



# The NASA Star and Exoplanet Database (NStED) Periodogram Service

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# Overview

- Looking for planets using time series data
  - Radial velocity
  - Transit detection
- Extracting periodic signals
- Periodograms at NStED



# Looking for planets: Radial Velocity

- “Wobbles” in the radial velocity measurements over time can indicate a planet
  - <http://www.howstuffworks.com/planet-hunting2.htm>
- Most of the known extra-solar planets were detected with this method



# Looking for planets: Transits

- Periodic dip in intensity of a star
  - May occur when a planet passes (“transits”) in front of the star
  - [http://en.wikipedia.org/wiki/File:Planetary\\_transit.svg](http://en.wikipedia.org/wiki/File:Planetary_transit.svg)
- Many surveys for transiting planets
  - Space Missions: Kepler, CoRoT
  - Ground-based Transit Search Programs: TReS, HAtNet, XO, ...
  - 200,000 light curves at NStED



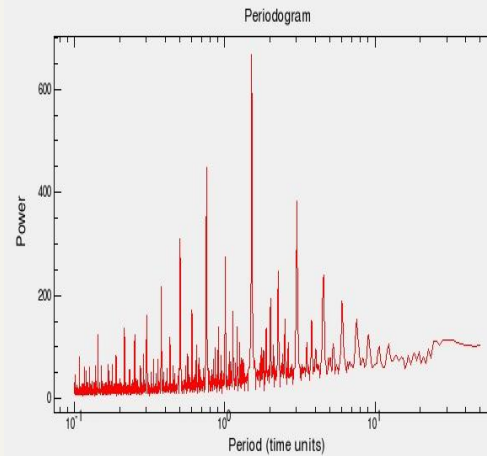
# Extracting periodic signals

- In both cases, looking for repeating variations over time
- Apply transform techniques to calculate the significance of different periods
  - Note that with astronomical data, we cannot assume even time-sampling
- Plot of power at each period called a “Periodogram”

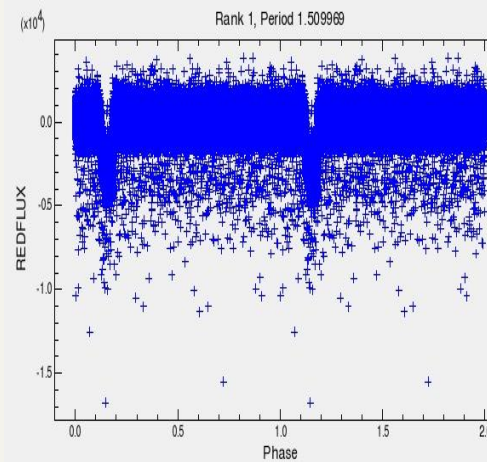


# Periodograms at NStED

- Algorithms
- Examples
- Implementation
- Performance
- Release Plan



*Periodogram for CoRoT-1.*



*Phased Light Curve for CoRoT-1 showing the transiting exoplanet signal*

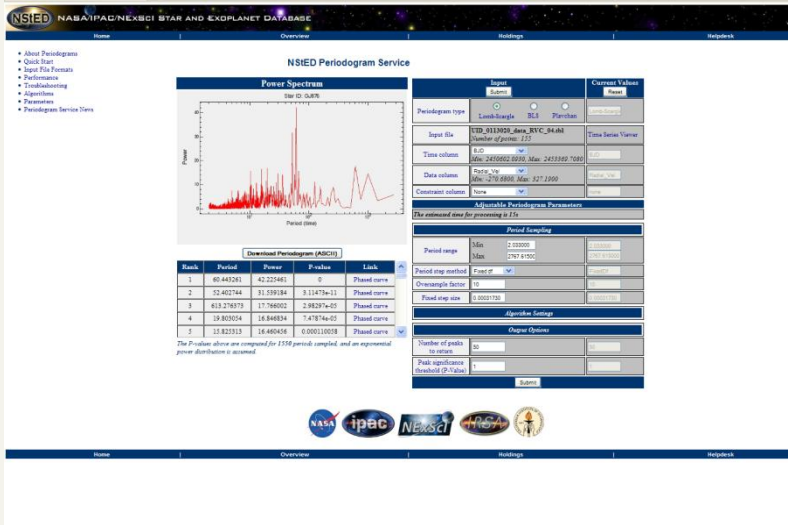


# Periodograms at NStED: Algorithms

- Lomb-Scargle
  - Approximation of Fourier transform for unevenly sampled data, so best for sinusoidal variations (e.g. radial velocity)
  - [Horne and Baliunas, Ap J, 302,757 \(1986\)](#); [Scargle, Ap J, 263,835 \(1982\)](#)
- Box-fitting Least Squares
  - Optimized for "box"-like signals (e.g. transiting planets)
  - [Kovacs, Zucker, and Mazeh, A&A, 391, 377 \(2002\)](#)
- Plavchan
  - Binless phase-dispersion minimization algorithm that identifies periods with coherent phased light curves (i.e., least “dispersed”) regardless of signal shape
  - [Plavchan, Jura, Kirkpatrick, Cutri, and Gallagher. ApJS, 175,19 \(2008\)](#)



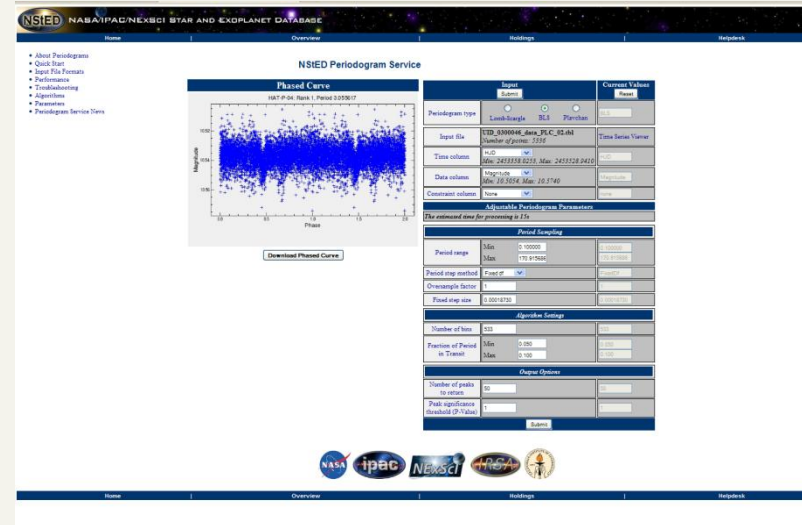
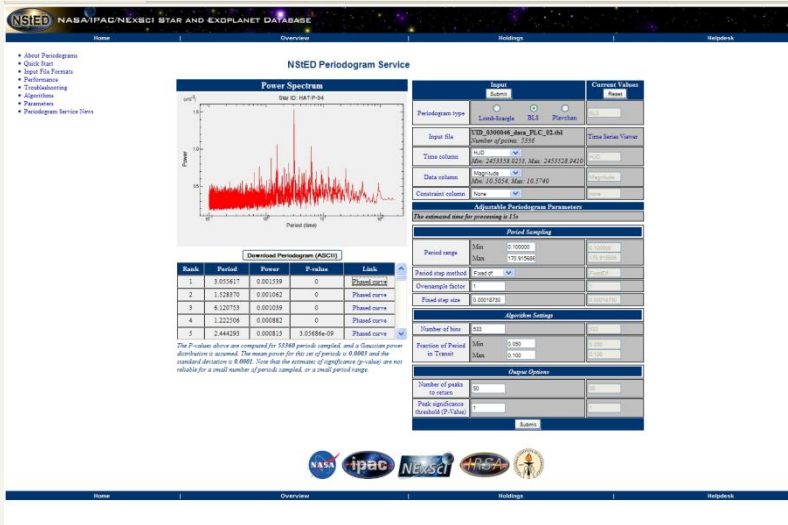
# Periodograms at NStED: Example 1



Periodogram and phased curve for GJ 876 radial velocity curve



# Periodograms at NStED: Example 2



Periodogram and phased curve for HAT-P-4 light curve

# Periodograms at NStED: Implementation

- Written in C
- Parallelized on 128-processor cluster of Dell 1950 servers
  - Processing of each period in output space is independent of all others
  - Front end divides jobs into sets of periods, distributes to processors on the cluster, combines results when complete
  - Performance improvement approximately 100x relative to serial processing



# Periodograms at NStED: Performance

Data Points	Approximate Run Time (one processor)			Periods Sampled
	L-S	BLS	Plavchan	
1,000	2 s	0.5 s	3 s	10,000
10,000	20 s	12 s	36 s	10,000
10,000	3.5 m	2 m	6 m	100,000
420,000	9 h	4 h	41 h	420,000

- Processing time with L-S algorithm for a 422,952-point CoRoT light curve reduced from ~560m on a single processor to under 5m on the cluster



# Periodograms at NStED: Release Plan

Release	Date	Service
1	6/18/10	Web interface to Kepler light curves
2	8/15/10	a. Program Interface to CoRoT light curves b. Web interface to transit data sets at NStED
3	11/1/10	Bulk processing service



# Summary

- Tool for rapidly finding periods in time series
- Undergoing final testing and validation
- Releases planned during Summer and Fall







# Questions?



# Thanks!

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