

Other Statistical Measures

Data Mode

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

any combination

- 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 Distribut
- Time-Scale Distribution
- …

Jeff Scargle

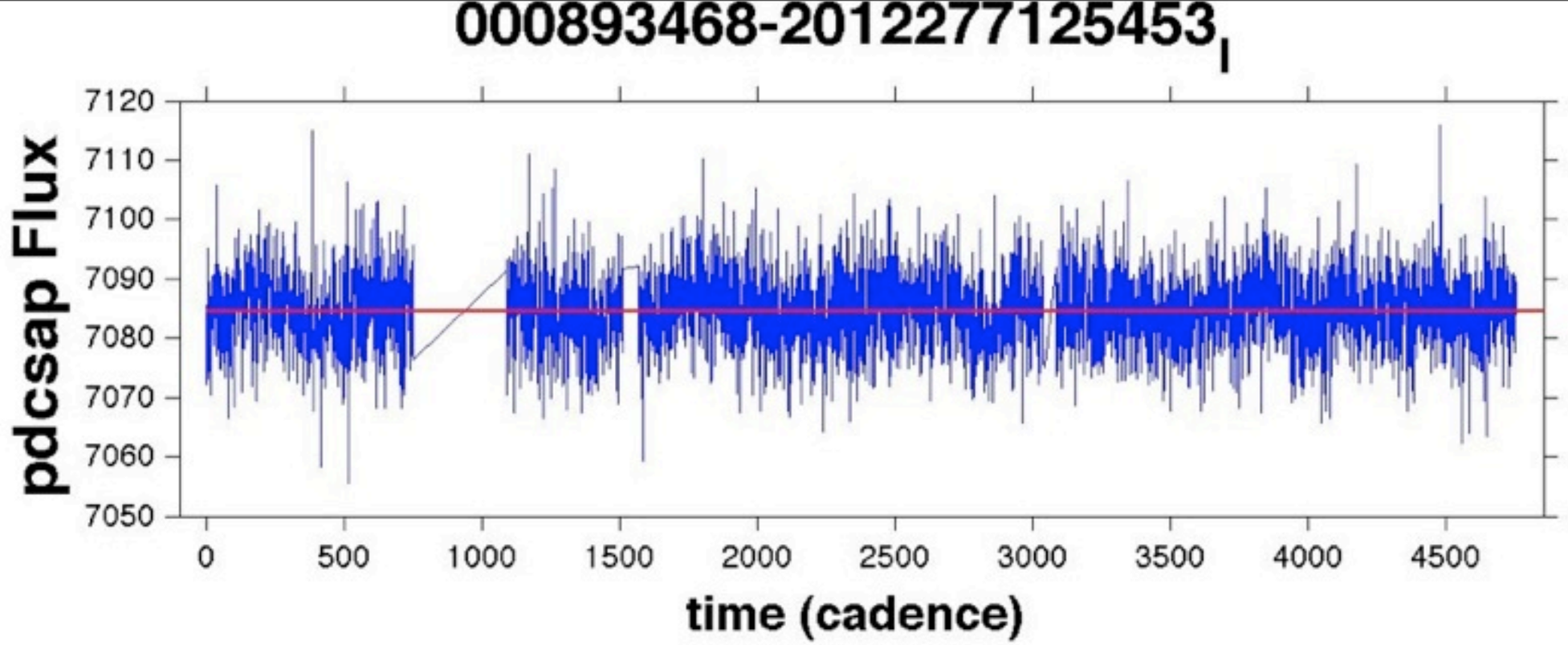
Function	Domain	Range	Auto-	Cross-	Physical Interp
Bayesian blk. Light Curve	Time	Flux	✔	✔ multivar. BB	Flares, events etc.
Scatter Plot	Flux 1	Flux 2		✔	Dependency (not just cor.)
Correlation	Lag	$<X^2>$ $<XY>$	✔	✔	Correlated behavior/lags
Spectrum	Frequency	Power	✔	✔	Periodicity 1/f noise …
		Phase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

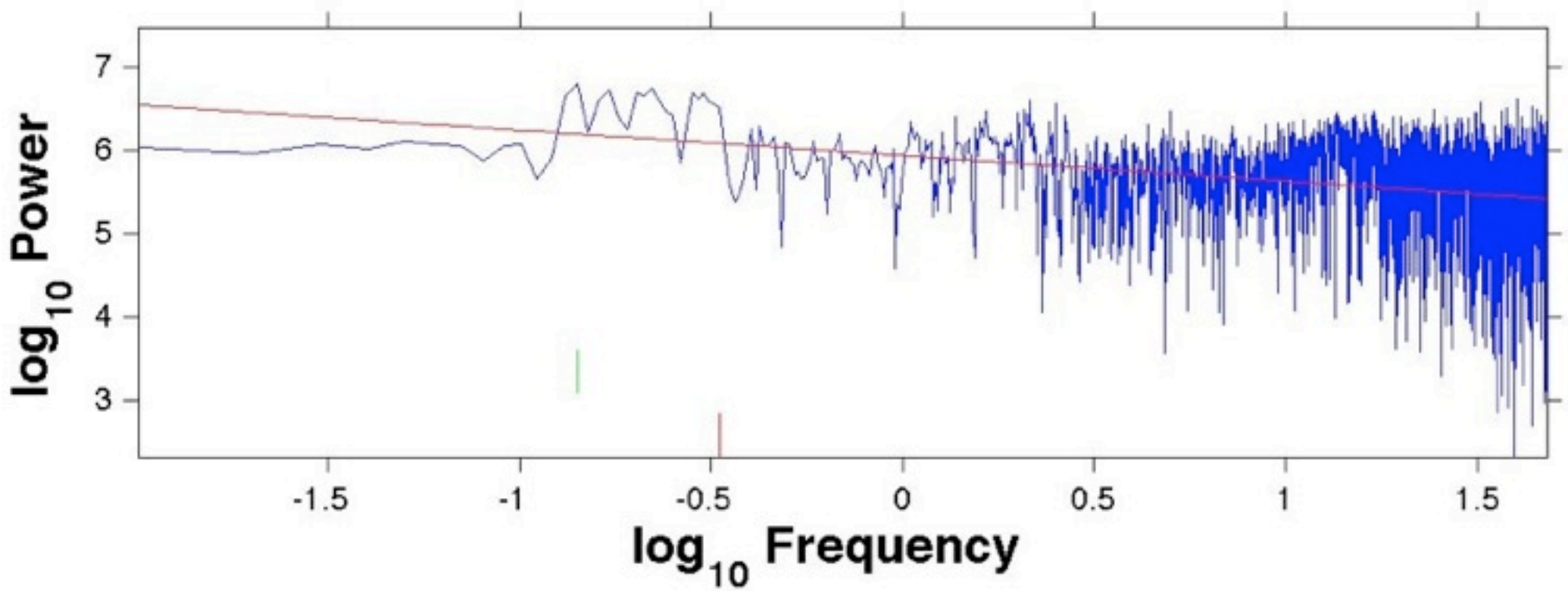
The Analysis:

(A) Bayesian Blocks
(B) Power Spectrum
- Linear Detrend
- Interpolation to Even Spacing
- Fourier Transform

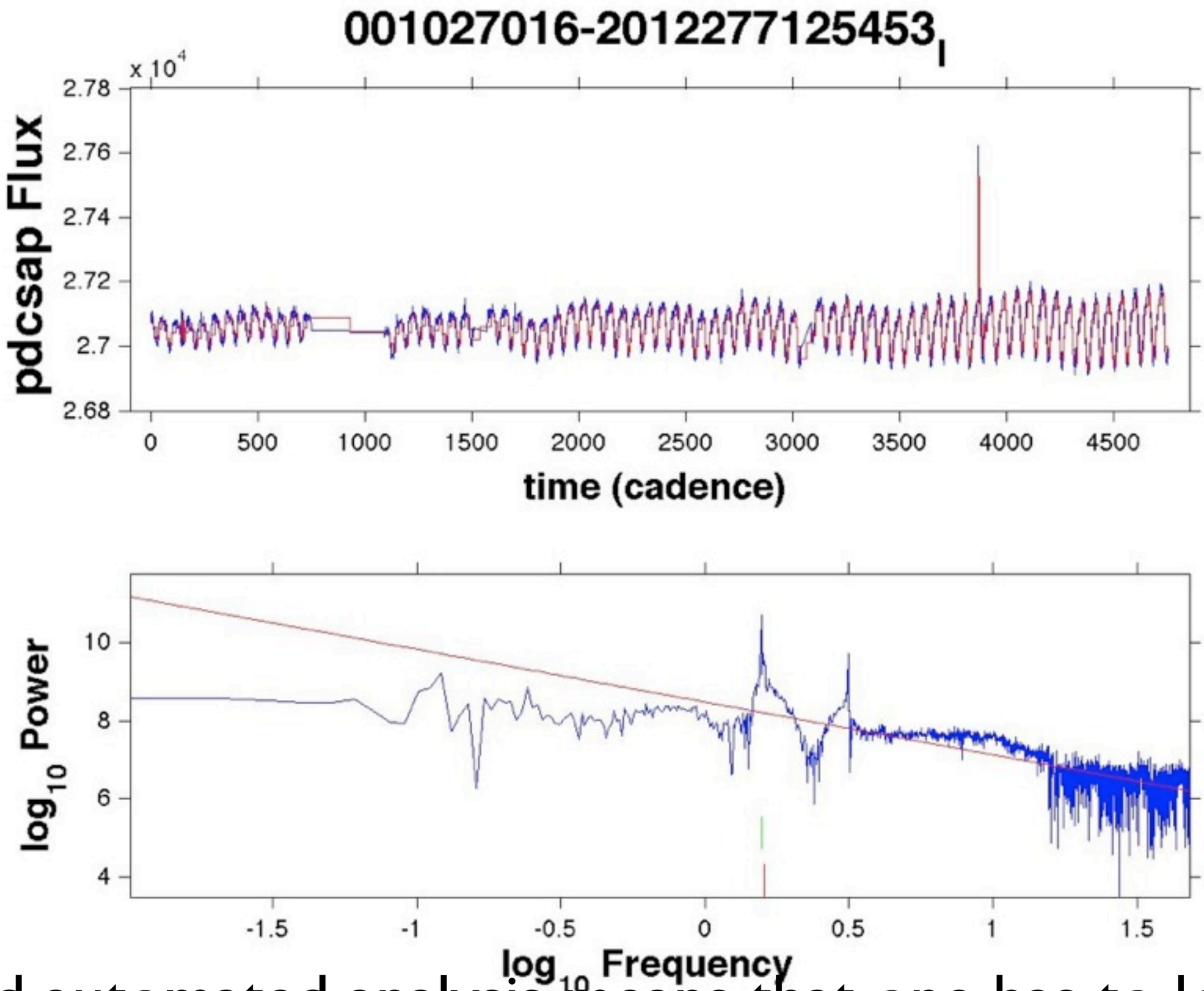
Derived Parameters:

(1)	Slope of 1/f component of spectrum	(B)
(2)	Number of change points	(A)
(3)	Peak frequency	(B)
(4)	Number of peaks	(A)
(5)	Average period (intervals between peaks)	(A)
(6)	Standard deviation of (5)	(A)
(7)	Total variation	(A)
(8)	dF/dt	(A)
(9)	max(Flux) / min(Flux)	
(10)	Peak amplituder / Continuum amplitude	(B)

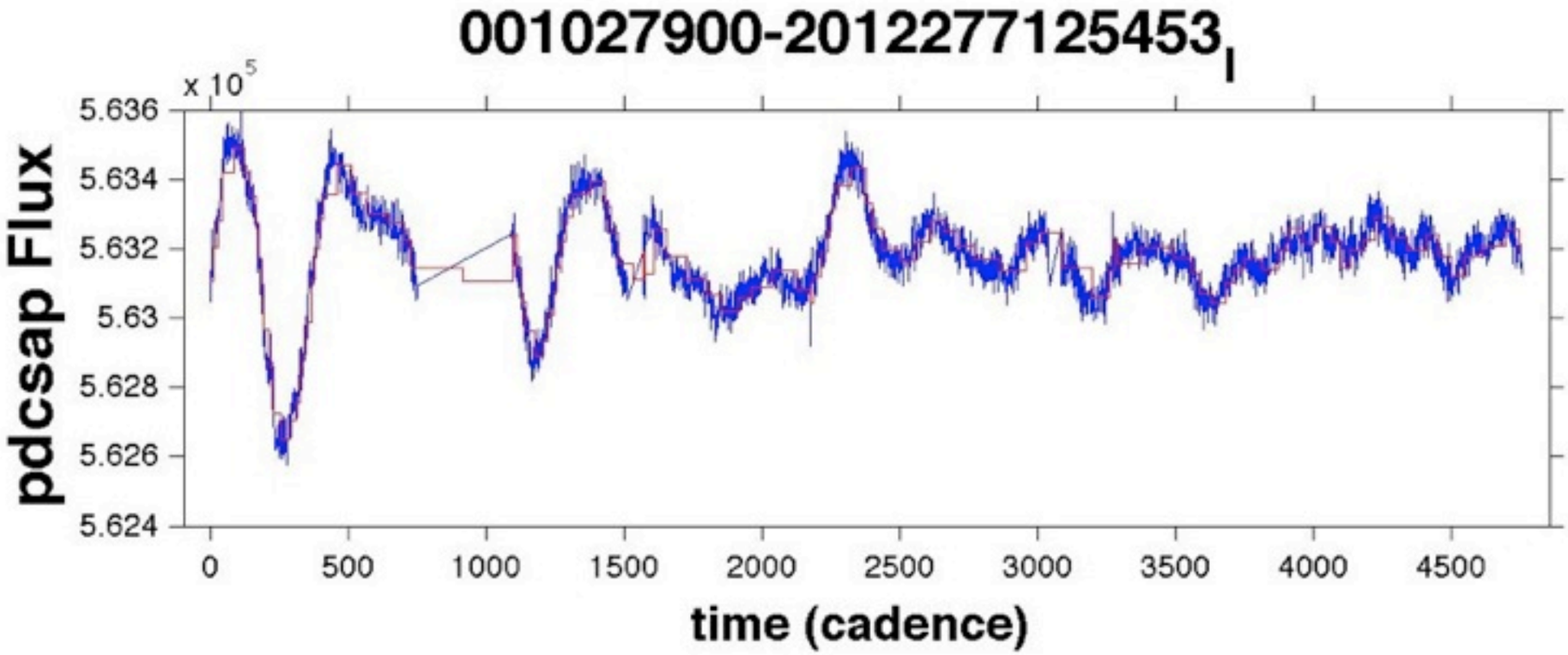


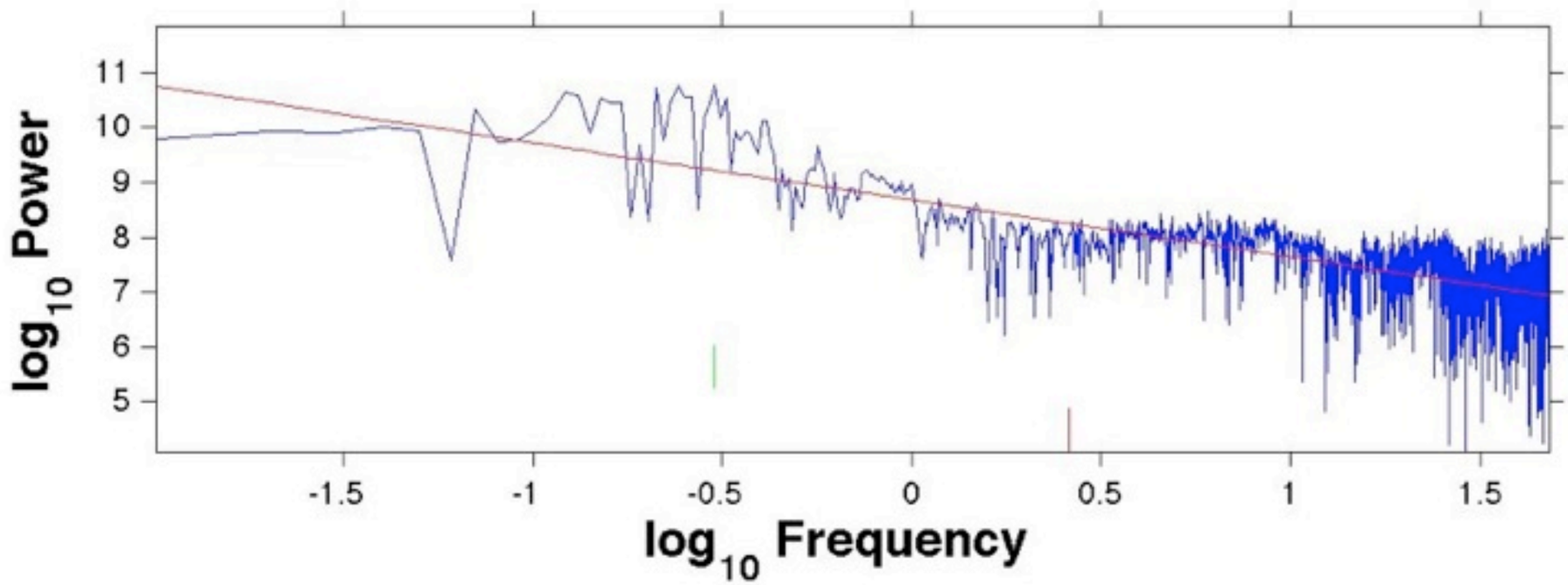


Blind automated analysis means that one has to look at a few selected results -- as a reality check. Here is a non-variable case.

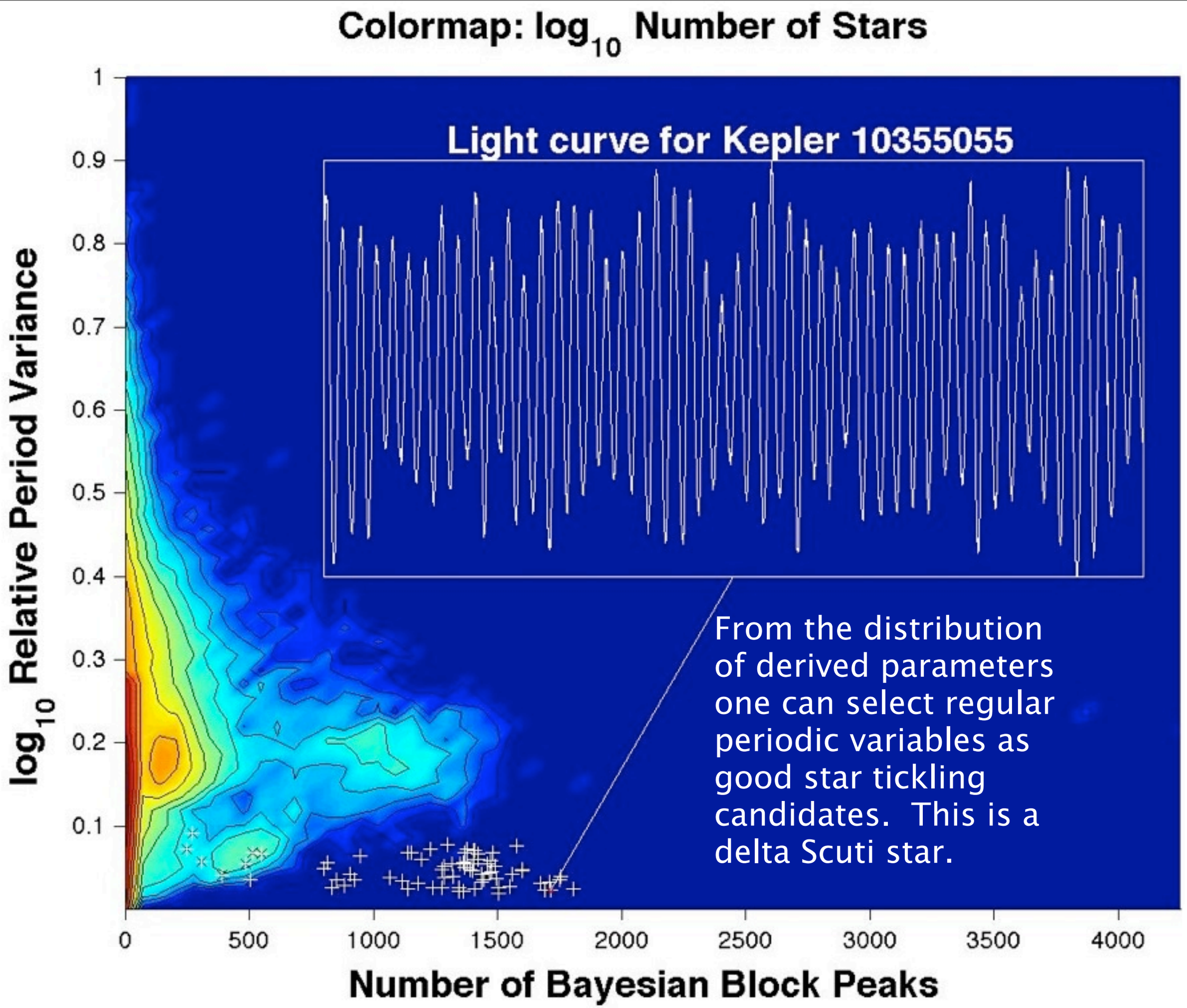


Blind automated analysis means that one has to look at a few selected results -- as a reality check. Here is a periodic case.



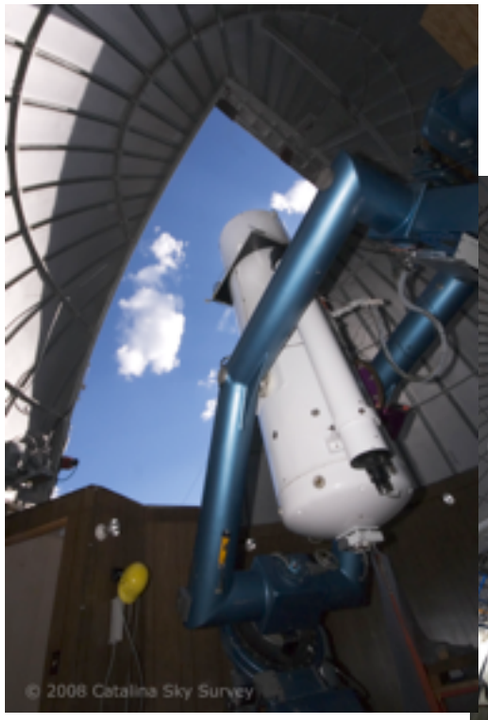


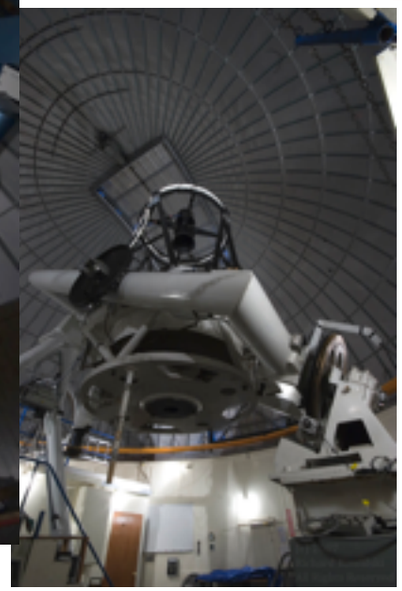
Interesting variability!


Colormap: log10 Number of Stars
Light curve for Kepler 10355055
log10 Relative Period Variance
Number of Bayesian Block Peaks
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
500
1000
1500
2000
2500
3000
3500
4000
From the distribution of derived parameters one can select regular periodic variables as good star tickling candidates. This is a delta Scuti star.

Time Series Analysis in

The Age of Digital Astronomy



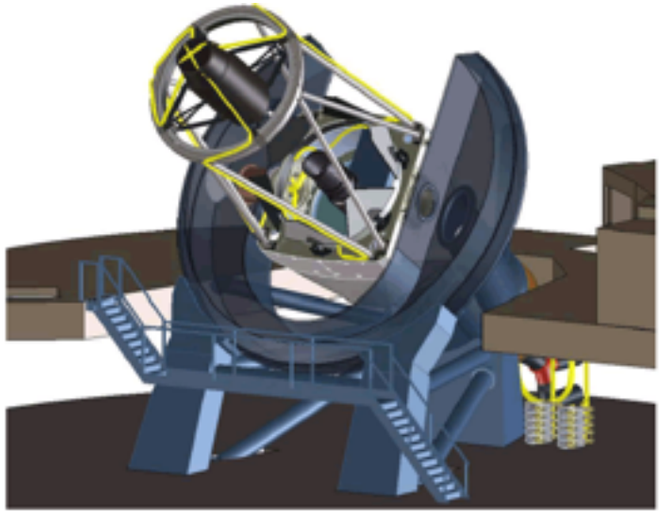


Catalina Transient Survey

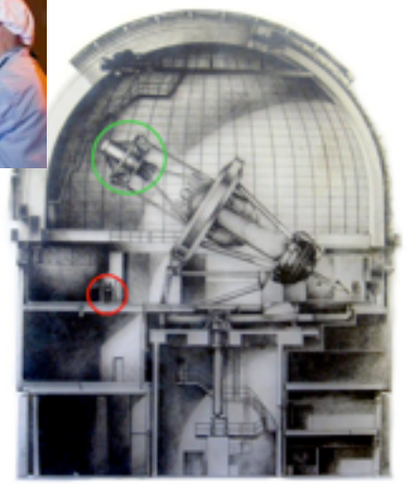
Panoramic Survey Telescope & Rapid Response System

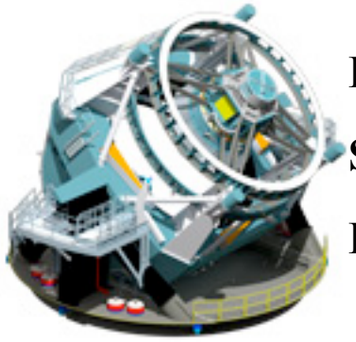
Palomar Transient Factory

Sloan Digital Sky Survey



Dark Energy Survey





Large Scale Synoptic Survey LSST

BigBOSS: Baryon Acoustic Oscillation Experiment