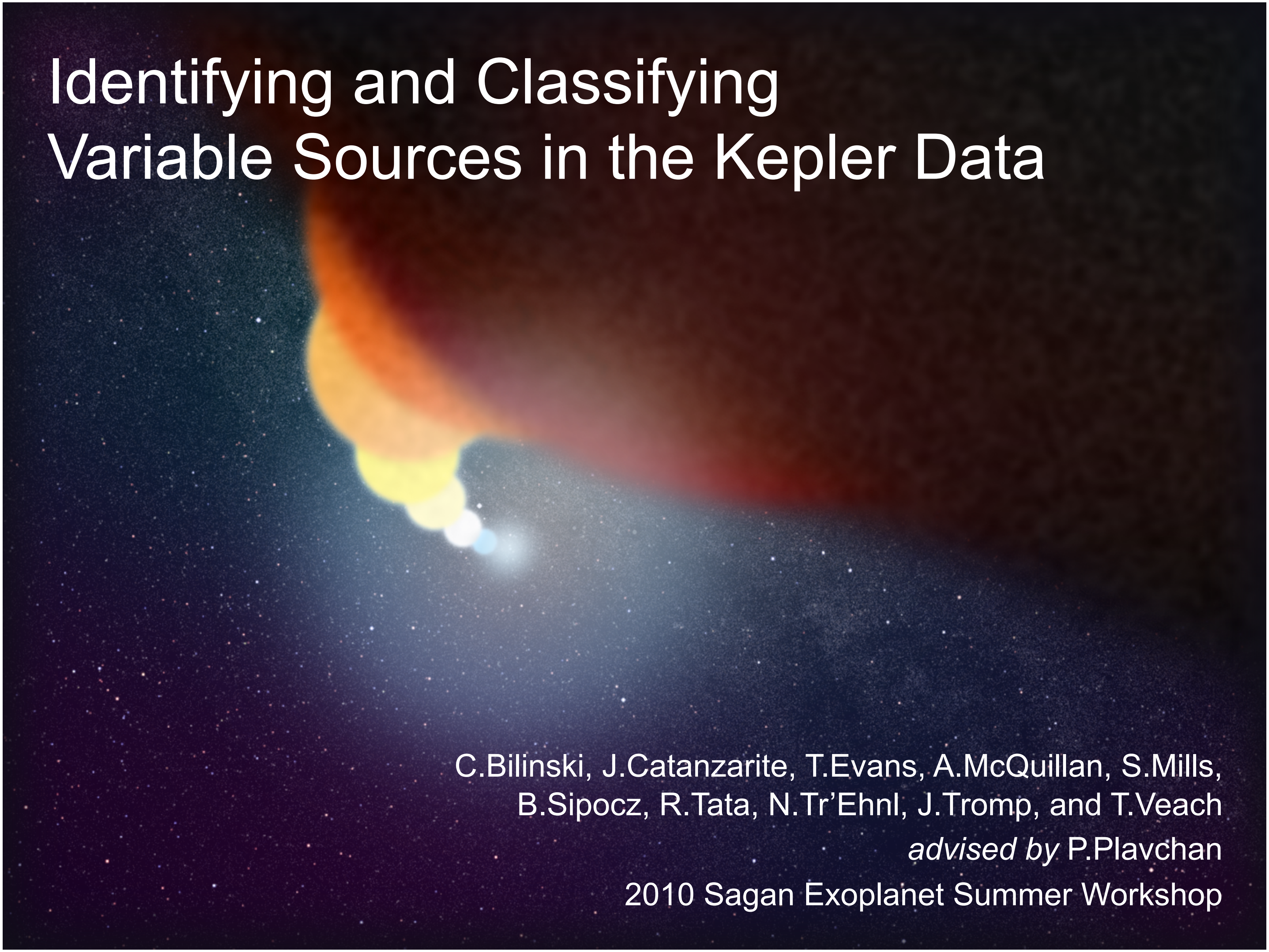
Identifying and Classifying
Variable Sources in the Kepler Data
C.Bilinski, J.Catanzarite, T.Evans, A.McQuillan, S.Mills,
B.Sipocz, R.Tata, N.Tr'Ehnl, J.Tromp, and T.Veach
advised by P.Plavchan
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Identifying and Classifying Variable Sources in the Kepler Data

Outline

Introduction/Objectives

M-dwarfs and Cepheid Variables

- Target Selection
- Variability
- Statistics and Correlations, Examples

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Identifying and Classifying Variable Sources in the Kepler Data

Introduction / Objectives

Use:

- Kepler data set
- NStED standard variability statistics
- NStED periodogram and visualization tools

To:

- Define and identify a set of interesting light curves
- Identify and handle systematics
- Identify important time-scales
- Classify the light curves (inc. amplitudes of variability)?
- Use ancillary diagnostics to classify an object:

How might one scale these methods to large/multiple data sets?

Identifying and Classifying Variable Sources in the Kepler Data

Results on M-dwarfs: Target Selection

In KIC:

2MASS color-color cut: $0.5 < (J\text{-}H) < 0.7$ and $(H\text{-}K_S) > 0.2$

Temperature cut: $T_{eff} < 4000$ K

Radius cut: $R < 0.75\ R_{Sun}$

Both KIC FOV and KTC flags: 2

==> 560 objects

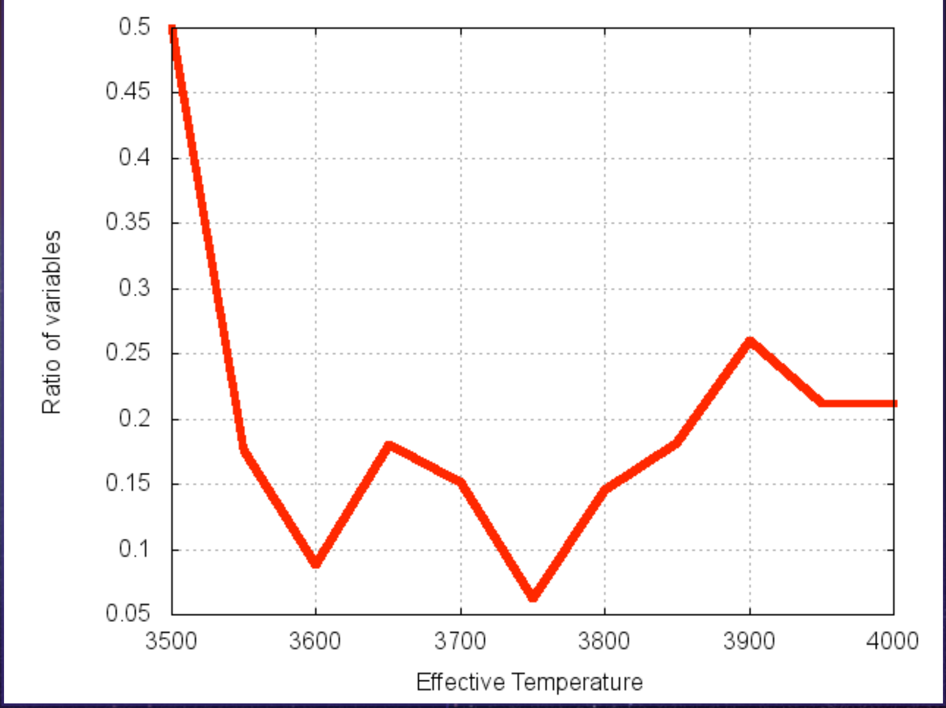
In KPD:

$T_{eff} < 4000$ K

$R < 0.75$

$chi^2 > 3$ ==> 503 objects

Cross-matched list: 94 stars



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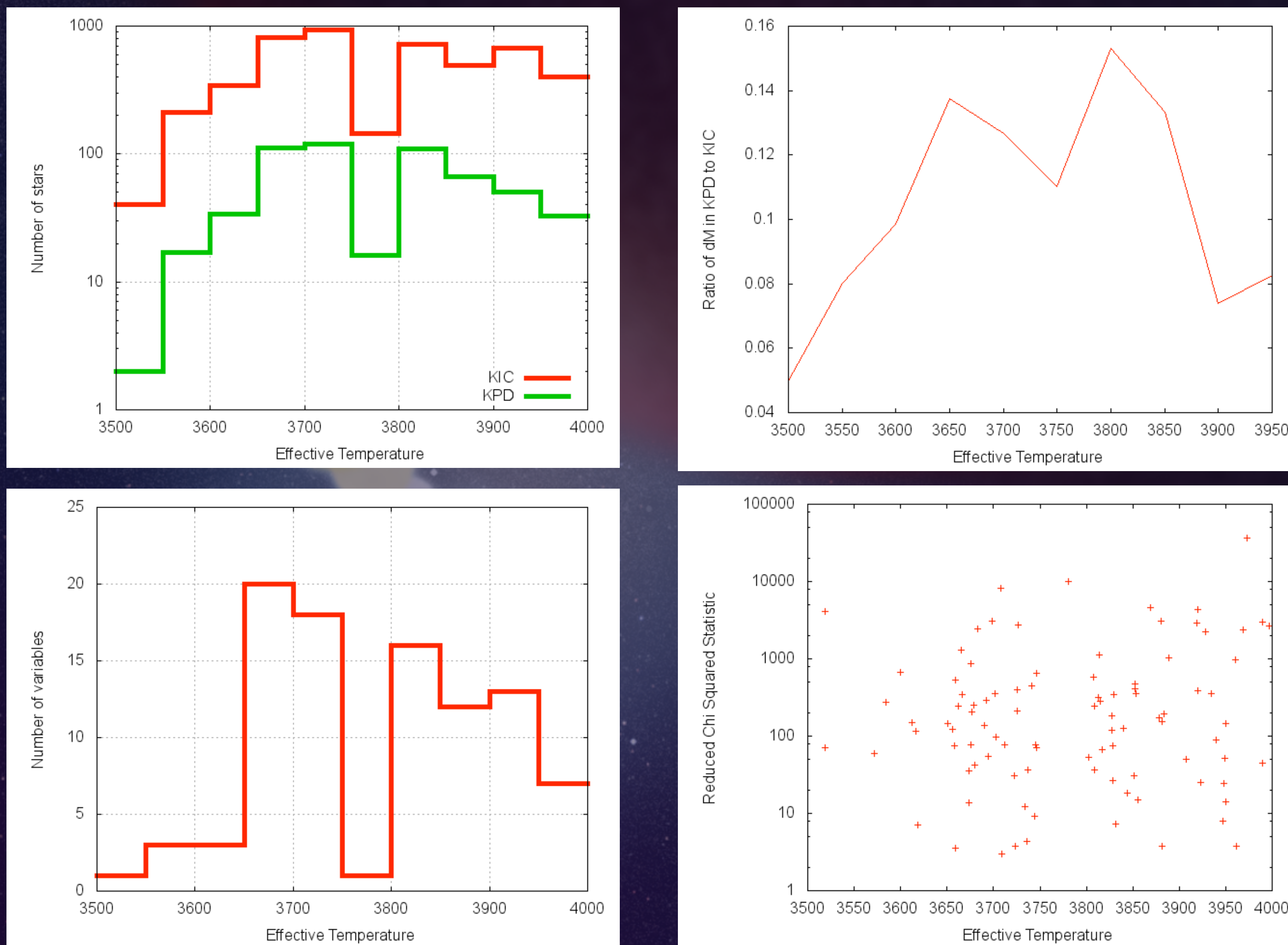
Results on M-dwarfs: Statistics and Correlations 2



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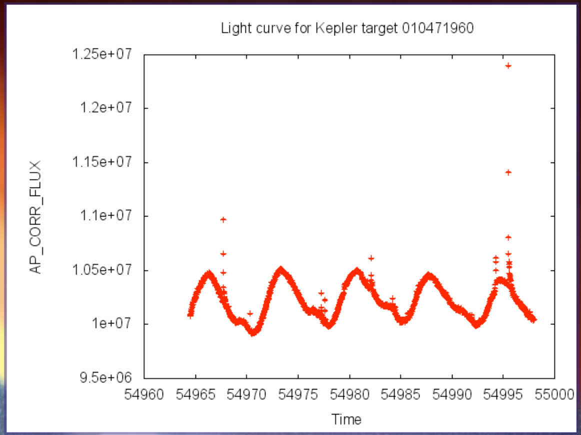
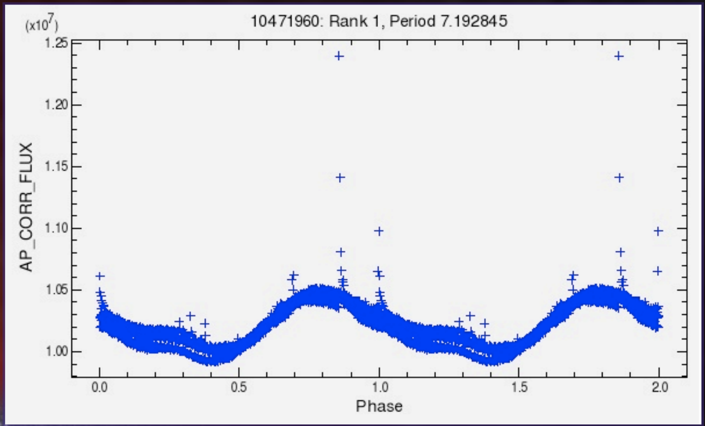
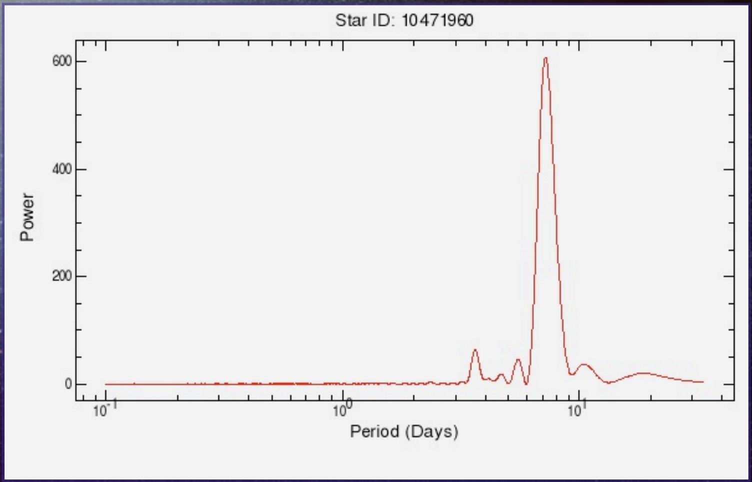
Results on M-dwarfs: Examples

Raw and phase-folded lightcurves for object 10471960





periodogram for object 10471960



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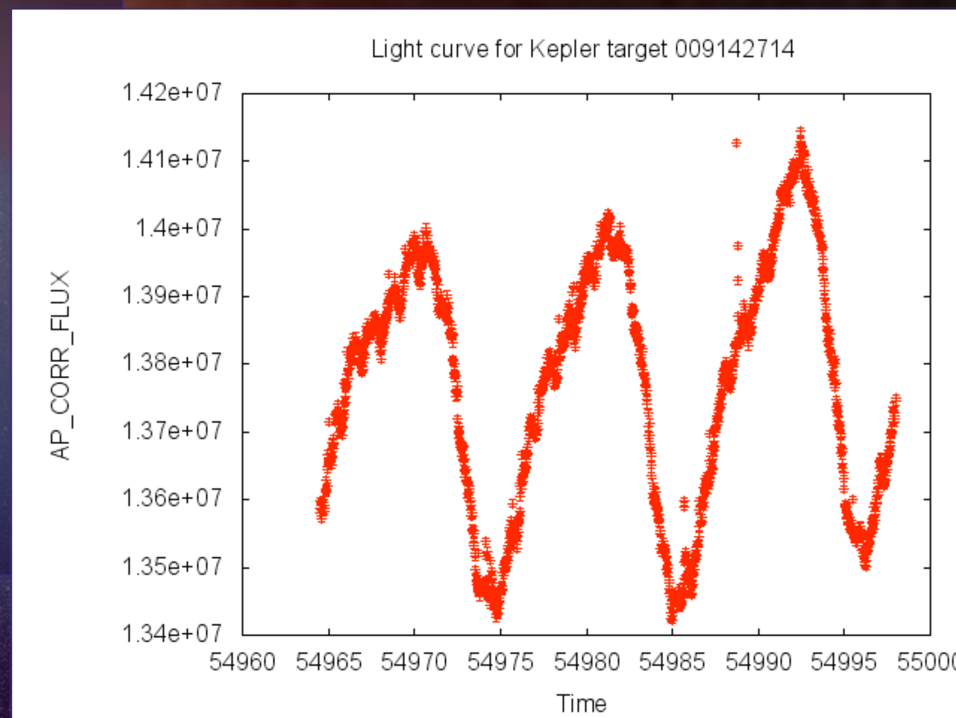
Results on M-dwarfs: Variability

Variability

- Microvariability (*seconds - hours*)
- Pulsations (*few days - tens of days*)
- Spots (*few days - tens of days*)
- Flares (*hours*)
- Eclipses (*hours - tens of days*)



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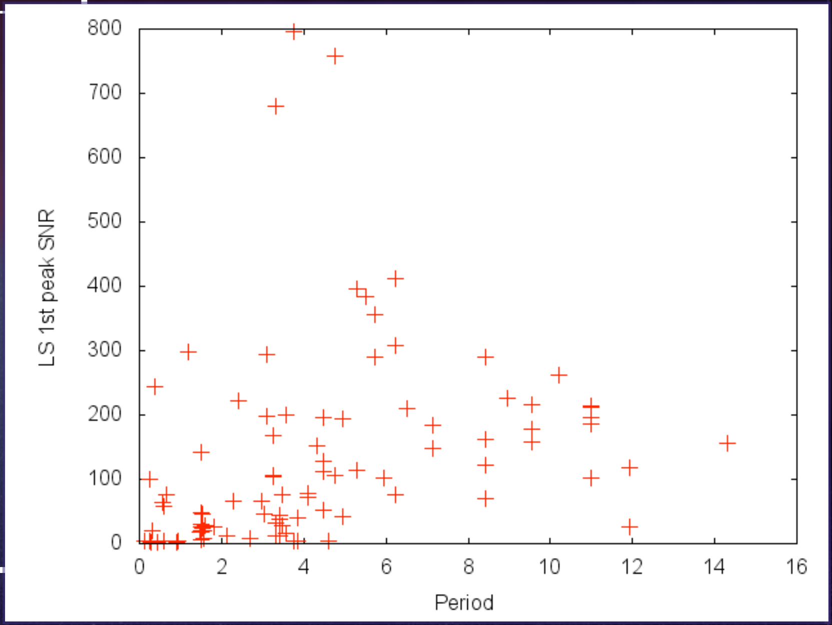
Results on M-dwarfs: Statistics and Correlations

From the set of 94 selected objects the following were determined from visual examination:

	# objects
High noise / no apparent periodic signal	8
Long period signal (>10days)	57
Short period signal (<10days)	31
Multi-periodic signal	5
Flares	26



65% of objects with flares had some short period (< 10 day) variability.

Used Kepler Pipeline-corrected light curves.

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Results for Cepheids: Typical Characteristics

Standard Cepheid Parameters

Pulsation Period : 1 to 50 days

Luminosity : 300 to 26000 L_{Sun}

Spectral Type : F5 to G5

Radius : 5 to 200 R_{Sun}

Mass : 3 to 15 M_{Sun}

(*source*: http://www.astrophysicsspectator.com/topics/overview/DistanceCepheids.html)

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Results for Cepheids: Selection Criteria

How did we comb through the data Set?

________All Sky Automated Survey Data

________Pojmanski, G. 2002, *Acta Astronomica*, **52**,397

Extremely Variable Stars:

High Percent Positive Search Parameters:

Temp: 4900 - 6400 K

Radius: > 5 R_{sun}

Surface Gravity: -4

Chi-squared: > 10000000

(*this ensures large variability*)

Fractional data points more than 5-sigma away from mean: 0

(this ensures smooth curves without big spikes such as in transits)

Results: Very limited number of objects (16); some successful hits, some uncertain but promising with more data, and some with too-rapid variations

Caveats: It was easier to use raw flux instead of the corrected flux to identify the cepheids.

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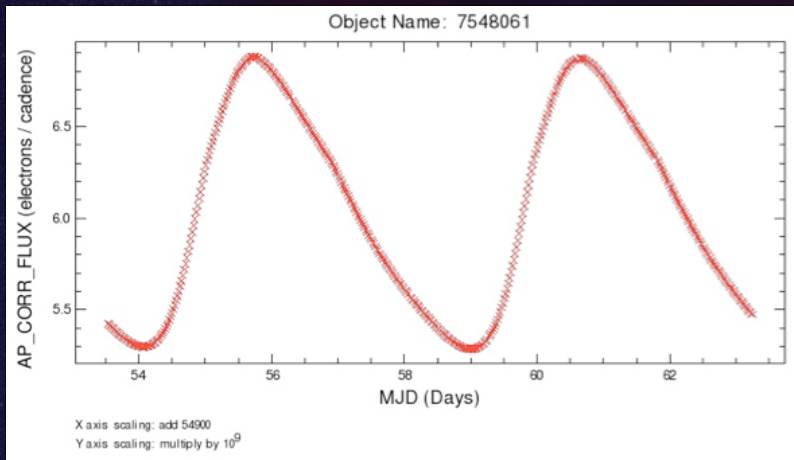
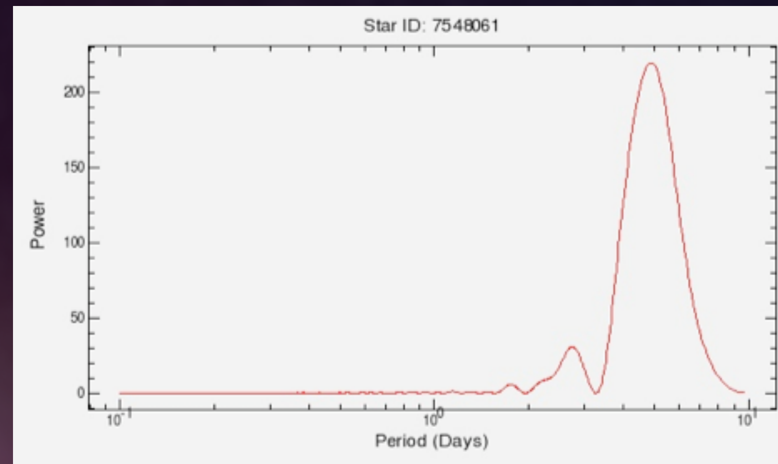
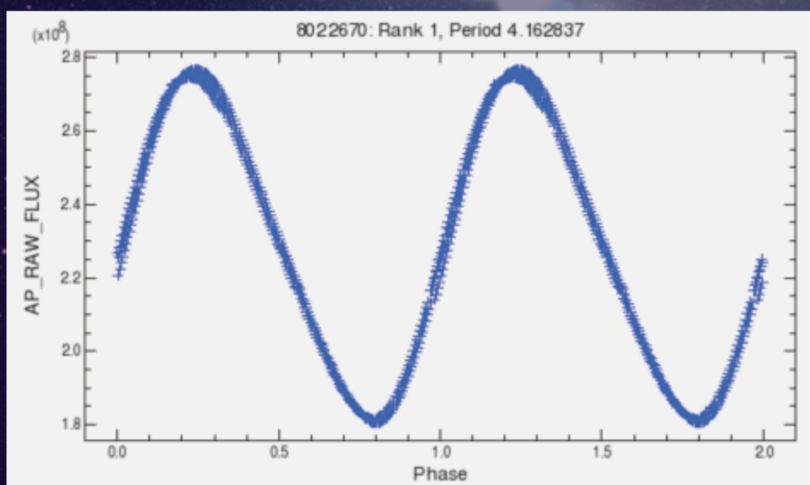
Results for Cepheids: Good Examples

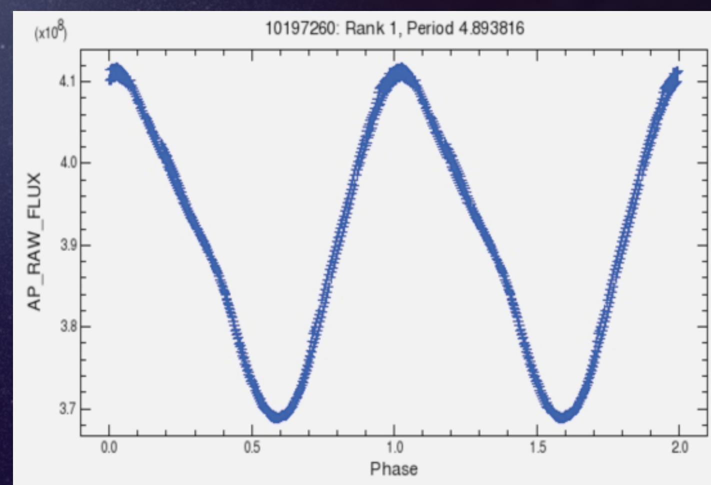




Above: Kepler object 7548061 ;   H (2MASS): 7.049 ;   Ks (2MASS): 6.918

Classified as a cepheid by an outside source





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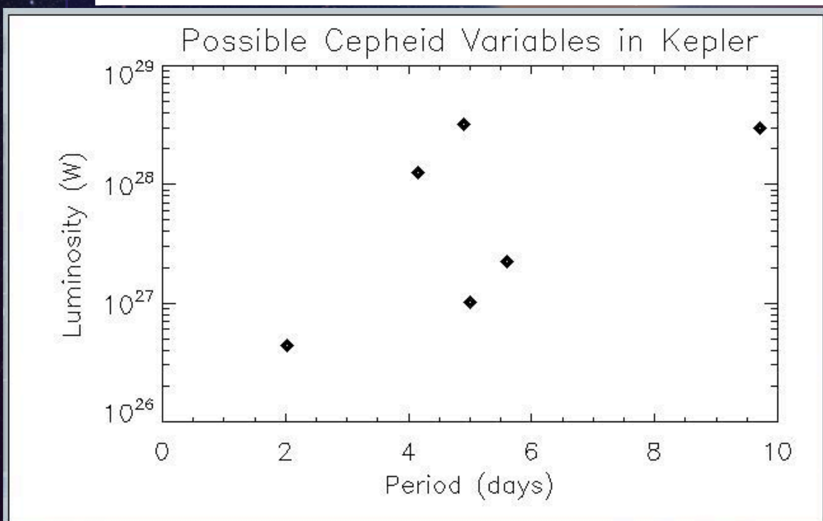
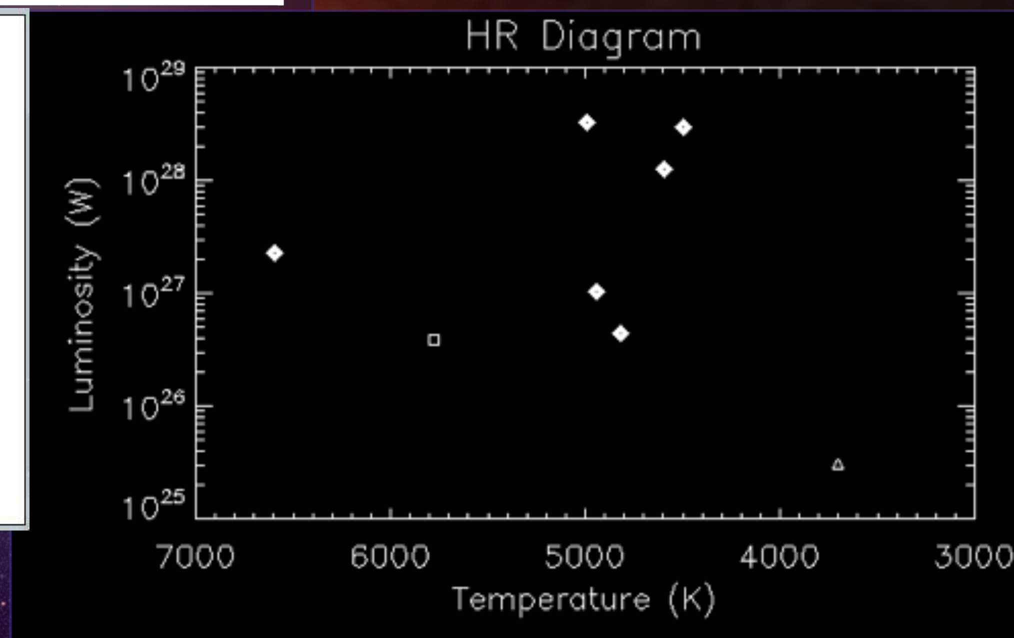
Results for Cepheids: Stellar Properties

KeplerID#	R (R_{Sun})	T_{eff} (K)	P (days)
7739728	1.532	4817	2.018
4245897	1.864	6595	5.609
10197260	2.233	4944	4.997
8022670	9.044	4594	4.163
7548061	12.312	4995	4.894





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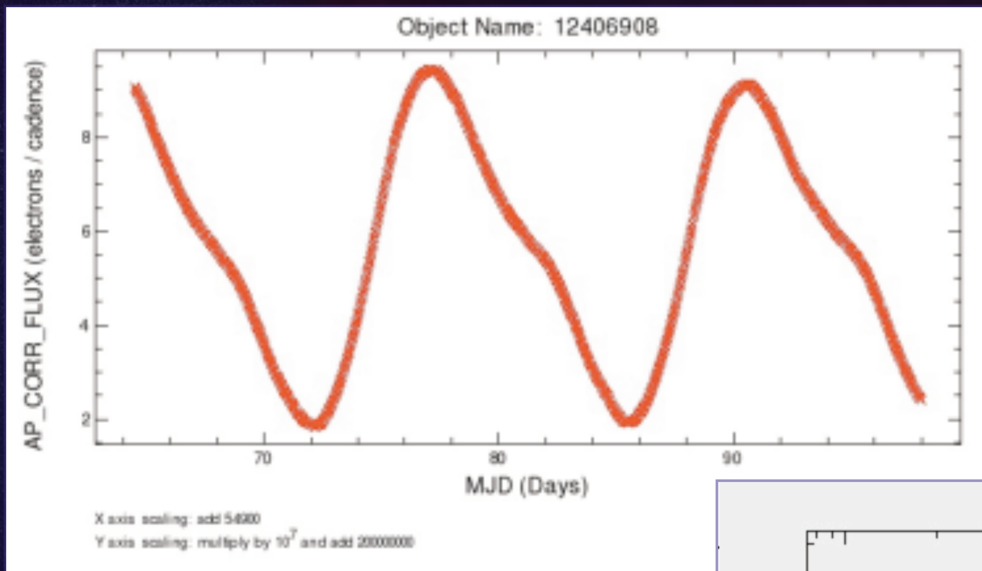
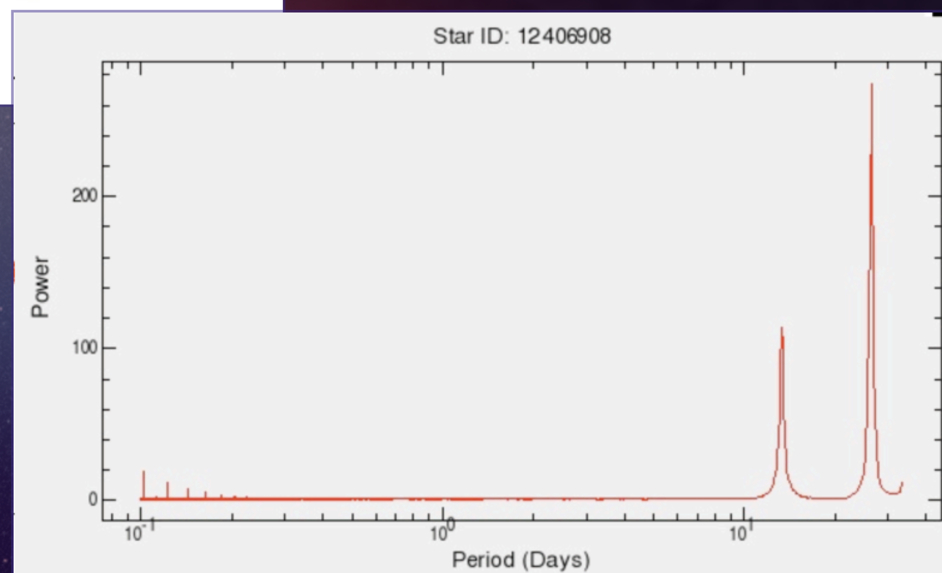
Results for Cepheids: Possibles





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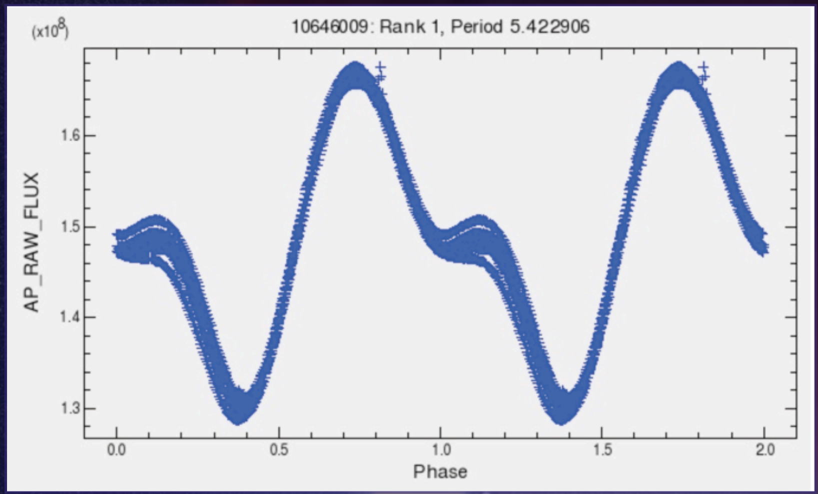
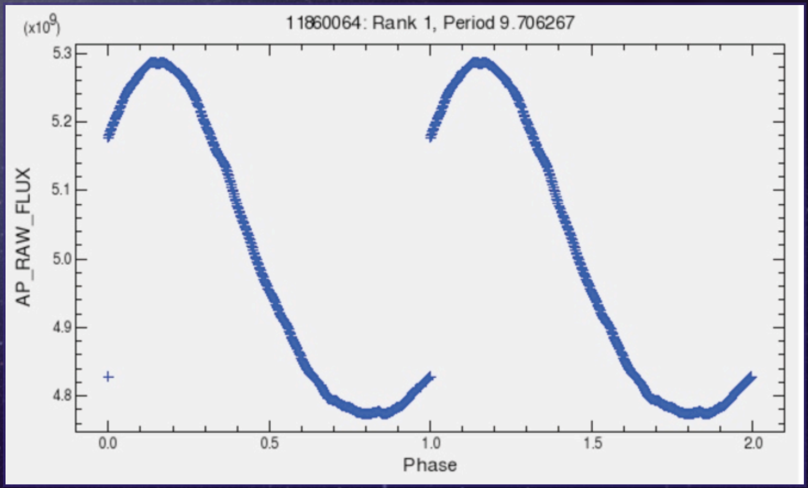
Results for Cepheids: Possibles





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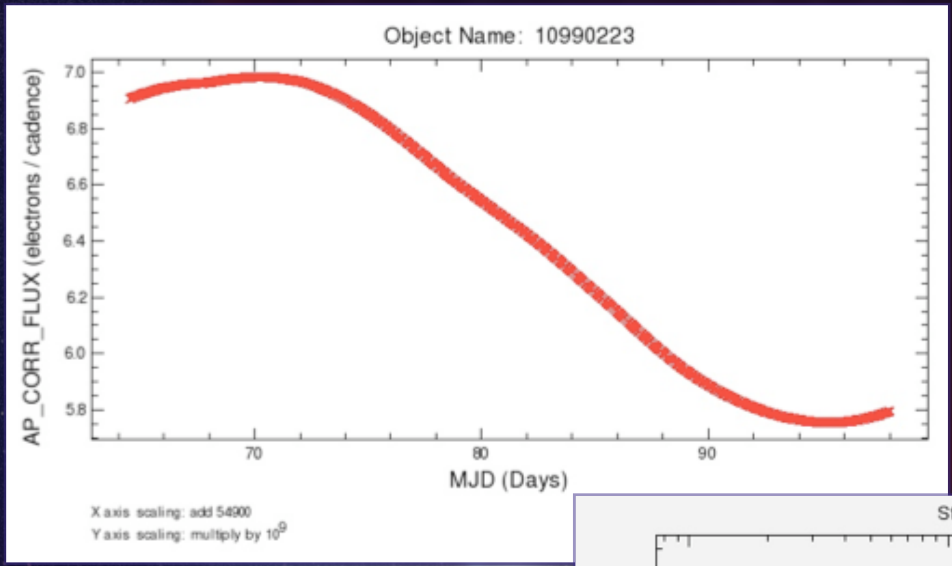
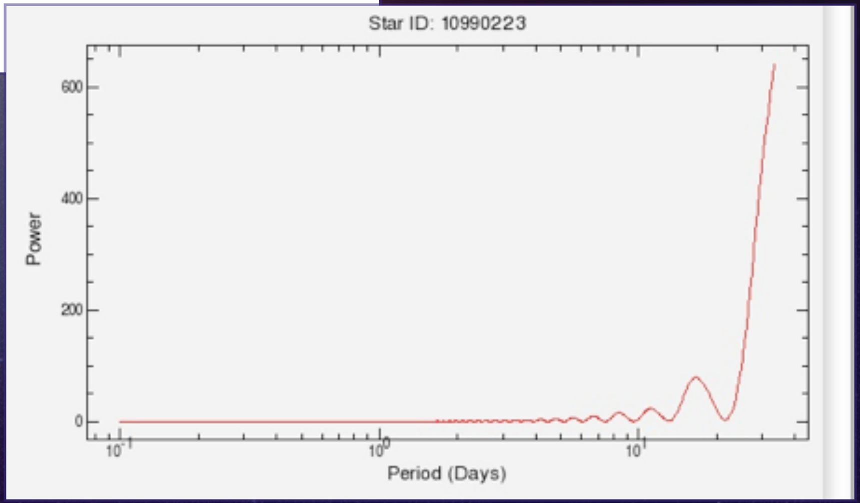
Extras: A Long-Period Cepheid?



H (2MASS) 5.297

Ks (2MASS) 5.070

Proper mass and H-K value



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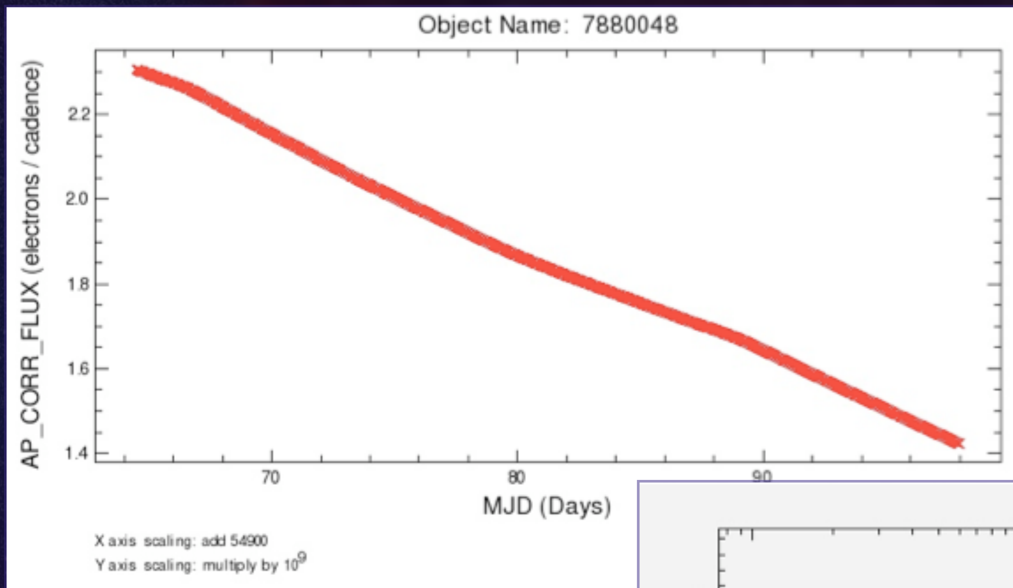
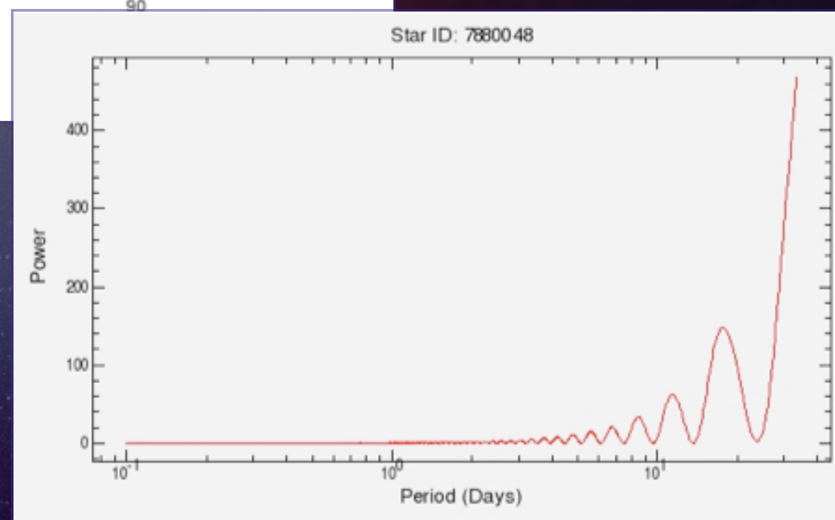
Extras: …?





H (2MASS)	6.029
Ks (2MASS)	5.600

Not enough data to draw a conclusion. Mass correct but H-K is higher than average

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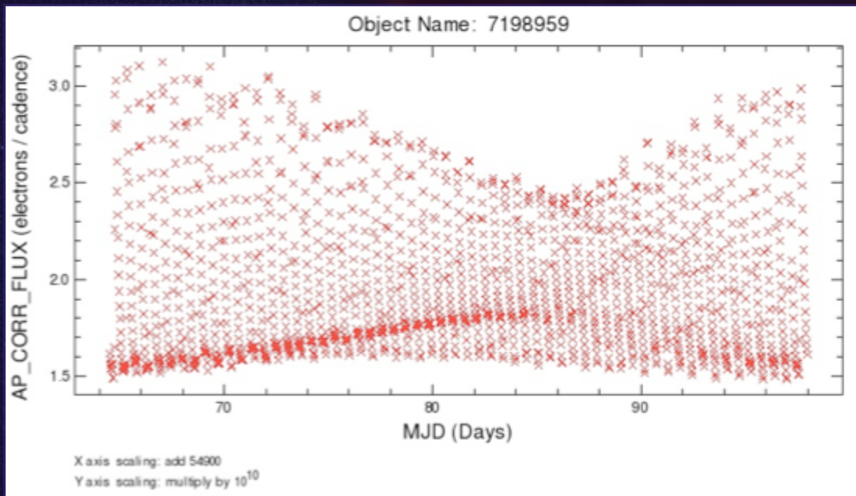
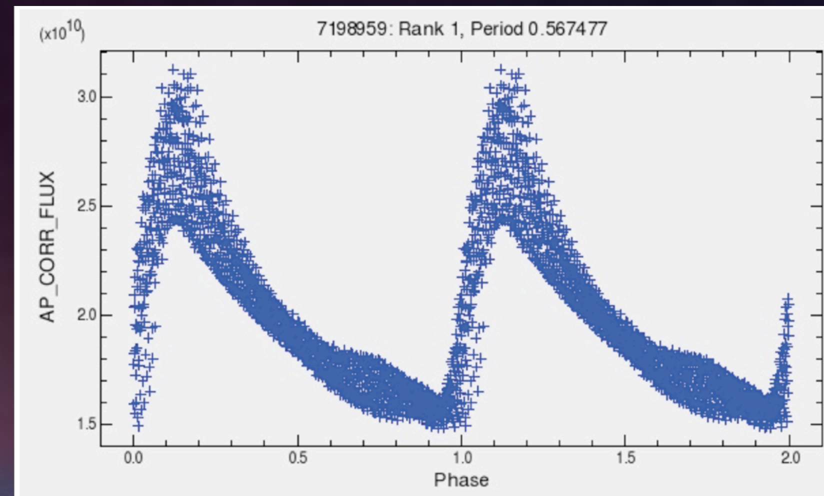
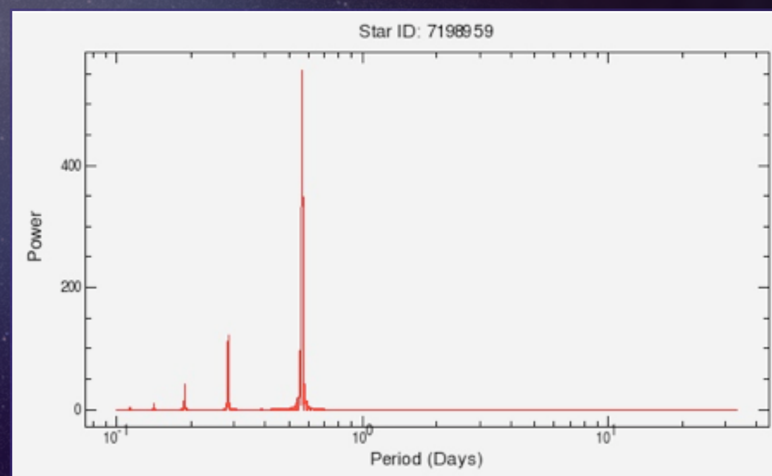
Extras: RR Lyrae





H (2MASS) 6.693

Ks (2MASS) 6.648



Right amplitude variation and size, but too short of period

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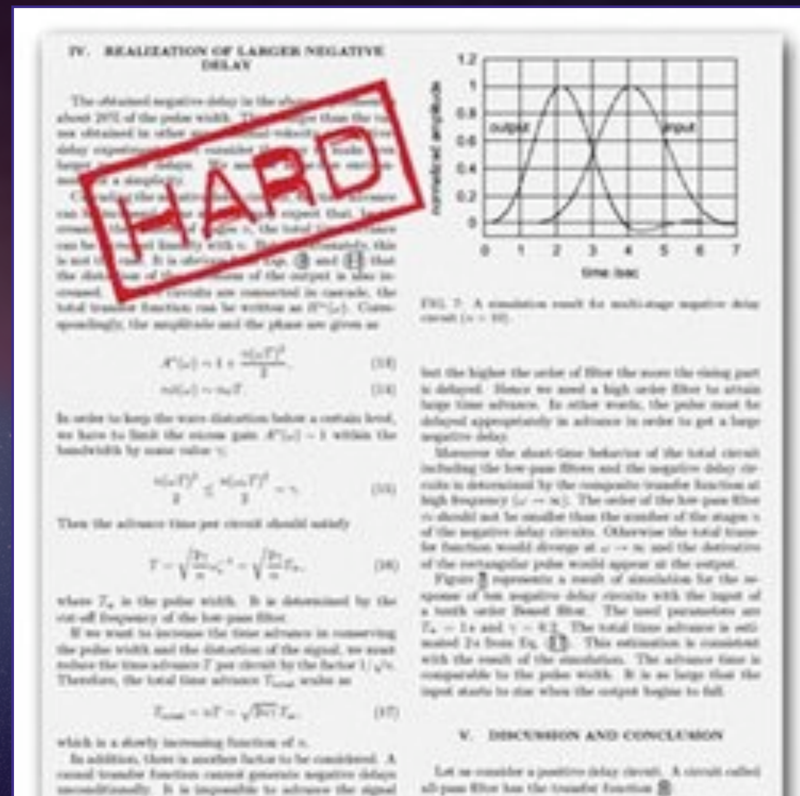
Conclusions / Future Work

Automation will be tricky!

(hurray for armies of undergrads!)



The Onion: Science is hard.

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