Evaluating the Pan-STARRS Variability Parameter

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By Thursday (4/18) we need: well thought out section titles and plots that show all the points we wanna make

remake prob(f) plot with all 300,000 stars (not only 80,000)

LS analysis on ATLAS Pathfinder Telescope data, verified PS variability criteria

INTRODUCTION

- why we care

- what made us care about this project

- NO structure / distance stuff (maybe put it in looking forward section at end)

- talk about PS catalog

- variability surveys (discuss other attempts to measure variables across the sky)

- why are variables interesting

- why do we want to find variables and care about where they are located

- Summary: we ran LS, analyzed stars, why did we do it all

- Mention what will be discussed: "in section 2 we describe the observations we used..."

ATLAS PATHFINDER 1 OBSERVATIONS

- we used data from ATLAS

- supplemented with ATLAS data [REF TONRY] (possibly make this s subsection)

- what was the weather like during observations

- PSF FWHM variations (only include if we discuss crowding)

- 'we recieved the reduced image data from the ATLAS pipeline; which gave us RA, Dec, mag, etc...'

[VERITY CORRECT CITATIONS $http : //rsta.royalsocietypublishing.org/content/$371/1992/20120269]
In determining variability of stars in our FOV, data from the *griProject* [4] was used.
[PATHFINDER USED FOR GRI DATA...the reduction process is discussed at length Tonry in...cite]
We received the reduced image data from the ATLAS pipeline [1, 3].

Data

Is it $b^{II} = +5°$ or $b = +5°$??
[NEED TO DEFINE FOV]
[VERIFY RA DEC RANGE (NOT WHAT WAS PUT INTO SIMBAD)]
[NEED TO CITE TONRY FOR OUR OBSERVATIONS]
[MENTION THAT OUR OBS NECESSARY TO REDUCE ALIASING]

Using the Pathfinder telescope, observations were made at two galactic latitudes ($b^{II} = \pm 5°$) and spanned a range of galactic longitudes ($202° < l^{II} < 232°$). Exposures were collected for 20 s and separated by 3° longitudinally. For implementation by the Pathfinder telescope, a conversion to RA and Dec was made; giving a range of $93 < RA < 119°$ and $-20° < Dec < 13°$, as shown by Figure 6. To account for the 0.05 ° gap between the detectors, a 0.1 ° offset in RA was implemented on every other night. Spanning 20 nights, 10 observations a night were collected on 3/8/16-3/27/16. On
[DATE]
overcast caused observations to be cut short, all other nights had weather perfectly attuned for observations.

[dRA = dangle / cos(Dec)]
[EXPLAINS EXACT OBSERVATIONAL PLAN...NECESSARY?]
Observations were traced out by moving the FOV 3° longitudinally, starting at $b^{II} = -5°$, $l^{II} = 202°$ and ending at $b^{II} = -5°$, $l^{II} = 232°$. Once observations at $b^{II} = -5°$ were complete, the FOV was shifted to $b^{II} = +5°$, $l^{II} = 232°$.

CONSTRUCTING STELLAR LIGHT CURVES

- how we selected stars (12+ obs, 1x1 deg^2, etc)

FAST LOMB-SCARGLE PERIODOGRAM

[INTRO TO WHAT IS PERIODOGRAM...WE CONSTRUCT PERGRAMS USING LS METHOD]

- extract variability from LS

- describe how it works and why we used LS

- major aliasing at 1 day and 0.5 day periods

- things that fall at at -50 (in Figure 5) means that those are VERY probably variable stars

- roughly _____ stars fell at -50 in Figure 5

- 315,992 stars tested for variability

- other stars (outside of 315,992) are statistically unlikely to be variable

- brief explanation of the fast LS

- period search range to avoid aliasing

- compute gri periods individually and compare each other
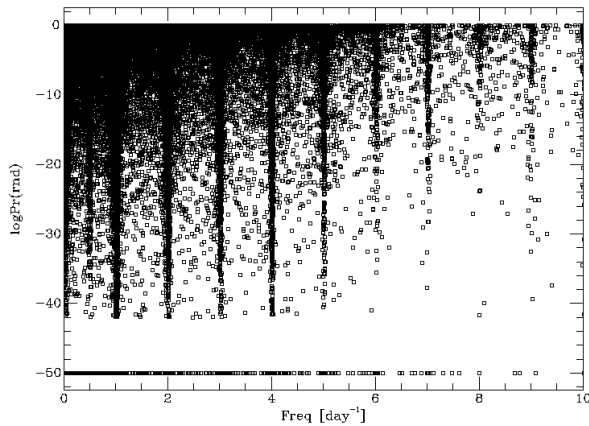
- Fourier series fit to extract variable types
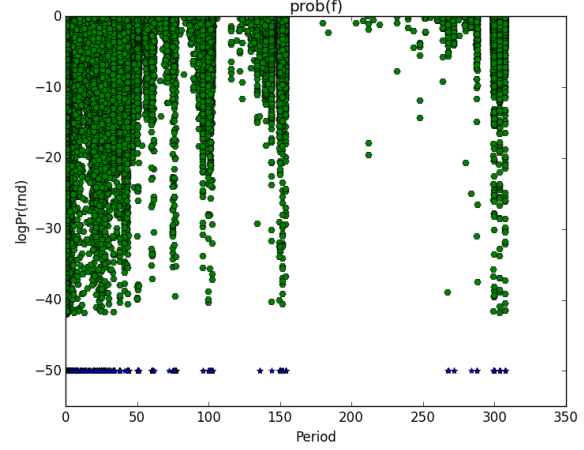
prob(f)

FIG. 3: *prob(f) of 80,000, most variable, stars LS was run on*

Fourier Series

- Fourier series fit to extract variable types

Period Error Estimation

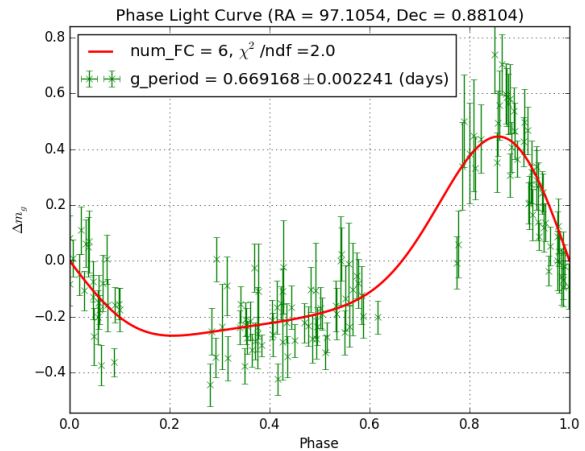- explanation of period error estimation using Fourier series

FIG. 2: *prob(f) of 80,000, most variable, stars LS was run on*
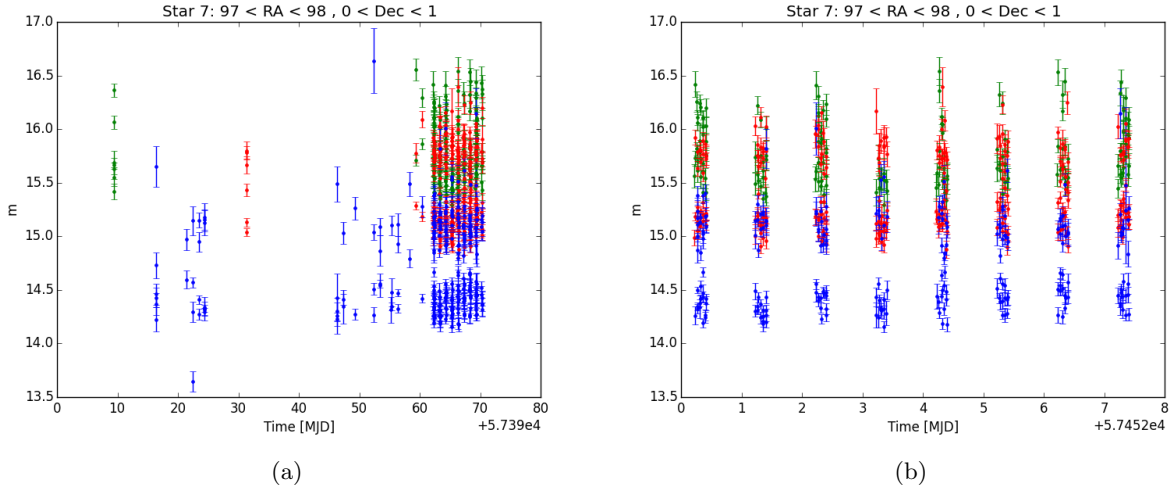

FIG. 4: *Type ab*

FIG. 1: *Light Curve of a variable star. Panel '(a)' shows a light curve constructed using all collected and ATLAS data. Panel '(b)' is a restricted selection of '(a)', not showing any observations made by ATLAS.*
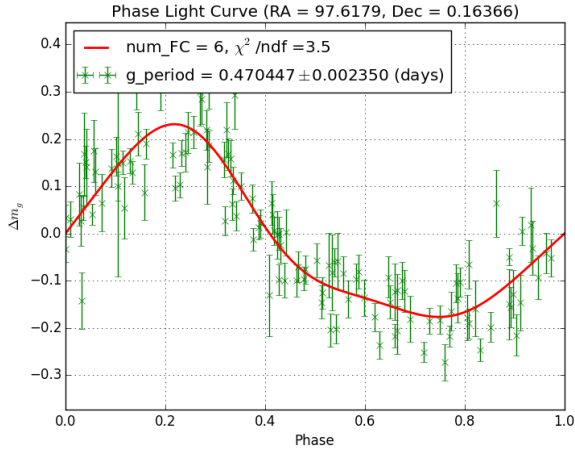

FIG. 5: *Type c*

RESULTS

- compare with PS

- density/distribution of variables in sky

- (what LS gave us for our catalog)

- put a table with 5 stars, to show off part of catalog

Simbad Completeness

- Pull established RR list from Simbad

- Pull other variable data from simbad, too

- Compare list of observed RR to catalogs

- Is anyone actually reading this outline, this bullet point serves no purpose

- Wow, its sad how little Jeff did since class began (especially after JT gave him the code to do it a month ago) - 6 obs x 4 nights = January-April work period haha

- Establish completeness with Simbad

[FIX SIMBAD CITATION]
In order to evaluate the completeness of our results, comparisons needed to be made to other variable star catalogs. Simbad [2] provided a list of variable stars within our FOV. Pulsating sources encompasses all variable objects.
[OF THESE WE MATCHED...RR LYRAE...REF FIGURE]

[review what he did, but heres a summary:]
[48 simbad objects overlay our FOV]
[33 have an entry in lsum.dat]
[Of 15 that overlap w/o lsum entry]
[14 are defective]
[at least one filter has less than 10 detections]
[=¿ it's a survey problem, not an LC problem]
[P(rand) for the 33 that do occur in lsum]
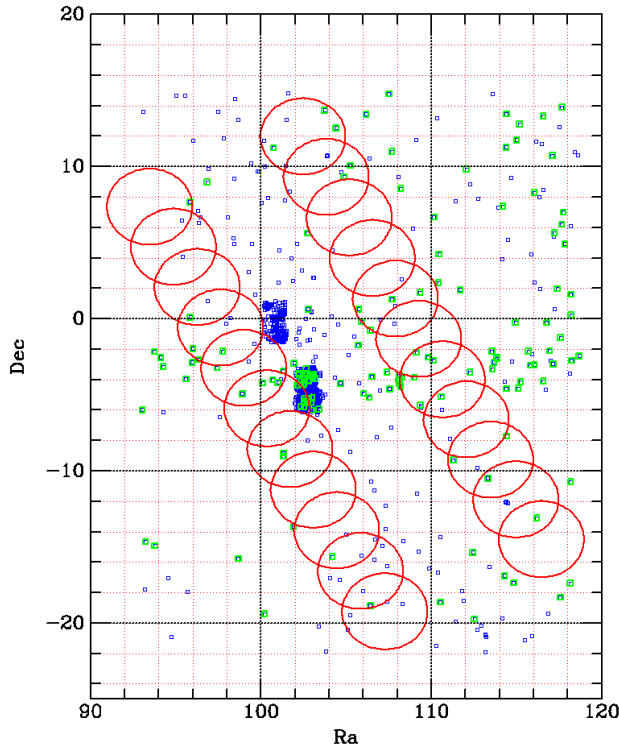[27/33 show up as high probability variables]

FIG. 6: *Observation path with Simbad pulsators in blue and RR Lyrae in green.*

DISCUSSION

- Evaluation of PS criteria

- what went wrong

- what could have gone better

- future outlook

- we could map spiral arms using x y and z

SUMMARY AND CONCLUSIONS

[TALK ABOUT IT]

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† Observational Astronomy 301

[1] Magnier E 2006 The Pan-STARRS PS1 image processing pipeline. In *Proceedings of the Advanced Maui Optical and Space Surveillance Technologies Conf.* (ed. Ryan S), *Wailea, Maui, HI, 1014 September 2006,* p. E5. Kihei, HI: The Maui Economic Development Board.

[2] Simbad Database
[3] Tonry JL, et al. 2012 The Pan-STARRS1 photometric system. *Astrophys. J.* **750**, 99. doi:10.1088/0004-637X/750/2/99

[4] Tonry JL, er al. 2016 (personal communications January-April 2016)