# V883 Scorpii Period Determination

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Neil Butterworth
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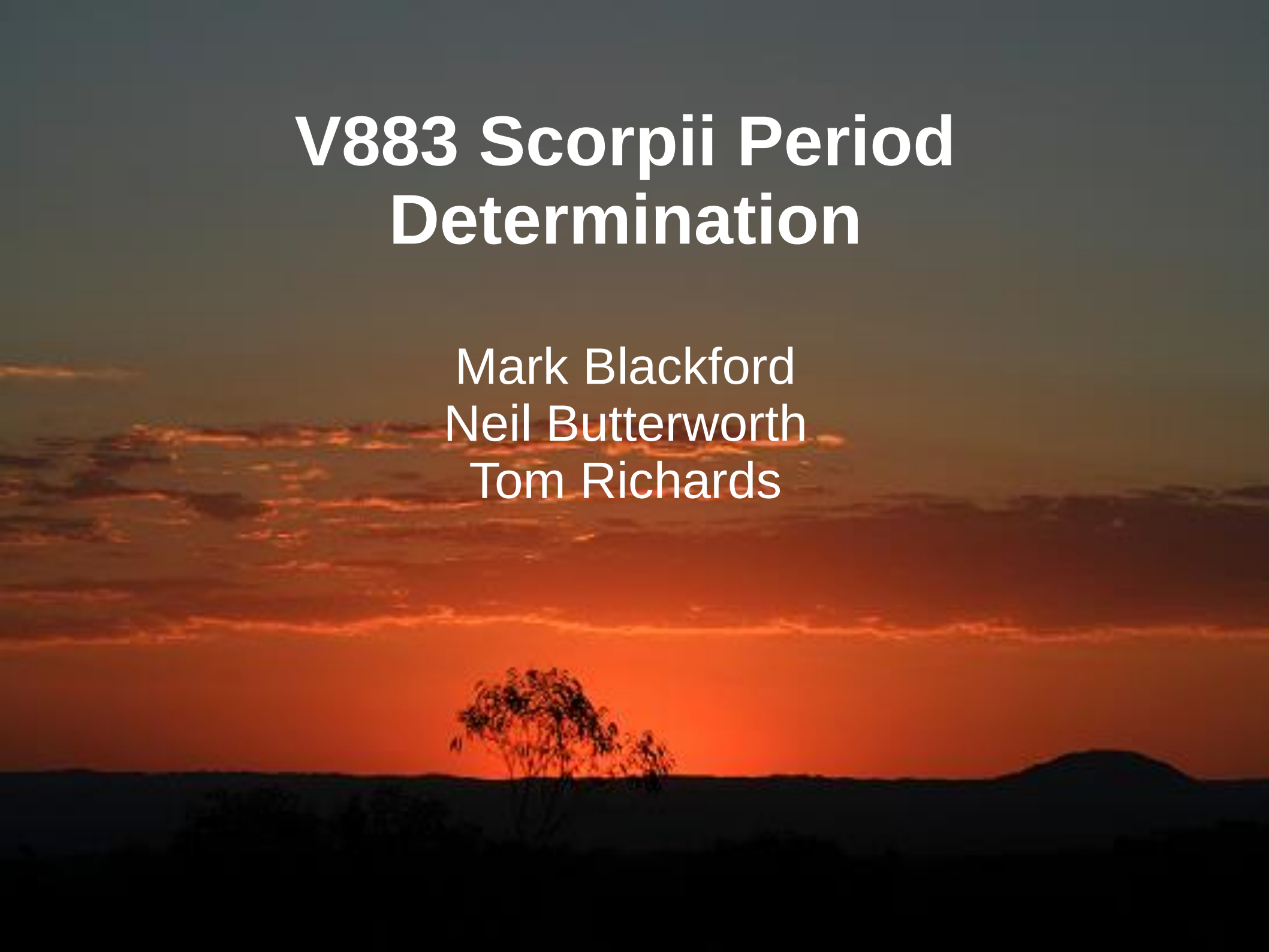


# Background

According to AAVSO VSX V833 Sco is an β Lyrae-type eclipsing system with both both components being close in size to their inner critical surfaces (EB/KE).

Magnitude 7.34 - 7.66 V according to VSX.

GCVS list its period as 1.29484 d and epoch HJD 2443285.794 (22 May 1977) from photographic studies by Strohmeier & Knigge (1973).

Included in VSS list of Southern DSLR EB-EW targets.

# Butterworth Observations

GCVS light elements are quite old but should predict eclipse times to within a few minutes.

Neil Butterworth began recording DSLR time-series in July 2015 with the aim of establishing a new epoch and refining the period.

After several attempts in which predicted eclipses were not recorded Neil contacted Tom Richards and myself in August 2015.

Clearly the GCVS period was significantly in error so we set out to determine the correct period.

# What Was Required?

Neil's observations up to that time did not record any minima so could not be used. He could have continued imaging each clear night until several eclipses had been recorded but that would be terribly inefficient.

A better solution was to find an existing source of high quality photometry spanning the whole light curve of V883 Sco.

The All Sky Automatic Survey (ASAS) and INTEGRAL-OMC are readily accessible sources of such observations.

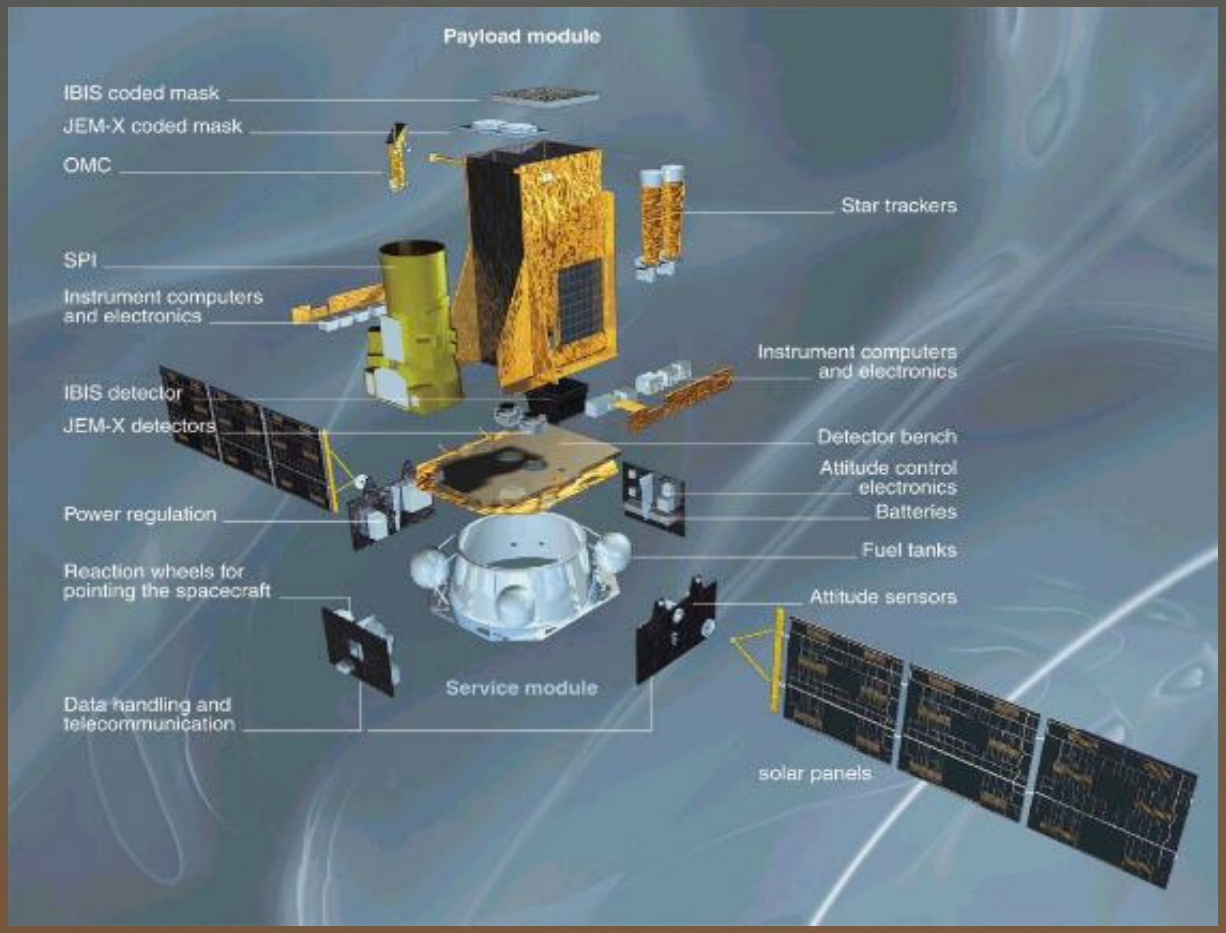
# ASAS-3 Telescopes

Two separate CCD cameras with 200mm f2.8 lens, one with V filter and one with I filter.

Las Campanas Observatory, Chile.

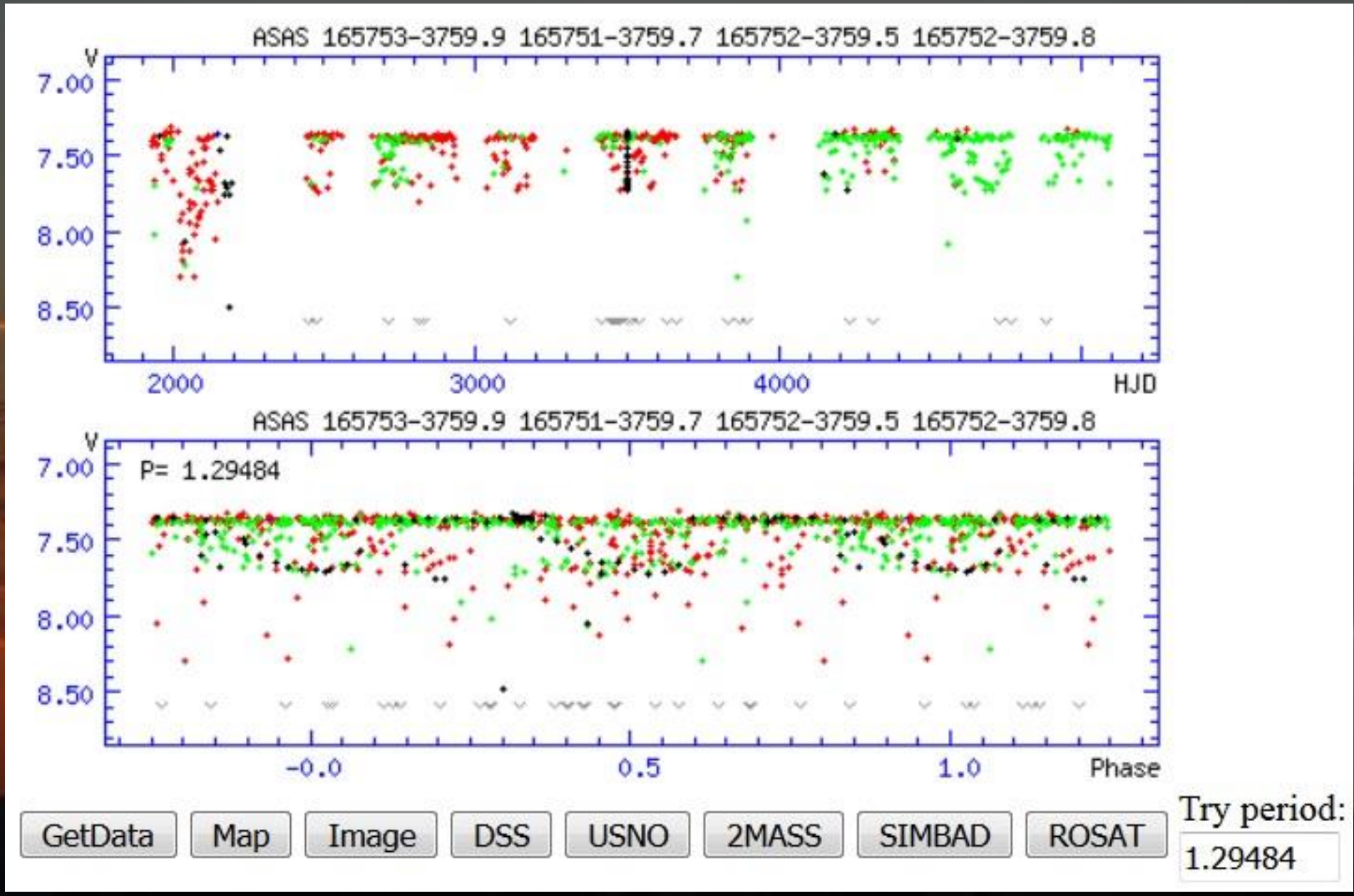
# INTEGRAL-OMC

Optical Monitoring Camera on ESA's International Gamma-Ray Astrophysics Laboratory satellite.



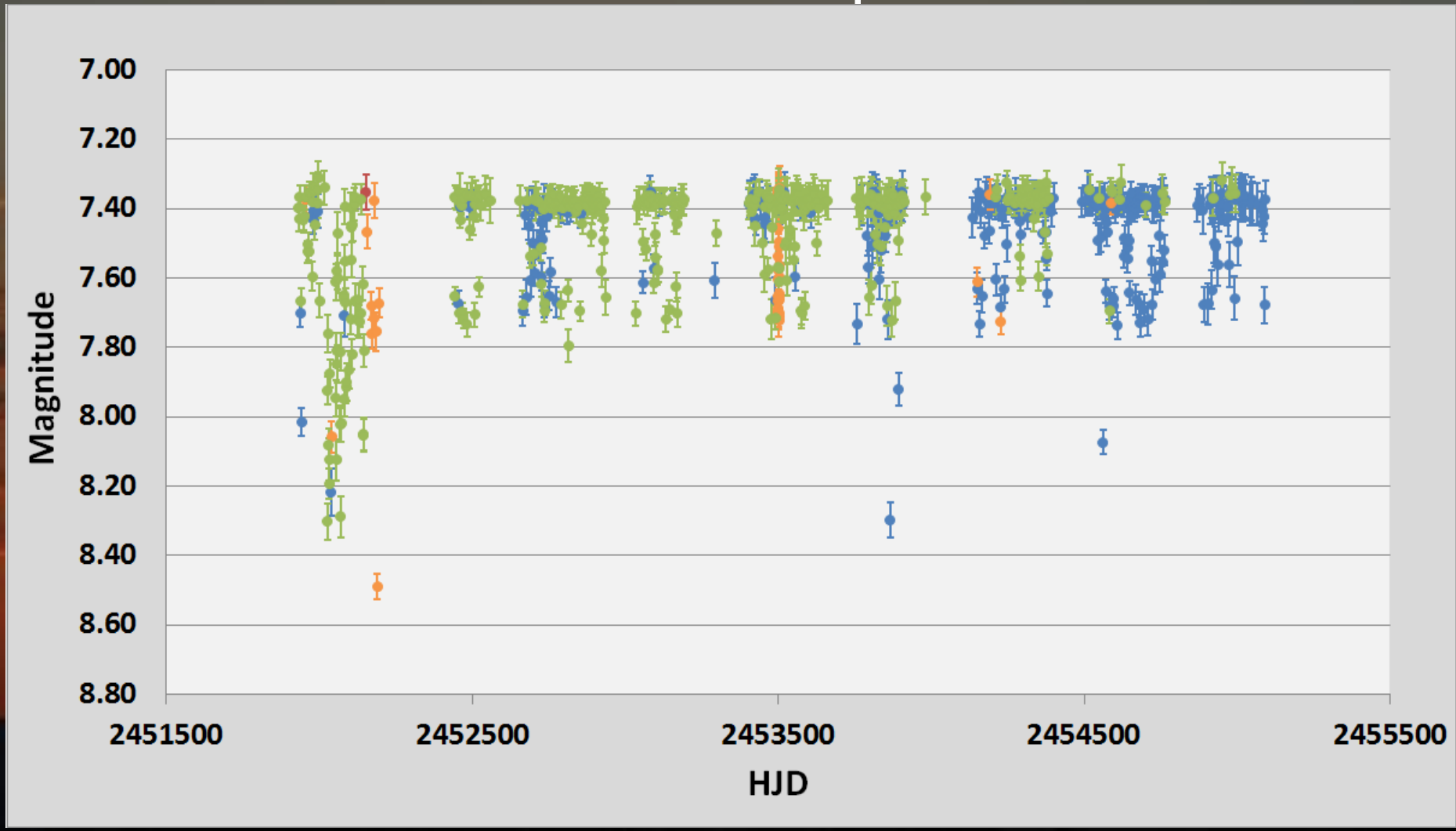
# ASAS Data

- ASAS V-band observations can be accessed through the AAVSO VSX web page, under External Links.
- Two plots are displayed, the first showing magnitude versus HJD and the second showing magnitude versus phase based on the light elements in VSX. Clearly the VSX period is incorrect.
- Observations can be downloaded as a text file suitable for importing into David Benn's VStar program or Excel for plotting and analysis.


ASAS 165753-3759.9 165751-3759.7 165752-3759.5 165752-3759.8
V
7.00
7.50
8.00
8.50
2000
3000
4000
HJD
ASAS 165753-3759.9 165751-3759.7 165752-3759.5 165752-3759.8
V
P= 1.29484
7.00
7.50
8.00
8.50
-0.0
0.5
1.0
Phase
GetData
Map
Image
DSS
USNO
2MASS
SIMBAD
ROSAT
Try period:
1.29484

# All ASAS Observations Plotted in VStar

## Jan 2001 to Sep 2009



# ASAS Data trimming

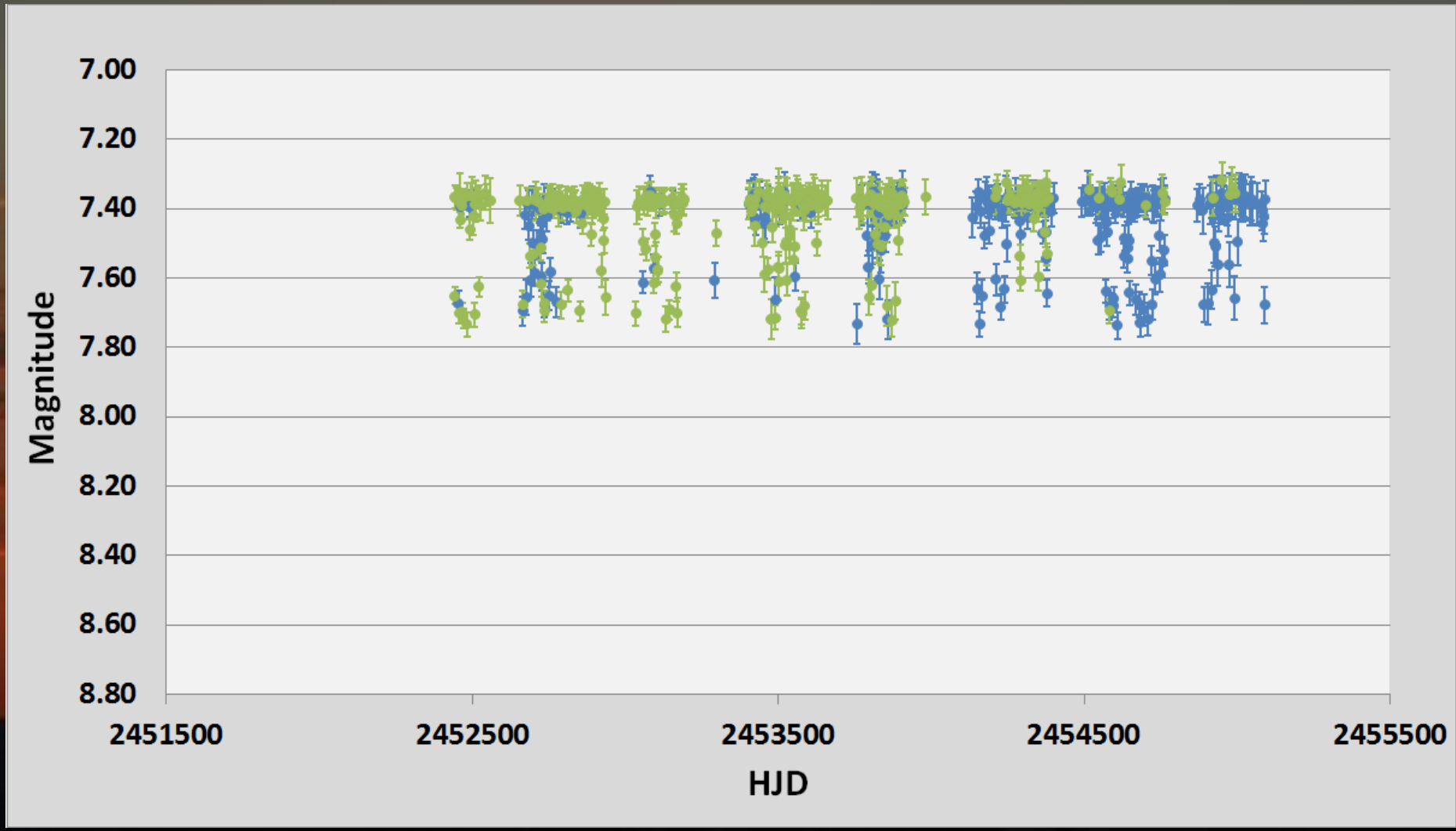
Need to remove some erroneous data points before proceeding with analysis:

1) removed earliest block of data which was often affected by saturation resulting in underestimated magnitudes. After 2001 the lenses were deliberately defocused to avoid saturation.

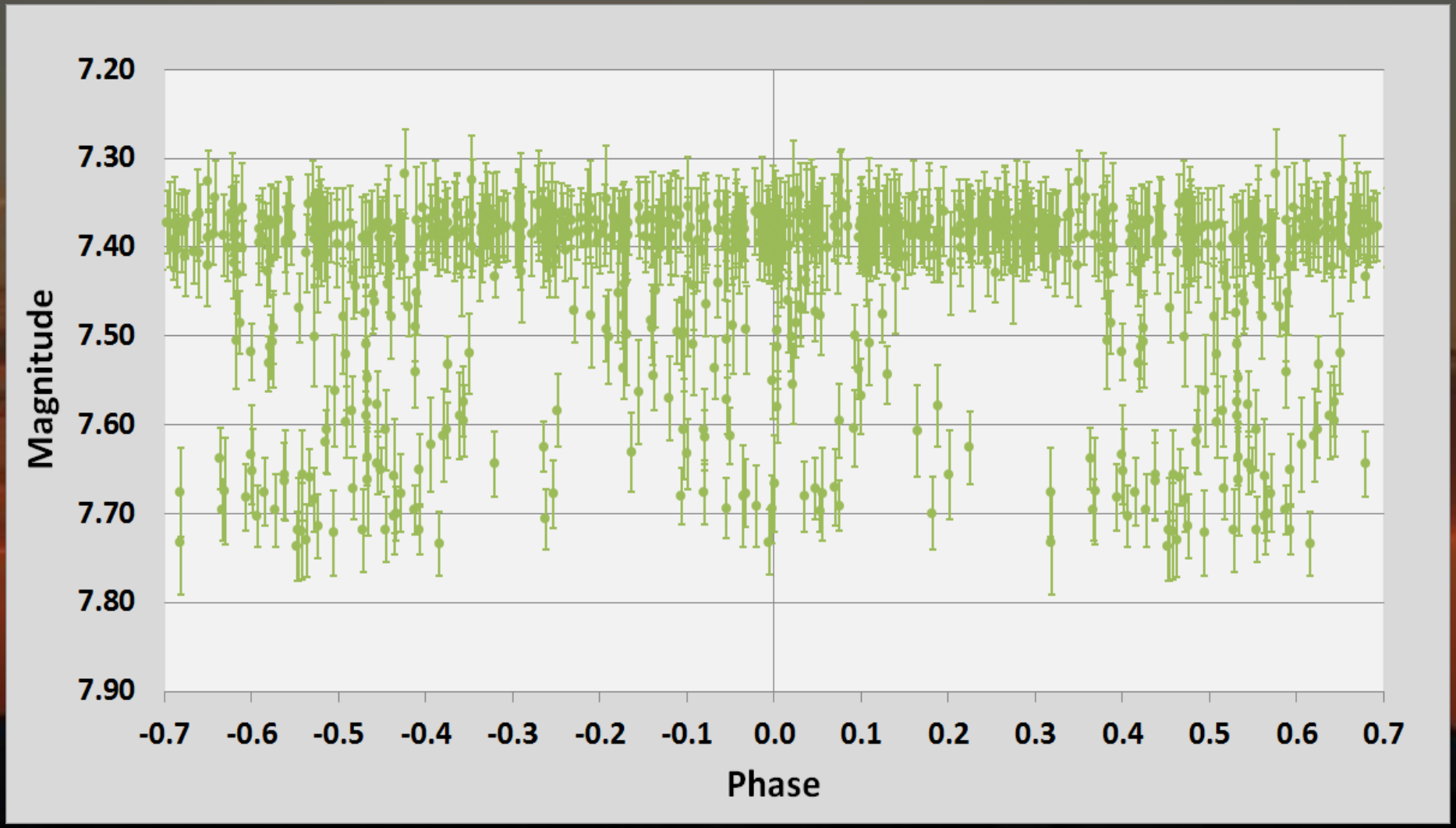
2) removed orange data set with only a few observations.

3) removed remaining observations fainter than 7.8 magnitude.

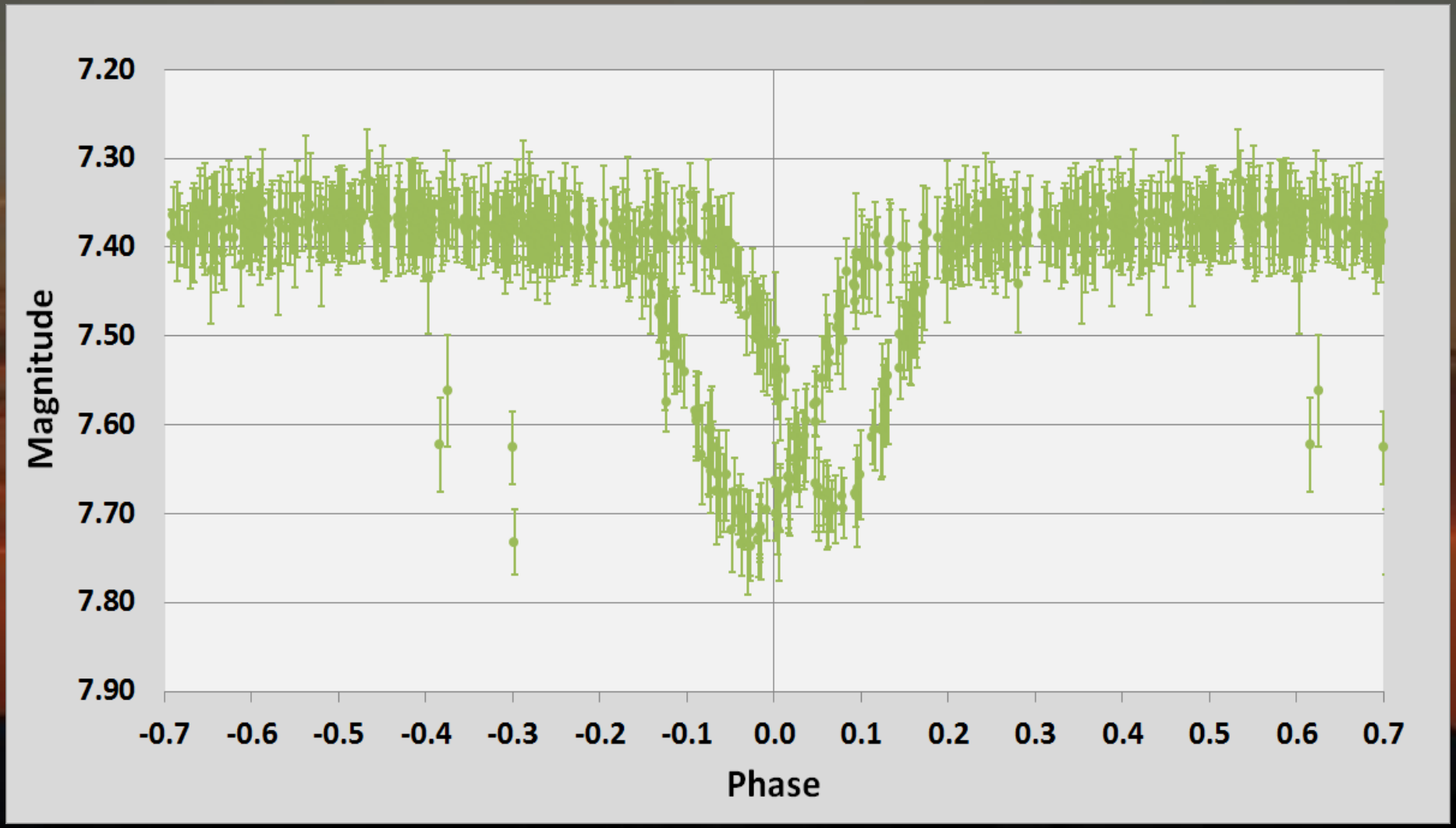
# Deleted datasets 1 and 4, then all observations before 2002, and 4 obviously discrepant points.



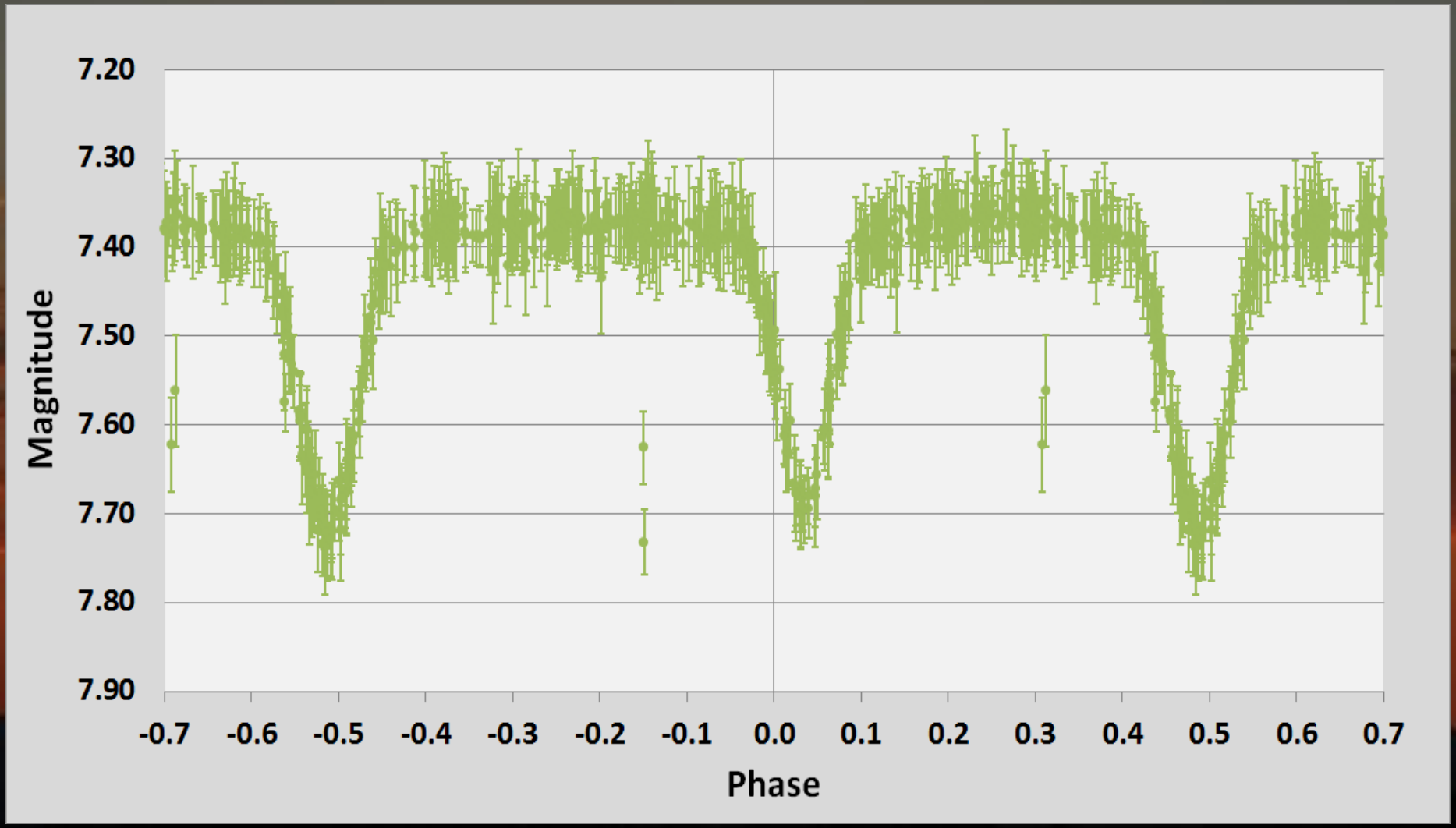
# Phased with GCVS light elements, period 1.29484 d, epoch HJD 2443285.794, period is clearly wrong.



# Date Compensated Discrete Fourier Transform (DCDFT) analysis in VStar found strongest signal at 2.1706 d period, still wrong but better.



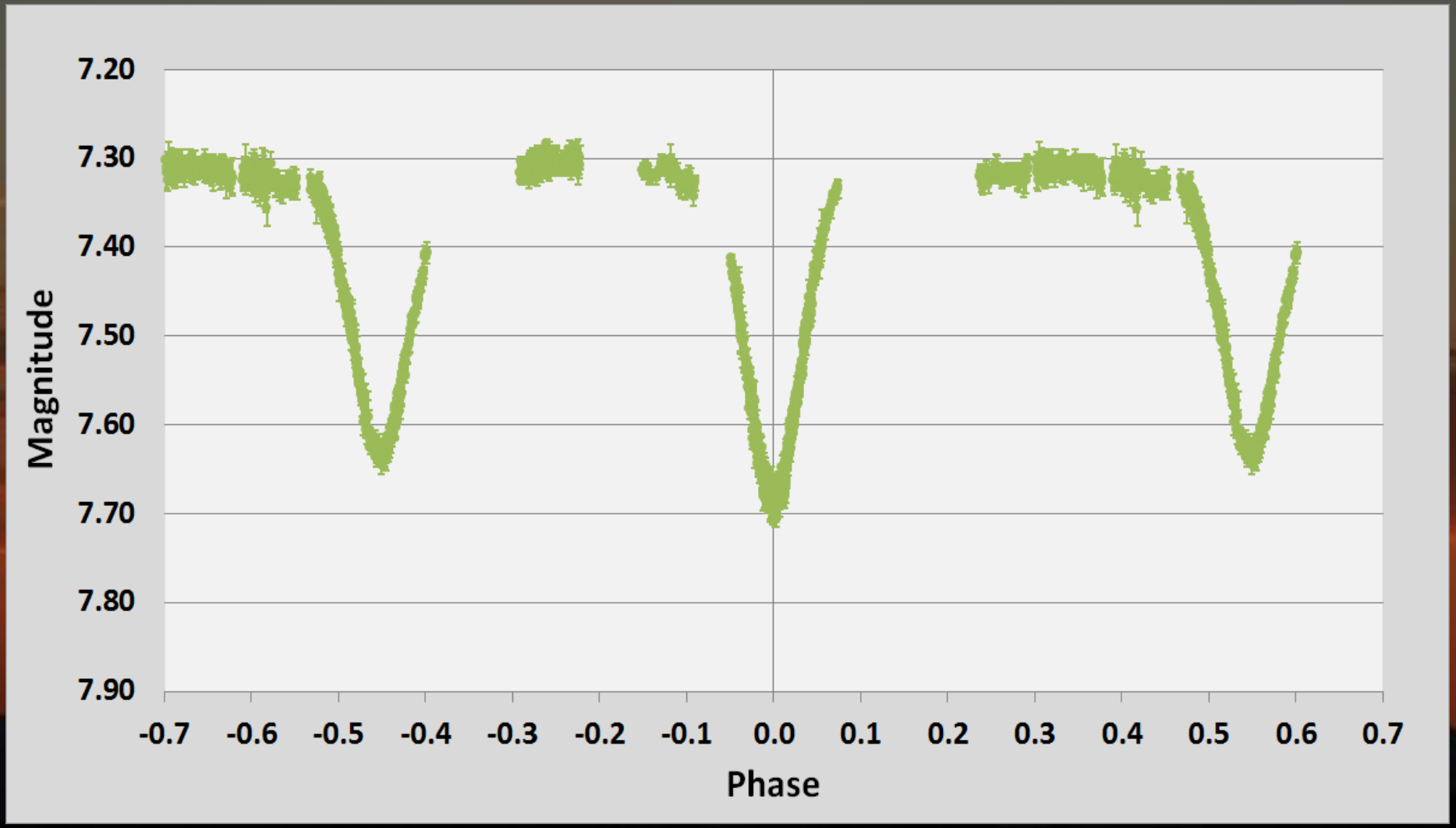
# Try 4.3412 day period – bingo!
# EA binary in an eccentric orbit, but epoch was for secondary eclipse.



# New period allowed Neil to plan for and observe 4 primary and 2 secondary eclipses between September 2015 and June 2017:

| HJD of min | error | Eclipse | Cycle | O-C (d) | error |
|---|---|---|---|---|---|
| 2457268.933 | 0.007 | S | -71.5 | 0.214 | 0.008 |
| 2457283.916 | 0.007 | P | -68 | 0.003 | 0.009 |
| 2457564.133 | 0.006 | S | -3.5 | 0.213 | 0.008 |
| 2457579.108 | 0.006 | P | 0 | 0 | 0.006 |
| 2457909.047 | 0.006 | P | 76 | 0.004 | 0.007 |
| 2457922.068 | 0.007 | P | 79 | 0.001 | 0.008 |

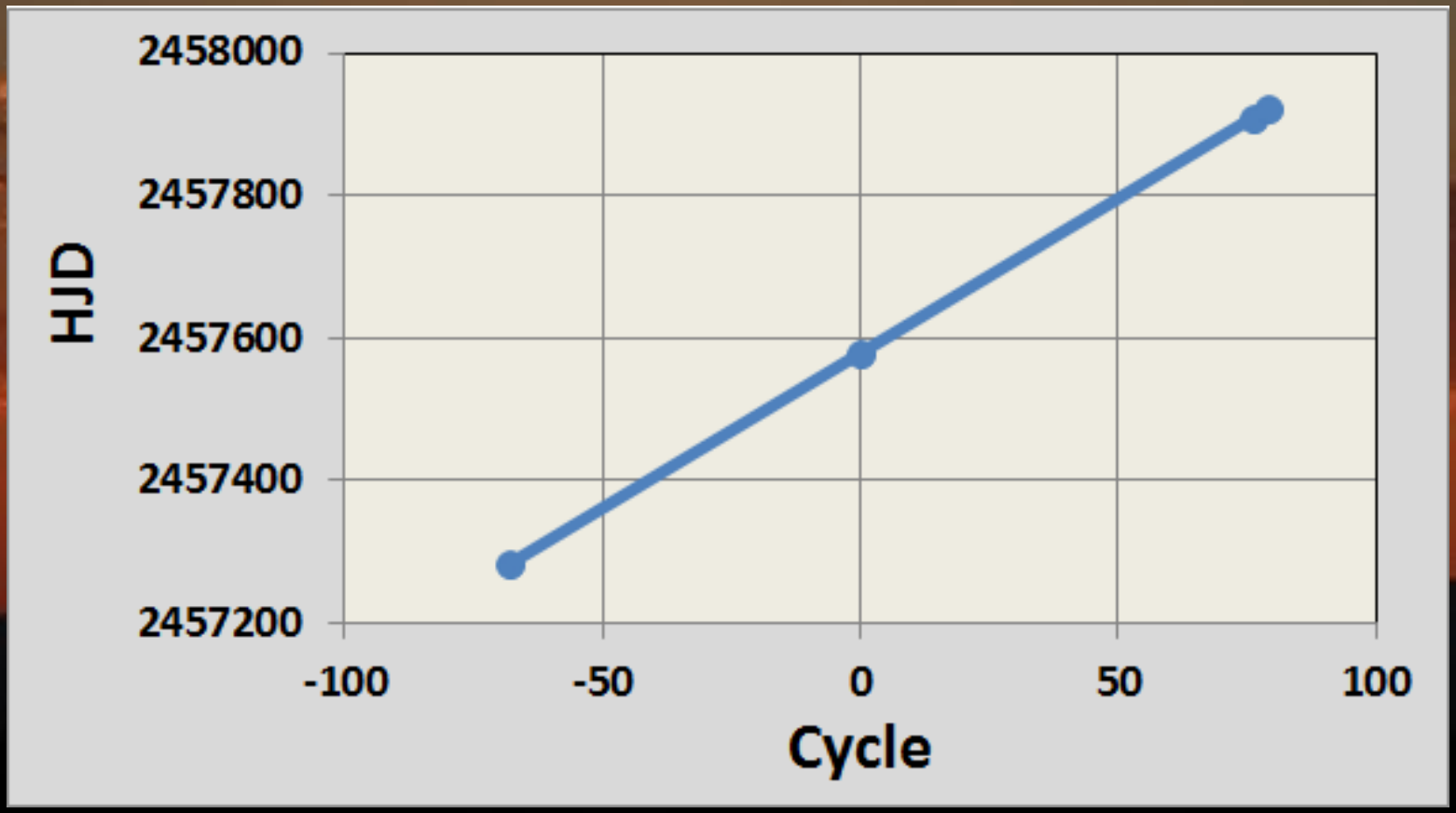
# Neil Butterworth Observations



# Light Element Refinement

Linear regression on primary minima times against cycle count gave the following light elements:

Primary Min = HJD 2457579.114(3) + 4.34119(4)E



Tom Richards used ASAS (2001 to 2009) and Integral-OMC (2003 to 2016) datasets to derive new times of minimum for 4 primary and 4 secondary eclipses.

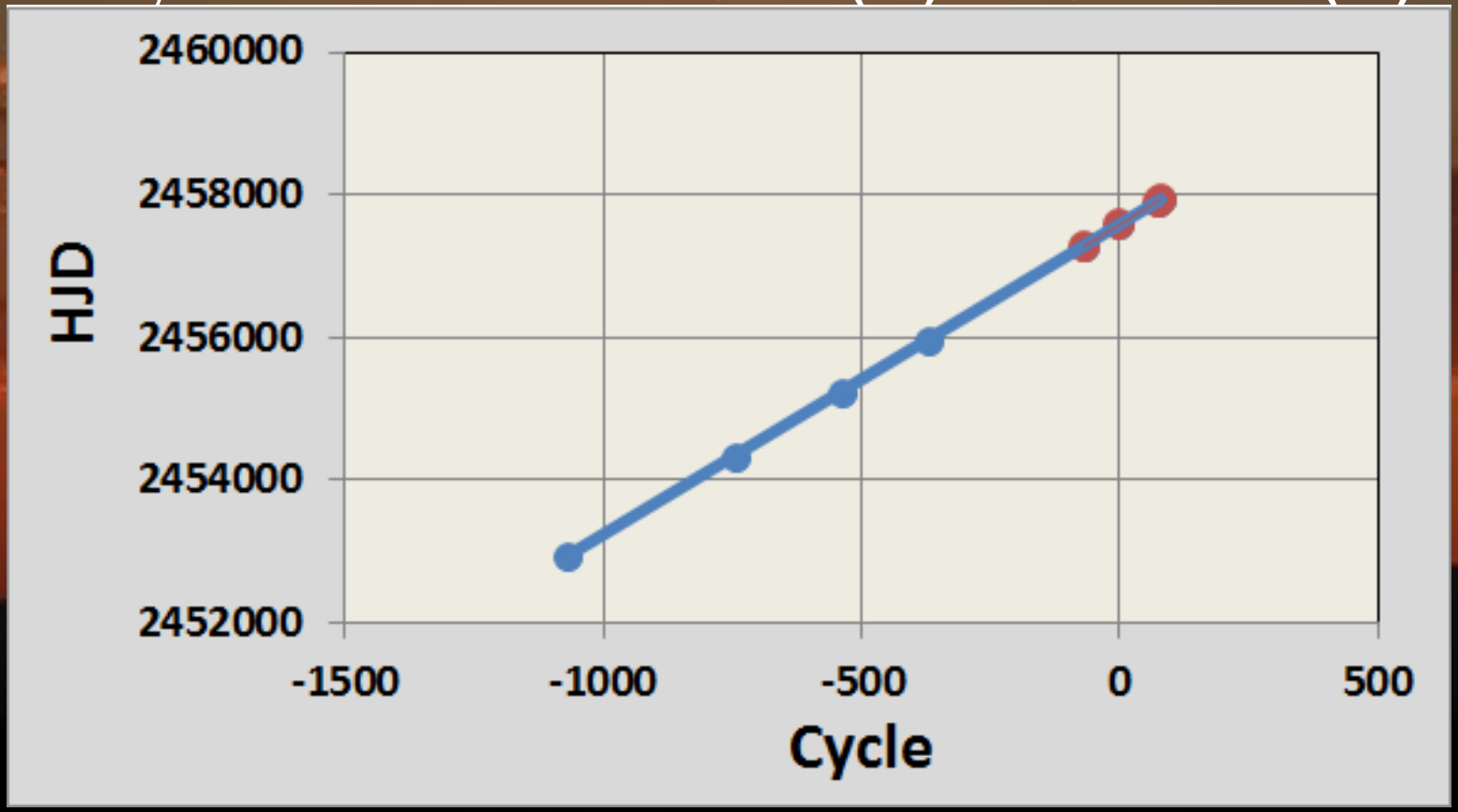
| HJD of min | error | Eclipse | Cycle | O-C (d) | error |
|---|---|---|---|---|---|
| 2452925.3884 | 0.0002 | P | -1072 | 0.047 | 0.006 |
| 2452927.7501 | 0.0010 | S | -1071.5 | 0.238 | 0.006 |
| 2454344.9487 | 0.0004 | P | -745 | 0.035 | 0.006 |
| 2454347.3233 | 0.0010 | S | -744.5 | 0.239 | 0.006 |
| 2455247.8954 | 0.0002 | P | -537 | 0.012 | 0.006 |
| 2455250.2880 | 0.0002 | S | -536.5 | 0.234 | 0.006 |
| 2455972.9098 | 0.0001 | P | -370 | 0.046 | 0.006 |
| 2455975.2731 | 0.0005 | S | -369.5 | 0.239 | 0.006 |

# Extending the time base of the linear regression improves the accuracy of derived light elements.

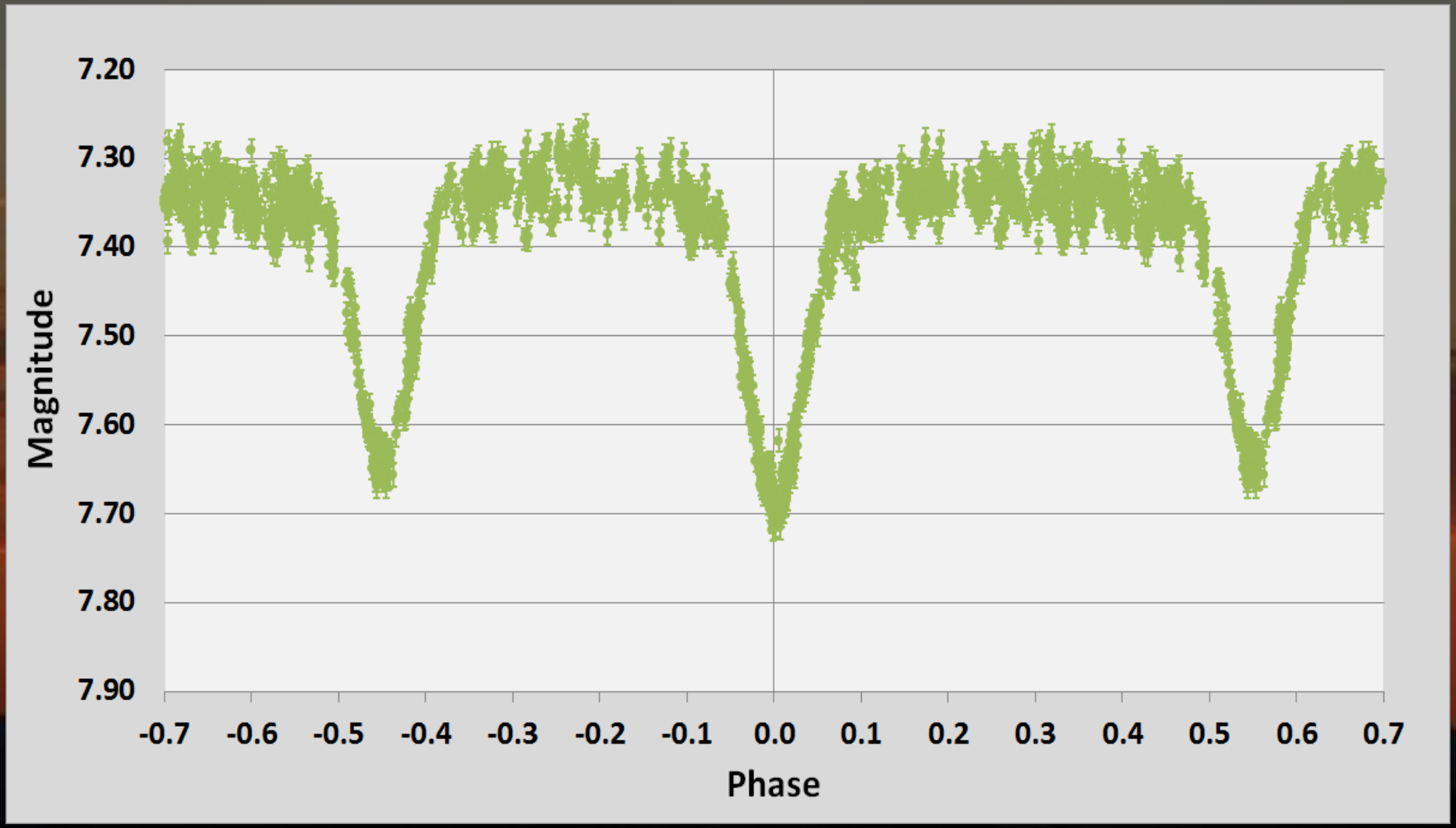
Red points: Butterworth: Blue points: ASAS and Integral-OMC

Primary = HJD 2457283.917(5) + 4.341164(11)E

Secondary = HJD 2457268.936(3) + 4.341182(6)E



# Integral-OMC light curve phased using the light elements shown on the previous slide



# Conclusions

V883 Sco is an EA binary in an eccentric orbit, not EB/KE as reported in the GCVS.

Our period estimate based on available CCD/DSLR minima data (ASAS, INTEGRAL-OMC and ours) is 4.341164(11) d, at variance with the GCVS period of 1.29484 d.

Secondary minimum is at phase 0.549 currently, but may change over time due to apsidal motion.

V883 Sco is worthy of further observations in coming years.