Identifying and Classifying Variable Sources in the Kepler Data

Identifying and Classifying Variable Sources in the Kepler Data Outline

Introduction/Objectives

M-dwarfs and Cepheid Variables

- Target Selection
- Variability
- Statistics and Correlations, Examples

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:

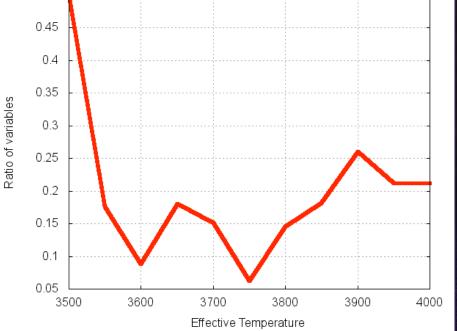
- Define and identify a set of interesting light curves
- Identify and handle systematics
- Identify important time-scales
- Classify the light curves (inc. amplitudes of variability)?
- Use ancillary diagnostics to classify an object:

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

Identifying and Classifying Variable Sources in the Kepler Data <u>Results on M-dwarfs: Target Selection</u>

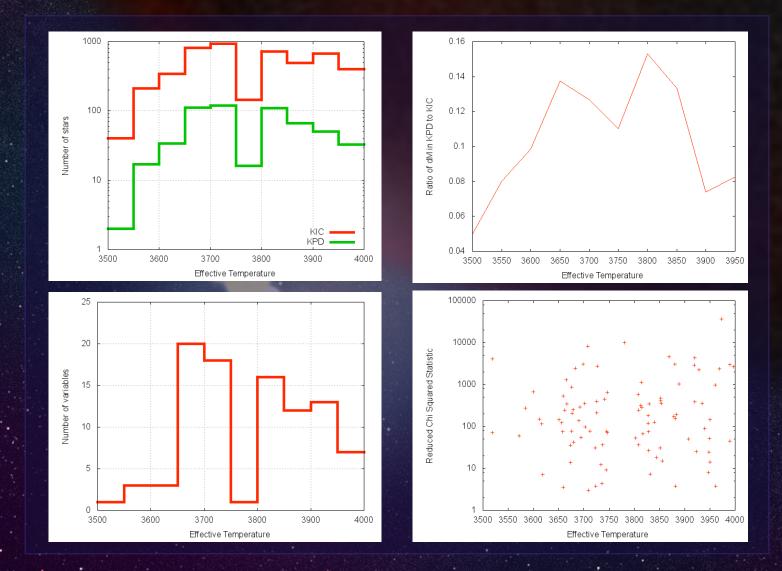


In KPD: $T_{eff} < 4000 \text{ K}$ R < 0.75 $chi^2 > 3 ==> 503 \text{ objects}$

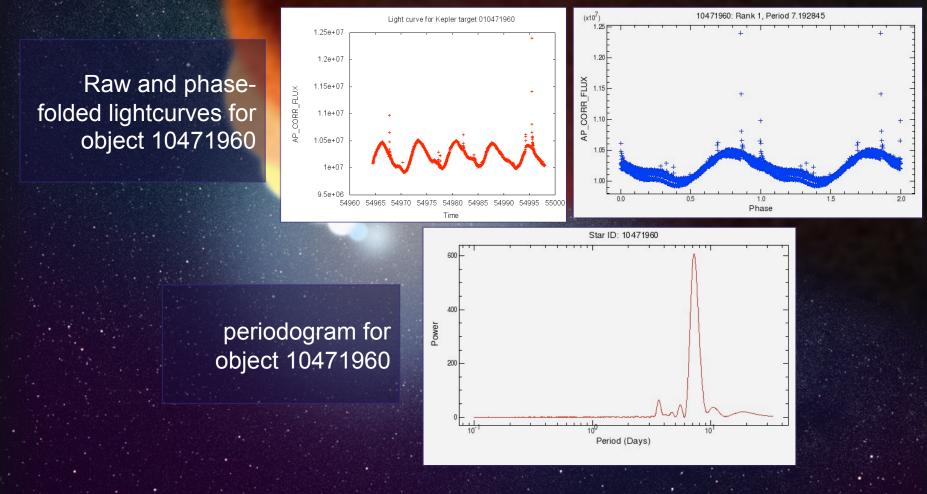


Cross-matched list: 94 stars

Identifying and Classifying Variable Sources in the Kepler Data Results on M-dwarfs: Statistics and Correlations 2



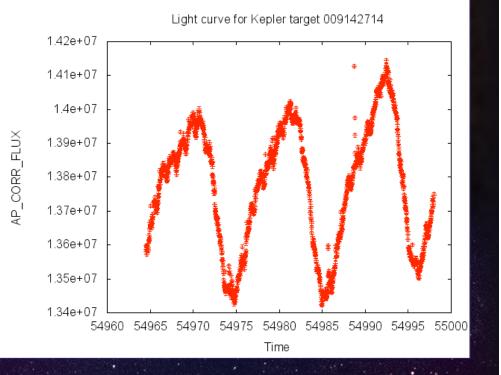
Identifying and Classifying Variable Sources in the Kepler Data <u>Results on M-dwarfs: Examples</u>



Identifying and Classifying Variable Sources in the Kepler Data <u>Results on M-dwarfs: Variability</u>

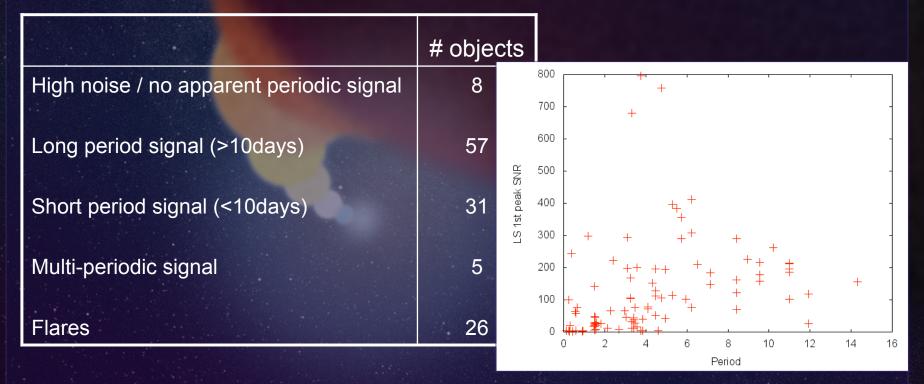
Variability

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



Identifying and Classifying Variable Sources in the Kepler Data Results on M-dwarfs: Statistics and Correlations

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



65% of objects with flares had some short period (< 10 day) variability. Used Kepler Pipeline-corrected light curves.

Identifying and Classifying Variable Sources in the Kepler Data 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)

Identifying and Classifying Variable Sources in the Kepler Data <u>Results for Cepheids: Selection Criteria</u>

How did we comb through the data Set? All Sky Automated Survey Data

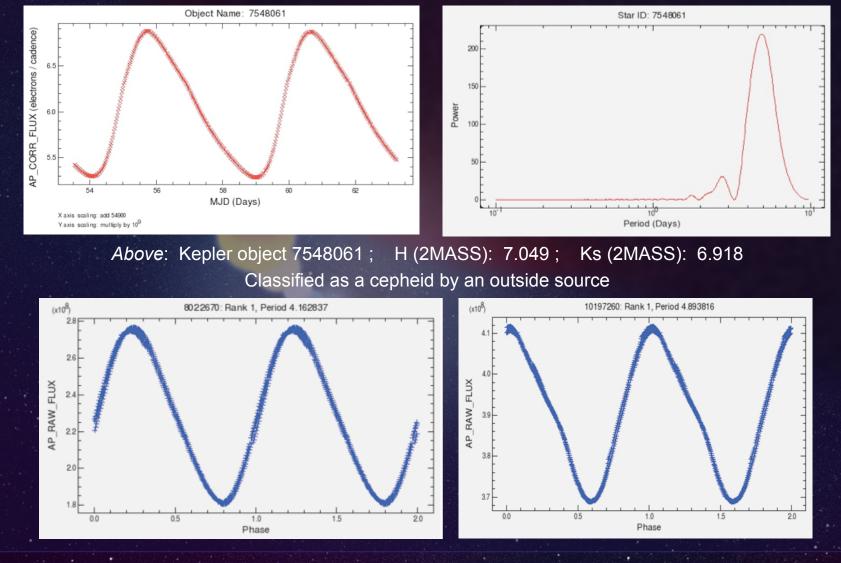
Pojmanski, G. 2002, Acta Astronomica, **52**,397

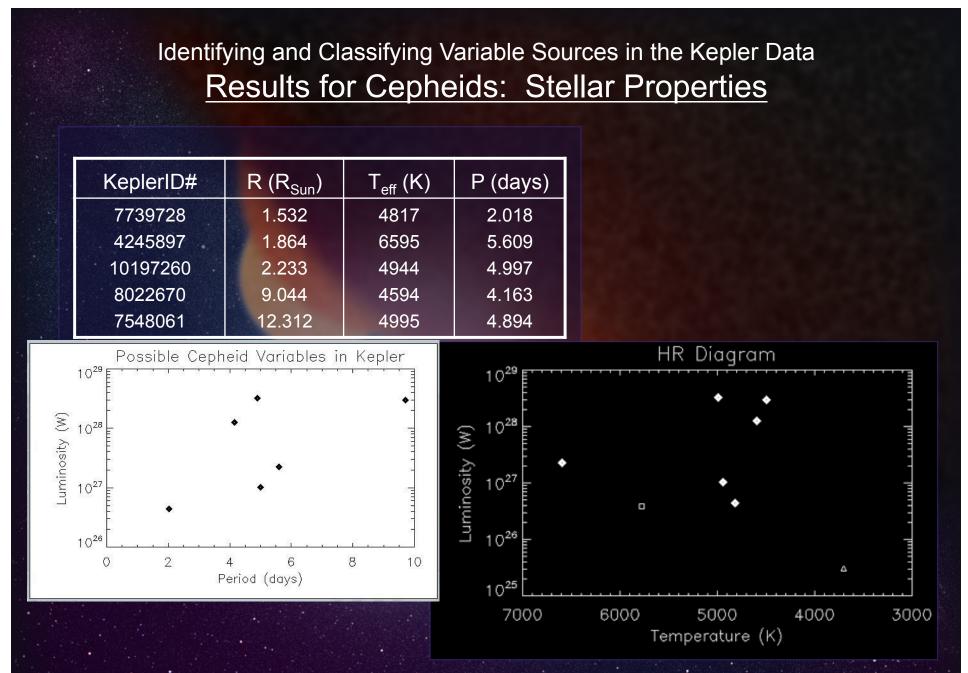
Extremely Variable Stars:

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*)

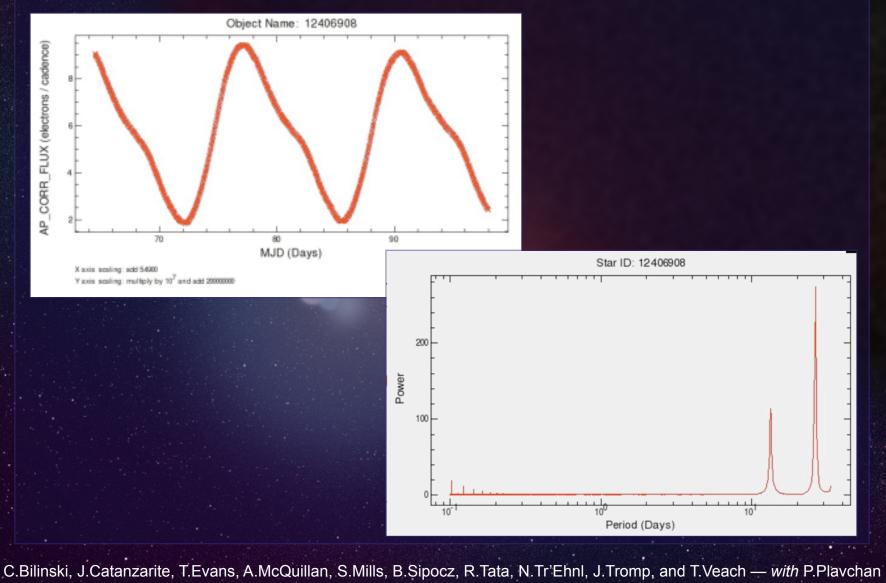
Results: Very limited number of objects (16); some successful hits, some uncertain but promising with more data, and some with too-rapid variations Caveats: It was easier to use raw flux instead of the corrected flux to identify the cepheids.

Identifying and Classifying Variable Sources in the Kepler Data Results for Cepheids: Good Examples



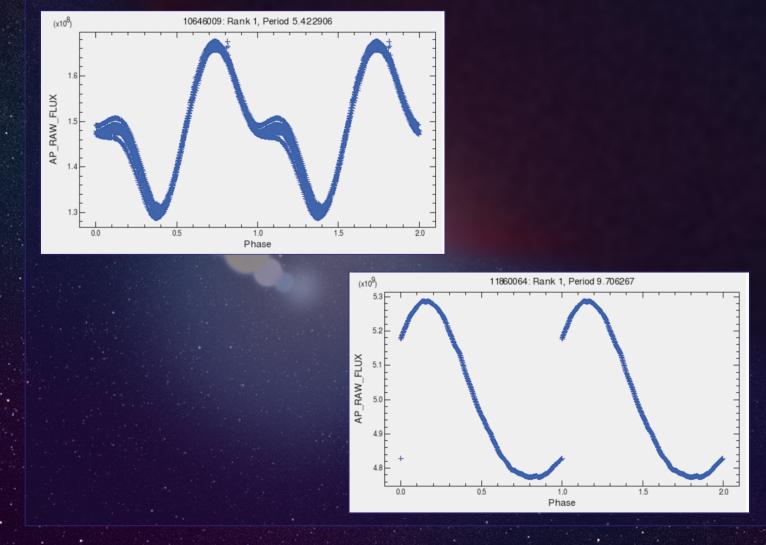


Identifying and Classifying Variable Sources in the Kepler Data <u>Results for Cepheids: Possibles</u>

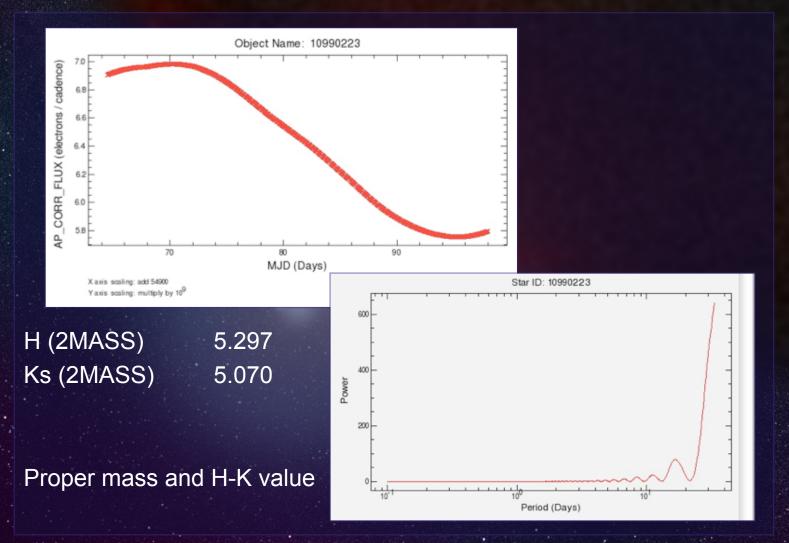


2010 Sagan Exoplanet Summer Workshop, 30 July 2010

Identifying and Classifying Variable Sources in the Kepler Data <u>Results for Cepheids: Possibles</u>

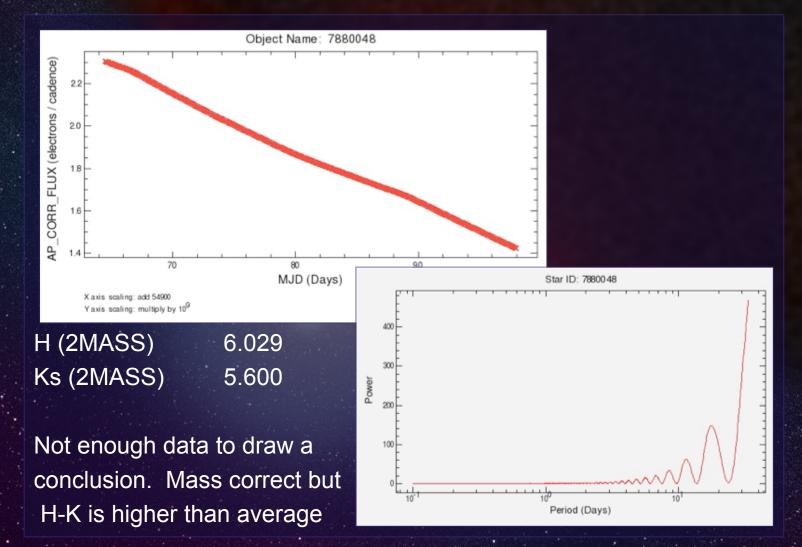


Identifying and Classifying Variable Sources in the Kepler Data <u>Extras: A Long-Period Cepheid?</u>

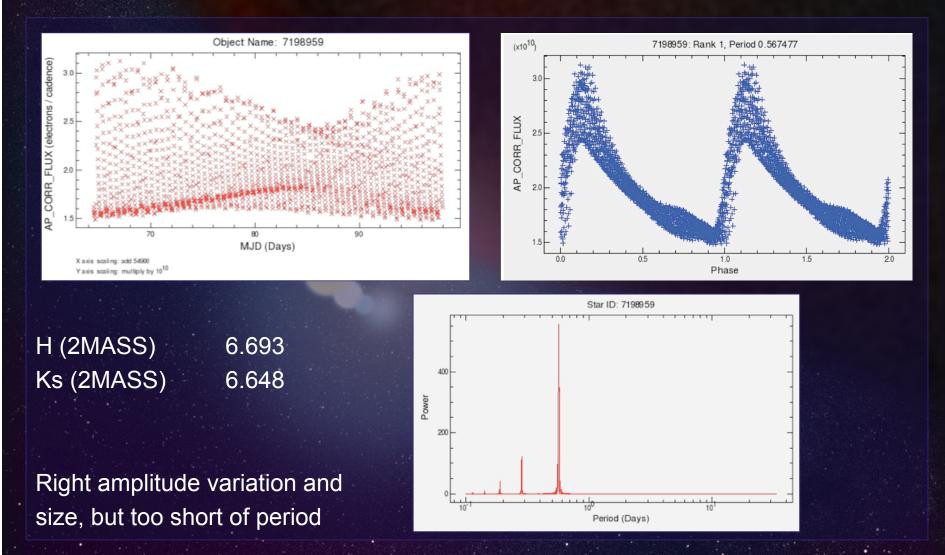


Identifying and Classifying Variable Sources in the Kepler Data

Extras: ...?



Identifying and Classifying Variable Sources in the Kepler Data <u>Extras: RR Lyrae</u>



Identifying and Classifying Variable Sources in the Kepler Data <u>Conclusions / Future Work</u>

Automation will be tricky!

(hurray for armies of undergrads!)



$$\mathcal{X}'(\omega) = 1 + \frac{\omega(\omega T)^2}{1}$$
,
with $1 - \omega \sigma T$.

In order to keep the wave distortion below a cortain level, we have to limit the energy pair. A^{*}[a] = 1 within the

bandwidth by mane value
$$\gamma_i^{-1} = i(\omega_i T)^2 = \gamma_i^{-1}$$
 (10)

Then the advance time per circuit should usinfy

$$T = \sqrt{\frac{p_T}{n}} c_e^{-1} = \sqrt{\frac{p_T}{n}} T_{p_T}$$

where T_{α} is the polar width. It is determined by the stat off Despenses of the low-pase filter. If we want to increase the tities advance in connecting

the pulse width and the distortion of the signal, we must taken the time advance T per closel by the factor $1/\sqrt{n}$. Therefore, the total line advance $T_{\rm total}$ scalars as

which is a dowly increasing function of n. In addition, there is another furtur to be consistent. A round transfer function current generate negative delays



study. It is impossible to identice the signal

12

FWI, 7: A simulation reself for multi-stopy segurity delay correct (n = 10).

but the higher the series of filter the score the sing gast is delayed. Hence we need a high order filter to attain large time schemes. In atthes works, the pulse must be sideped appropriately in advance in order to get a large magnitive sidep.

Inframework the chart-time behaviour of the total circuit including the low-pass filters and the impairies doiny its ratio is determined by the composite transfer hardware at high frequency ($\omega \rightarrow \infty$). The order of the low-pass filter ω dends in the consider them the consider of the tangen is of the negative sider circuits. Otherwise the total transfor fractions would drivery at $\omega \rightarrow \infty$ and the dottedies of the resplicit point would appear at the version.

Figure 2 represents a result of simulation for the sespone of bin requires delay denoits with the lapet of a torith with Theorem 1 personshers an $\Gamma_{n} = 1 + and \gamma = 4.2$. The total lines advance is with model 24 bins Eq. (2). This estimation is consistent with the result of the essentiation. The advance time is comparison for the polar width. It is as longs that the import starts in size when the output budges to full.

V. DESCUSION AND CONCLUSION

Let us consider a positivo delay circuit. A circuit called all-pass filter has the transfer function (2)

The Onion: Science is hard.

12.40

(140)

(10)