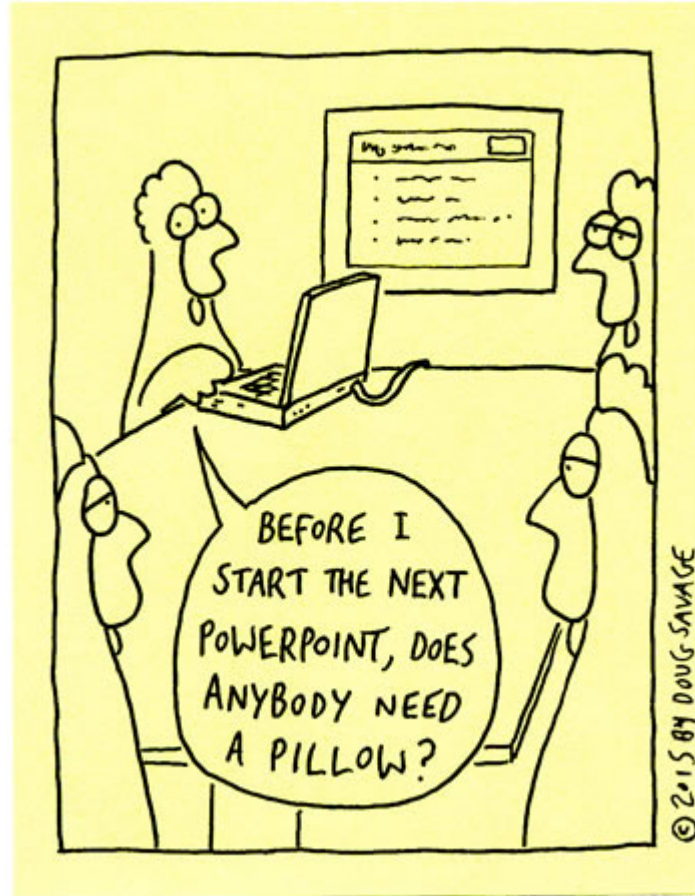


Savage Chickens

by Doug Savage





Variable Stars South

- Who we are
- What we do



Variable Stars South

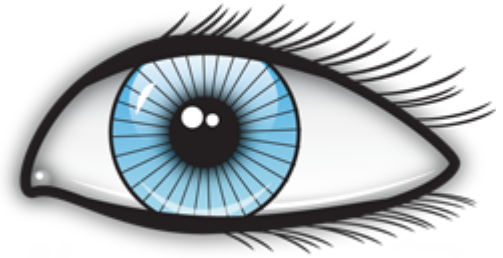
- We are a group of amateur astronomers.
- Mainly from Australia New Zealand with a few from other parts of the globe
- We study stars that vary in brightness for one reason or another.
- We are project-based
- We cooperate with professionals as well as publishing papers on our own.



Variable Stars South

- **Visual observers**

- Mk 1 eyeball
- Binoculars
- Telescope





Variable Stars South

- **Visual observers**

- Mk 1 eyeball
- Binoculars
- Telescope

- **Electronic detectors**

- CCD/DSLR
- Photoelectric photometer
- Spectrometer





Variable Stars South

- **Visual observers**
 - Mk 1 eyeball
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 - Telescope
- **Electronic detectors**
 - CCD/DSLR
 - Photoelectric photometer
 - Spectrometer
- **Data analysts**
 - Computer
 - Internet
 - Spreadsheet





Variable Stars South

- Anyone can join
- It's FREE
- We accept donations



Variable Stars South

Project based



Variable Stars South

- **Pulsating Variables**
 - Miras
 - Cepheids



Variable Stars South

- **Pulsating Variables**
 - Miras
 - Cepheids
- **Eclipsing Variables**
 - EA (Algol type)
 - EB (β Lyrae type)
 - EW (W Uma type)



Variable Stars South

- **Pulsating Variables**
 - Miras
 - Cepheids
- **Eclipsing Variables**
 - EA (Algol type)
 - EB (β Lyrae type)
 - EW (W UMa type)
- **Cataclysmic Variables**

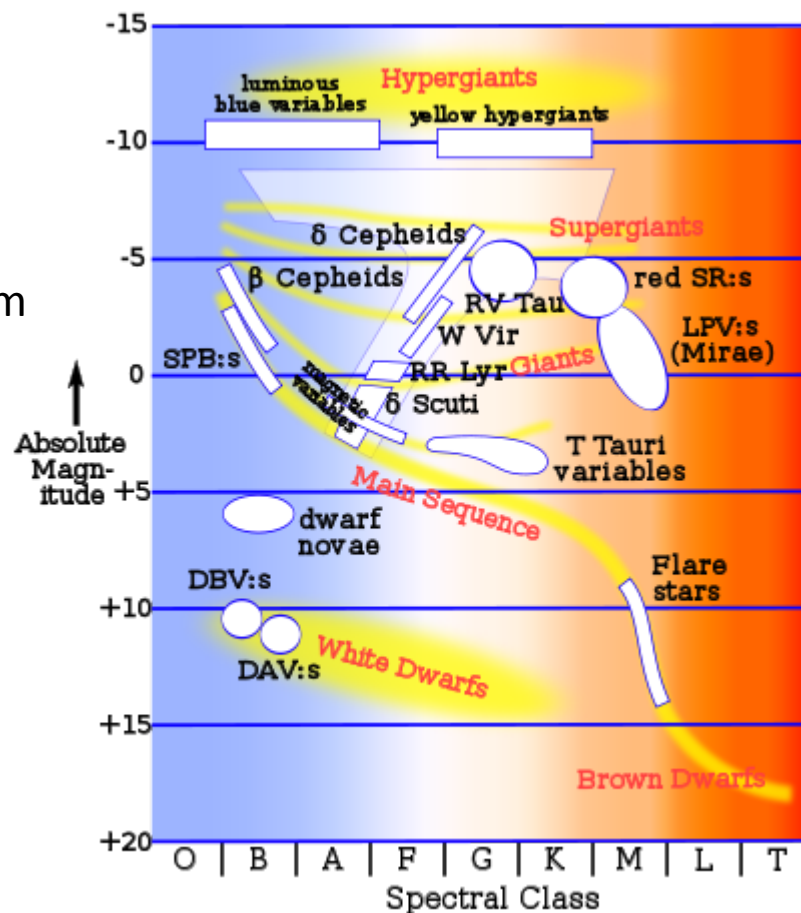


Variable Stars South

Project - Dual maxima Miras

Mira stars

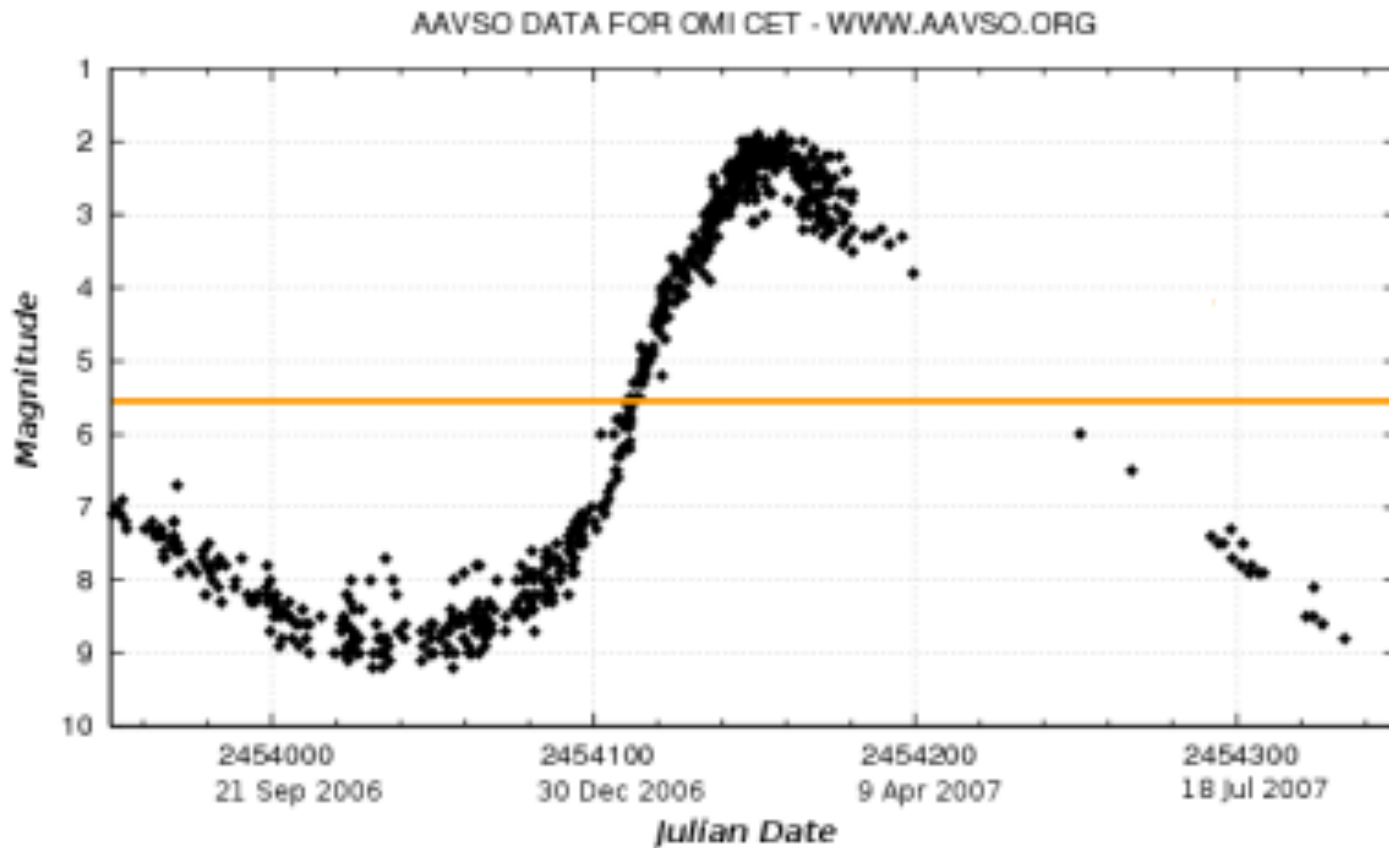
- Oxygen or carbon rich
- On asymptotic giant branch of the H-R diagram
- Very large – hundreds to thousands of R_{\odot}
- Cool – 3000 – 4000K
- Luminous – up to 10,000 L_{\odot}
- Large variability – from 2.5 to 7 magnitudes
- Long periods – hundreds of days
- Generally stable periods
- Subject to He shell flash





Variable Stars South

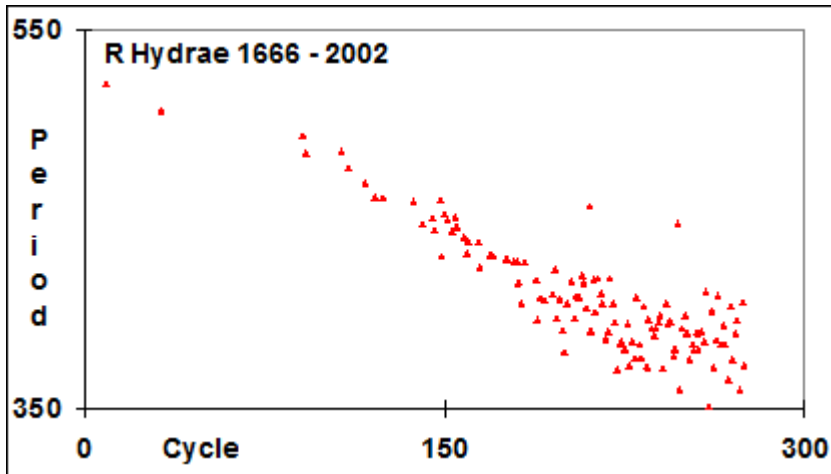
Light curve of Mira over 400 days





Variable Stars South

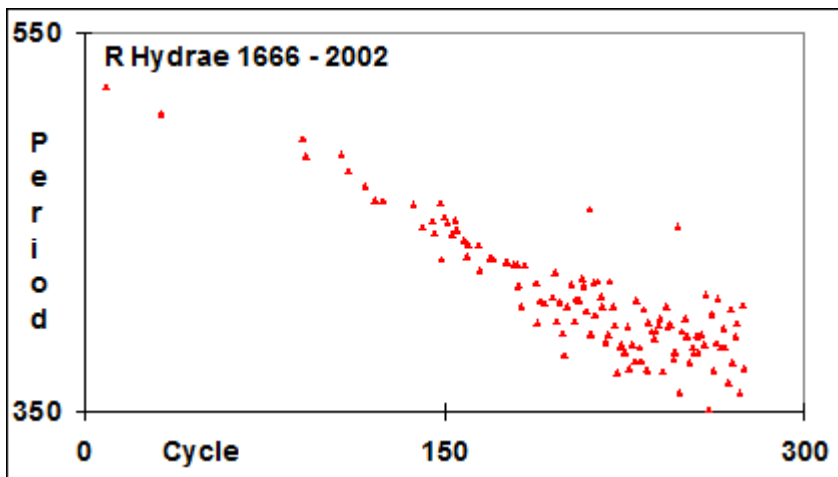
Period changes in R Hydrae since 1666



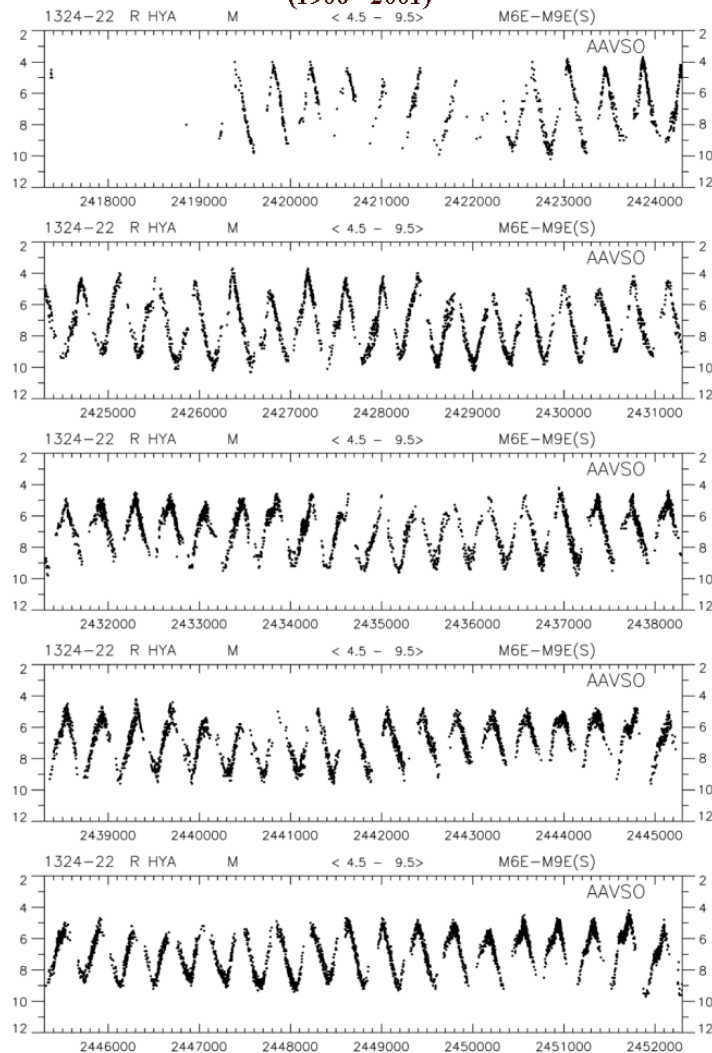


Variable Stars South

Period changes in R Hydrae since 1666



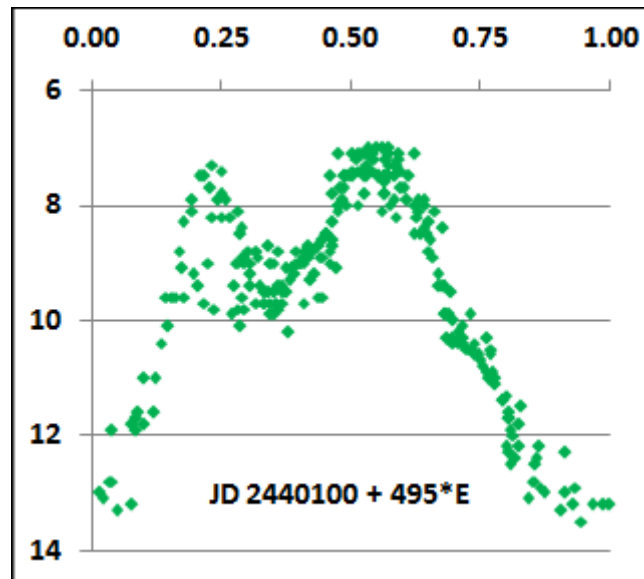
1324-22 R Hydrae
Observations from the AAVSO International Database
(1906 - 2001)





Variable Stars South

Visual light curve of R Normae made during the 1970s

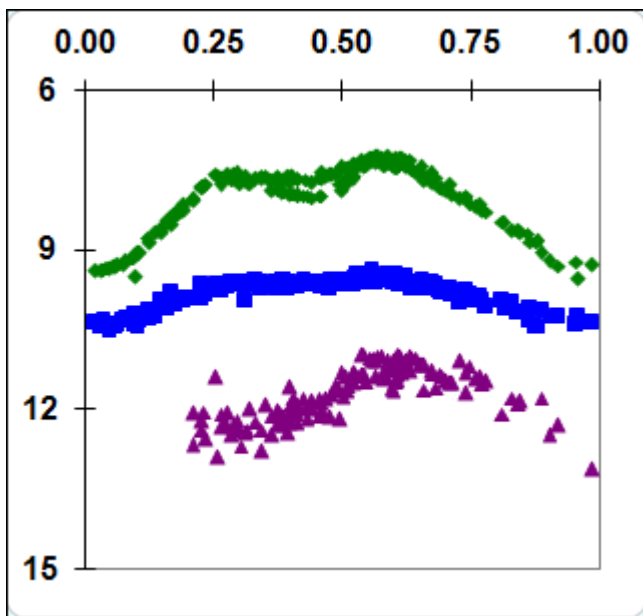


Graph from Stan Walker

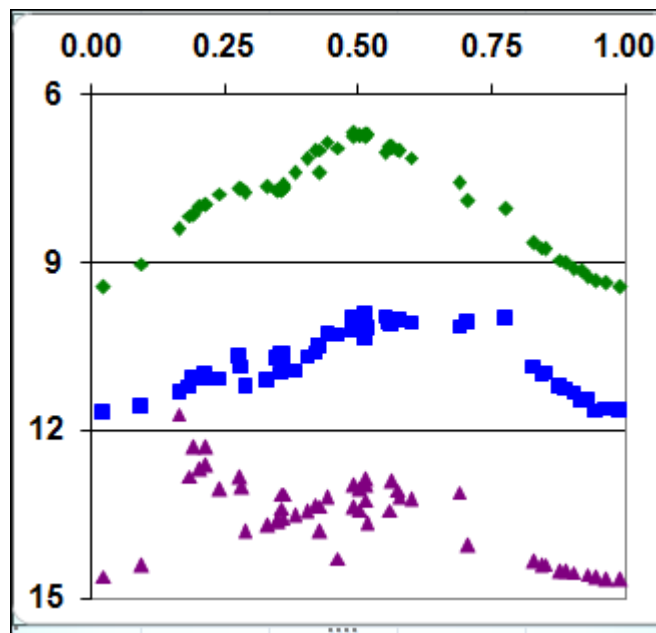


Variable Stars South

UBV light curves of BH Crucis (*Walker, W.S.G. JAAVSO Vol 37, 2009*)



Period 421 days (1970s)

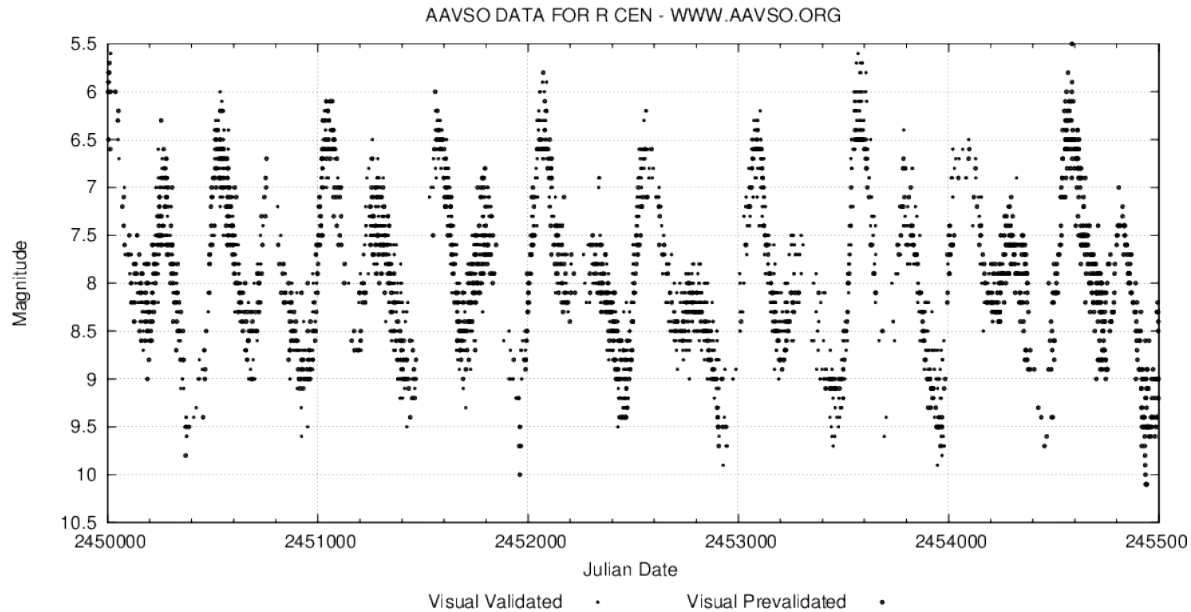


Period 525 days (2000s)



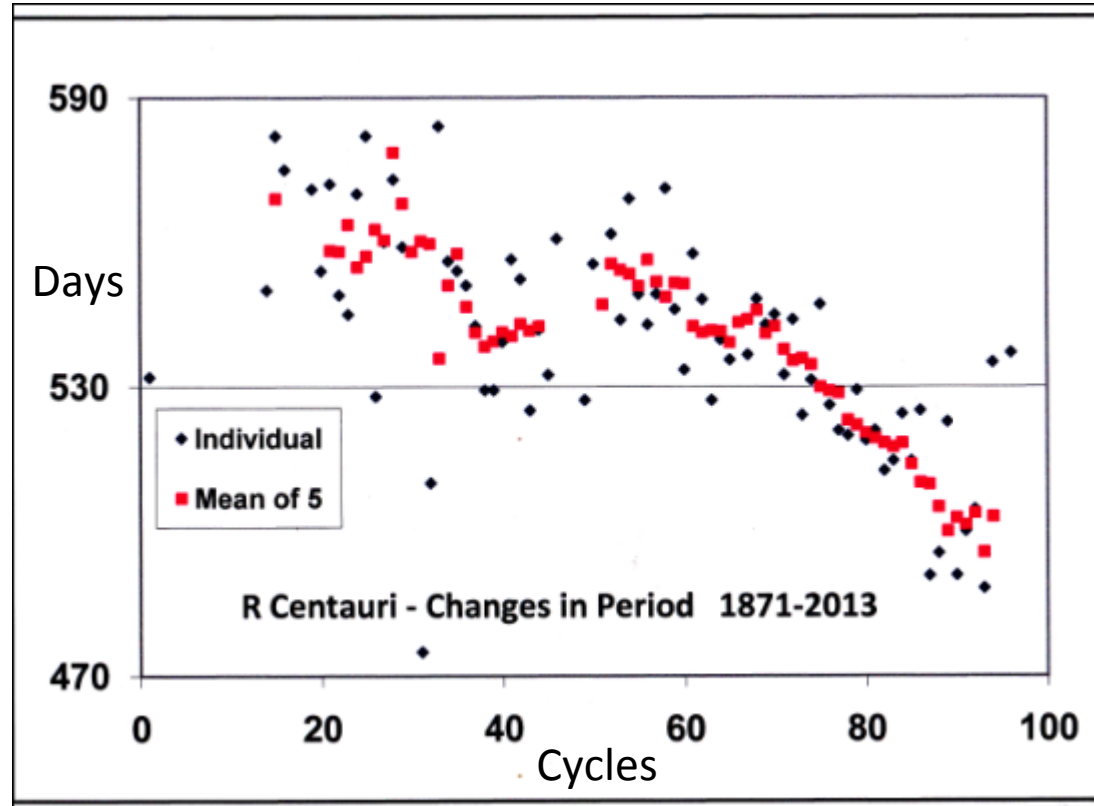
Variable Stars South

Light curve of R Cen over 5000 days





Variable Stars South



Data from AAVSO provided by Stan Walker



Variable Stars South

Star	RA	Dec	Max	Min	Period (days)	Type	B ₀	Comments
R Centauri	14 16 34	-59 54.8	5.8	9.0	500: V	Mira	1.21	Prototype
R Normae	15 35 57	-49 30.5	6.4	12.0	507	Mira	5.08	Prototype
BH Crucis	12 16 17	-56 17.2	6.5	9.8	530:V	Mira	6.25	Evolved
V415 Velorum	10 03 30	-46 49.2	9.6	11.8	413	Sra	~5	Strong duality
BZ Carinae	10 52 06	-62 29.0	11.7	13.8	427	SRa	-2.74	Very probable
TT Centauri	13 19 35	-60 46.7	9.0	13.4	462	Mira	1.90	Probable
UX Circini	14 20 52	-67 30.8	9.2	14.0	538	Mira	-6.12	Like R Cru now
BN Scorpii	17 54 10	-34 20.4	9.6	<15.0	616	Mira	-4.33	Probably not

List of southern dual-maxima target stars



Variable Stars South

Star	RA	Dec	Max	Min	Period (days)	Type	B ₀	Comments
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List of southern dual-maxima target stars

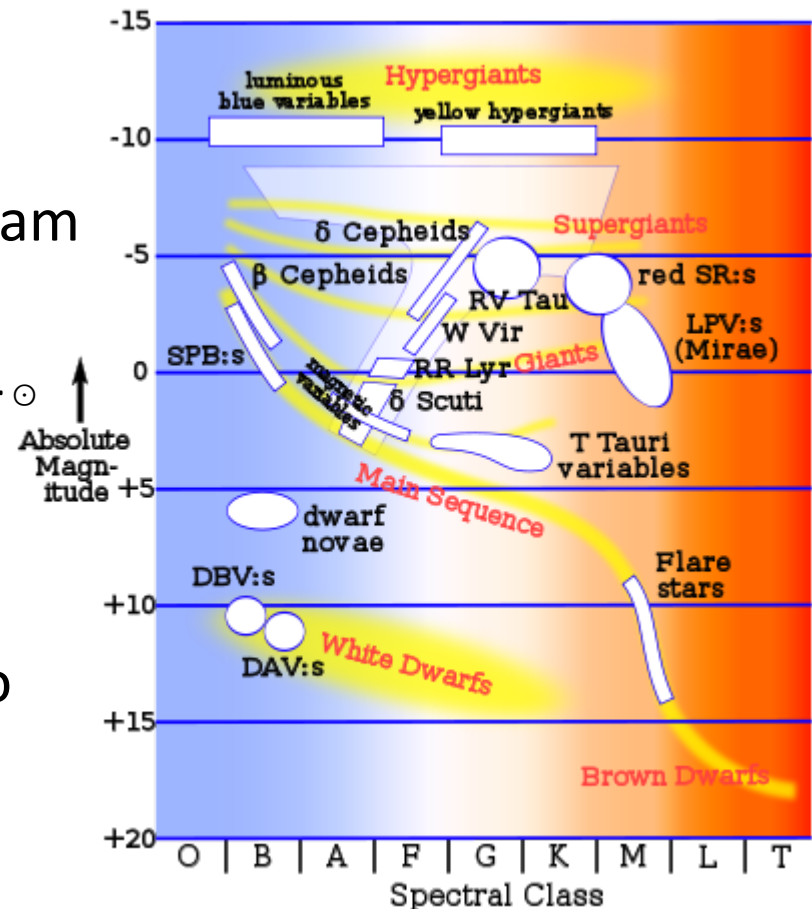
LX Cygni (dec +58) is an excellent northern hemisphere example of a Mira with a changing period



Variable Stars South

Project - Bright Cepheids

- Yellow or red supergiants
- On the Instability strip of HR diagram
- Massive $4-20 \times M_{\odot}$
- Very luminous – up to $100,000 \times L_{\odot}$
- Periods from 2 to 40 days
- Magnitude change ~ 1 mag
- Pulsating caused by κ (kappa) mechanism - He^{++} more opaque to radiation than He^{+}





Variable Stars South

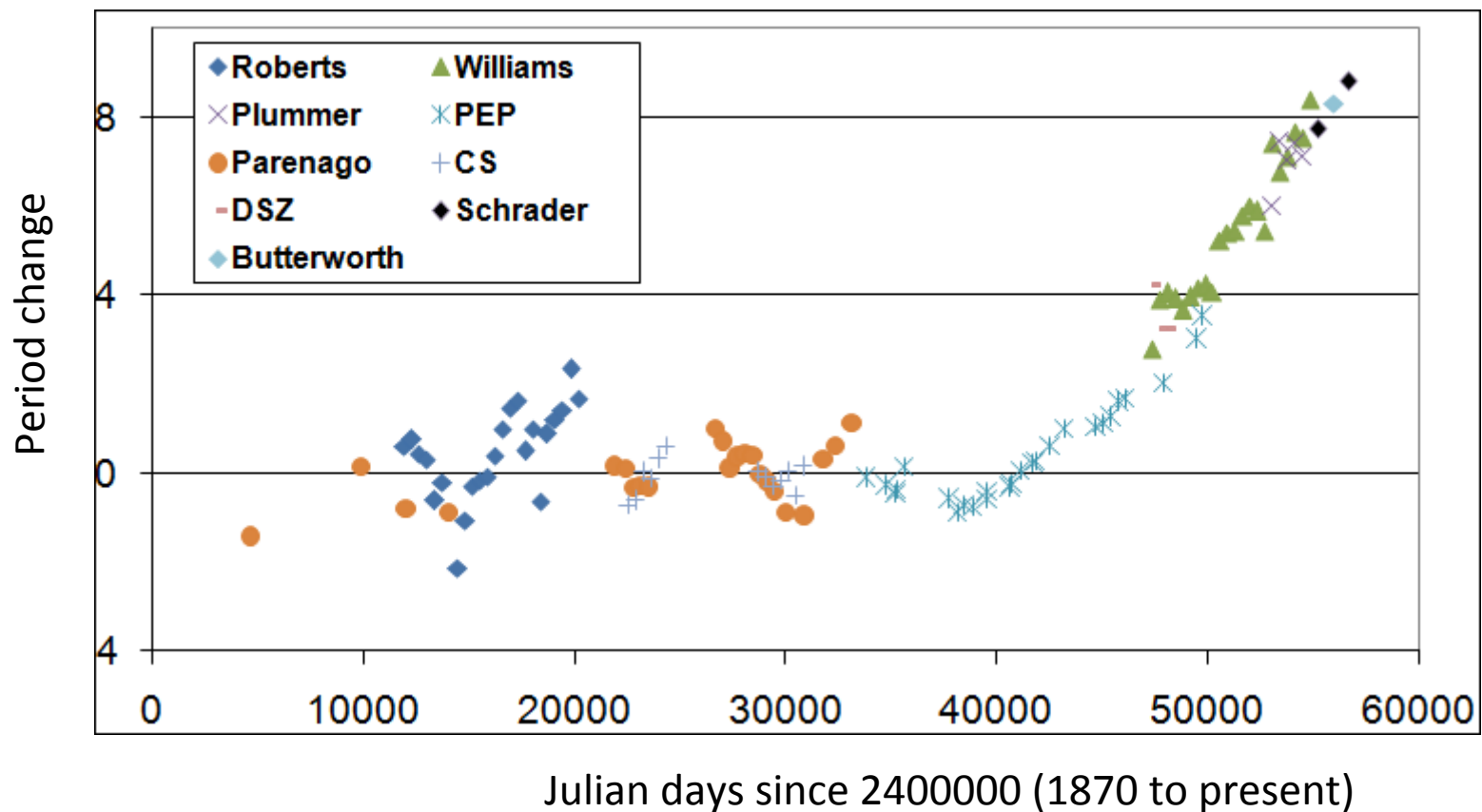
Project - Bright Cepheids

- Target stars suitable for DSLR photometry
- Magnitude < 9
- Good historical background
- Period > 10 days
- Goals over 5 to 10 years
 - Period changes
 - Amplitude, shape of light curve
 - Colour variations



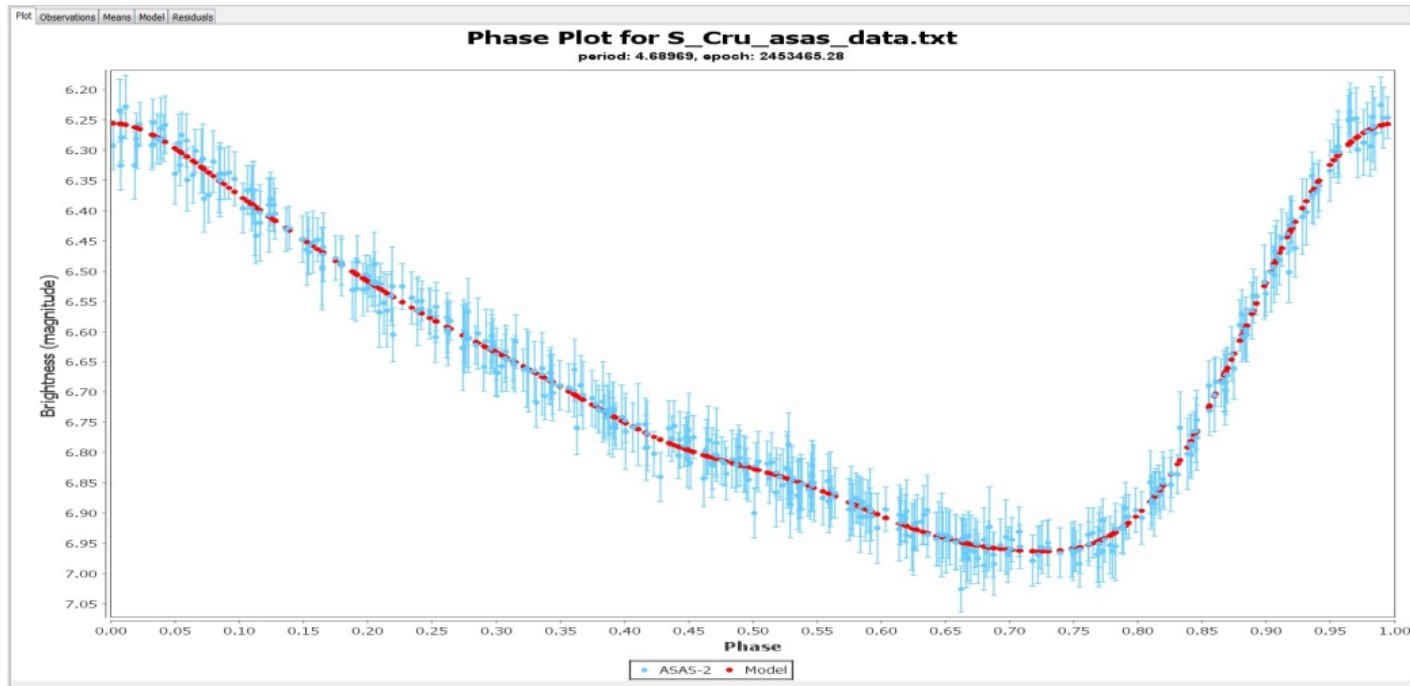
Variable Stars South

O – C diagram of $I(eI)$ Carinae JD 2412025 + 35.534 days





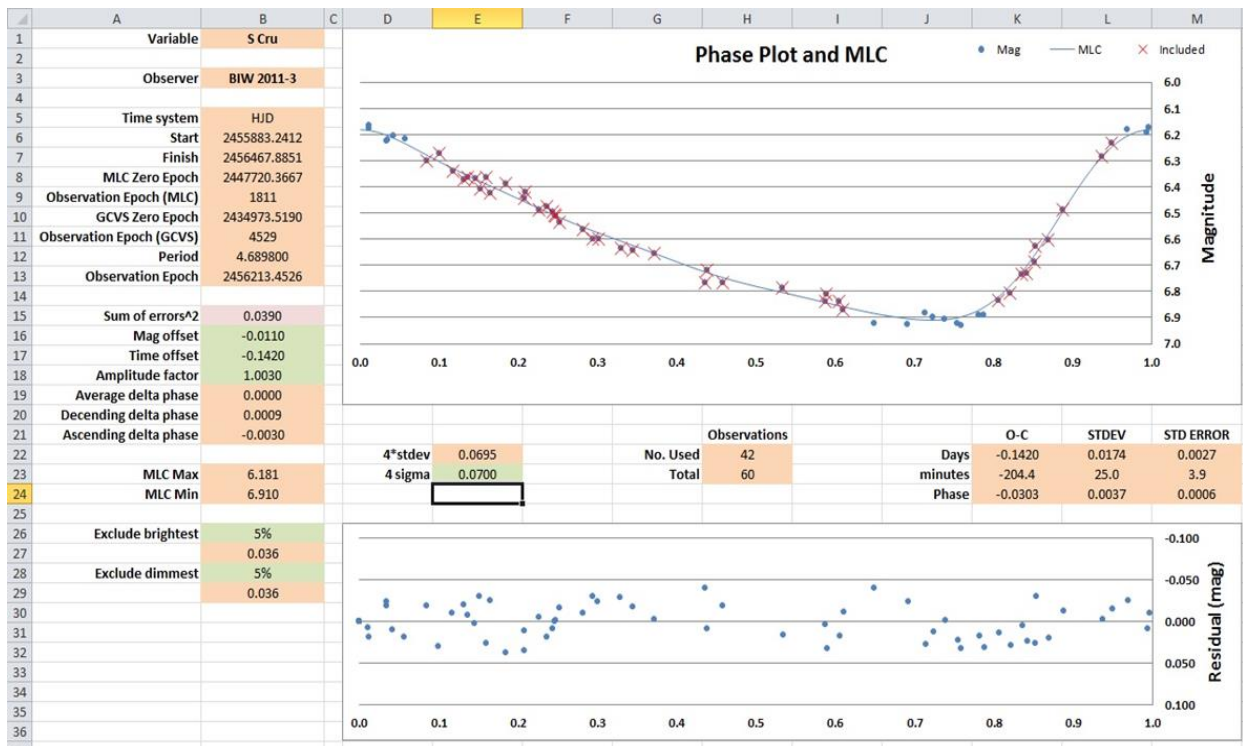
Variable Stars South



Model light curve (red) of S Cru from ASAS data (blue points)
Neil Butterworth



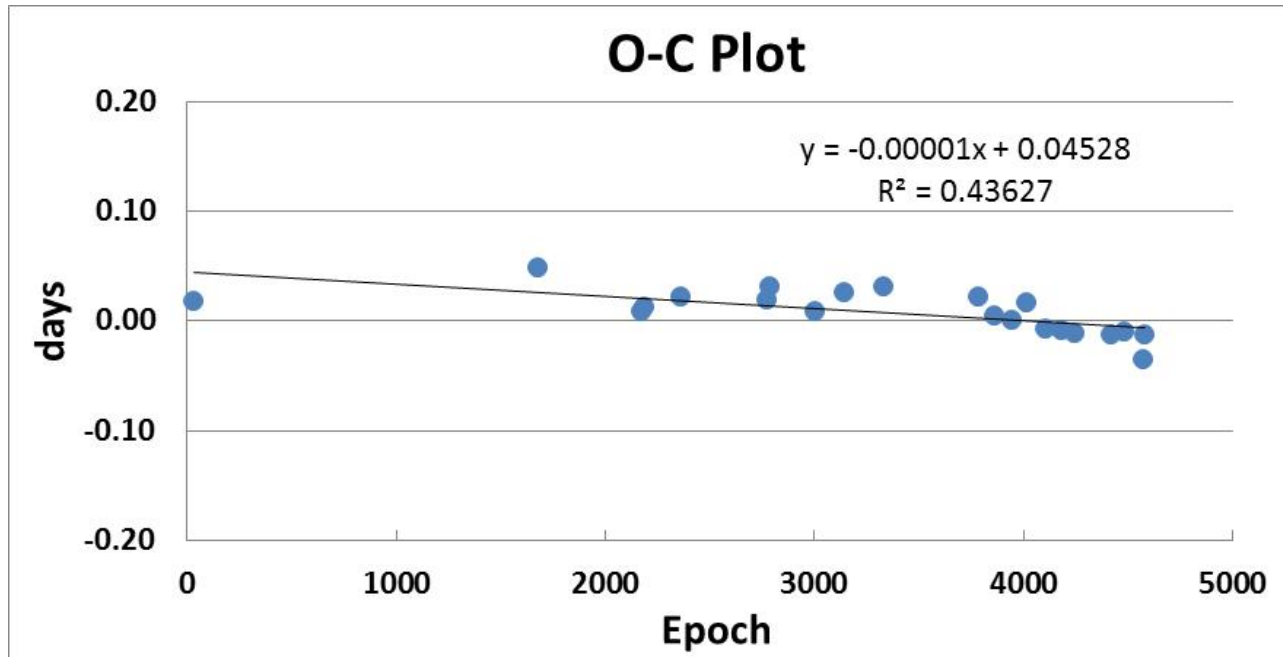
Variable Stars South



Excel spreadsheet for fitting MLC to seasonal light curve from DSLR photometry. (*Neil Butterworth*)



Variable Stars South

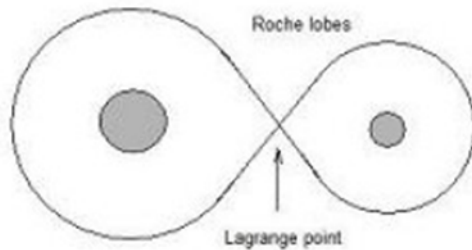


O – C for S Cru 1955 to 2013 showing no significant period change. (*Neil Butterworth*)



Variable Stars South

Eclipsing variables

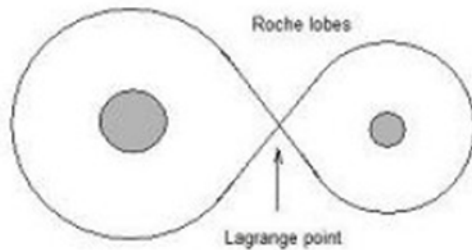


EA (Algol type) – detached, orbital plane 90° to line of sight. Do not change periods very much if at all. Mainly constant light between eclipses.

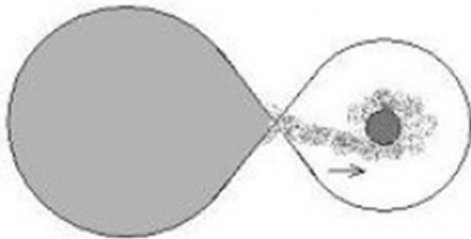


Variable Stars South

Eclipsing variables



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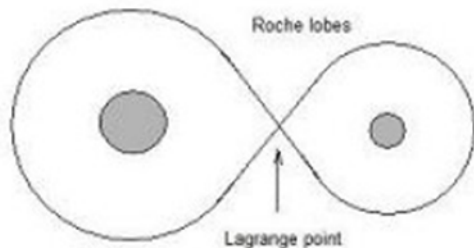


EB (β Lyrae type – mainly semi-detached with at least one ellipsoidal component. Sometimes difficult to specify exact times of eclipse. One star filling Roche lobe.

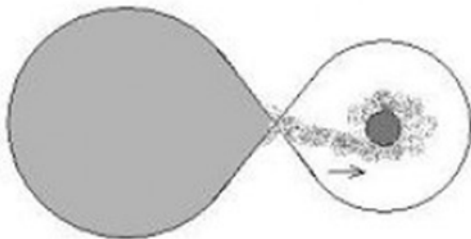


Variable Stars South

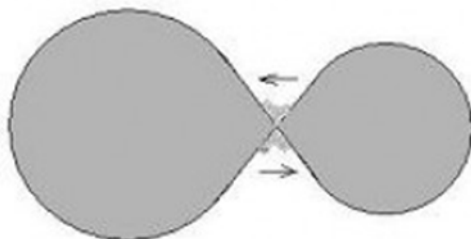
Eclipsing variables



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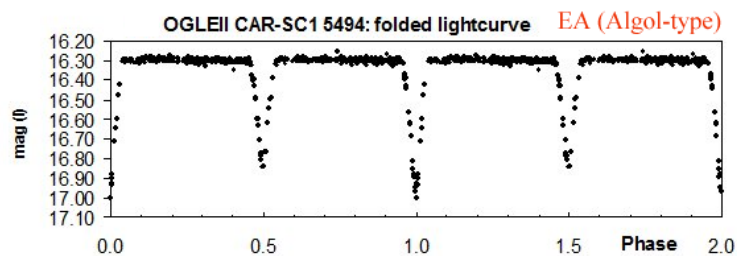
EB (β Lyrae type) - mainly semi-detached with at least one ellipsoidal component. Sometimes difficult to specify exact times of eclipse. One star filling Roche lobe.



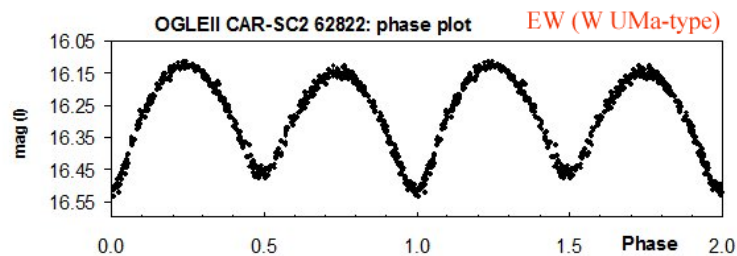
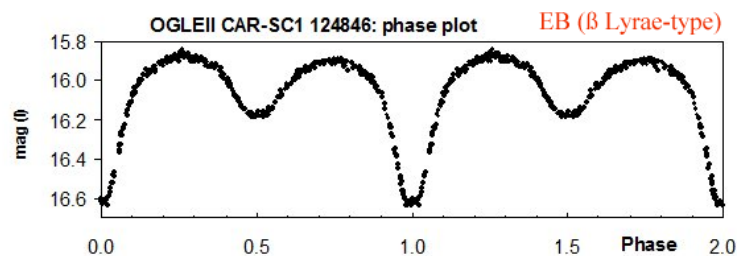
EW (W UMa type) – ellipsoidal components both overflowing Roche lobe. Depths of primary and secondary eclipse nearly equal, periods < 1 day. No constant light between eclipses.



Variable Stars South



Typical light curves of eclipsing binaries.
(from <http://www.vs-compas.belastro.net/bulletin/issue/2/p6>)





Variable Stars South

Eclipsing variables

Primary eclipse

Brighter star is eclipsed by the fainter one. Eclipse is deepest.

Secondary eclipse

When fainter star is eclipsed by the brighter one.

An eclipse is **total** if one star is completely obscured by the other for a period of time.

Periods can change due to orbital precession, mass loss (wind) or mass transfer between the stars.



Variable Stars South

Project – SPADES

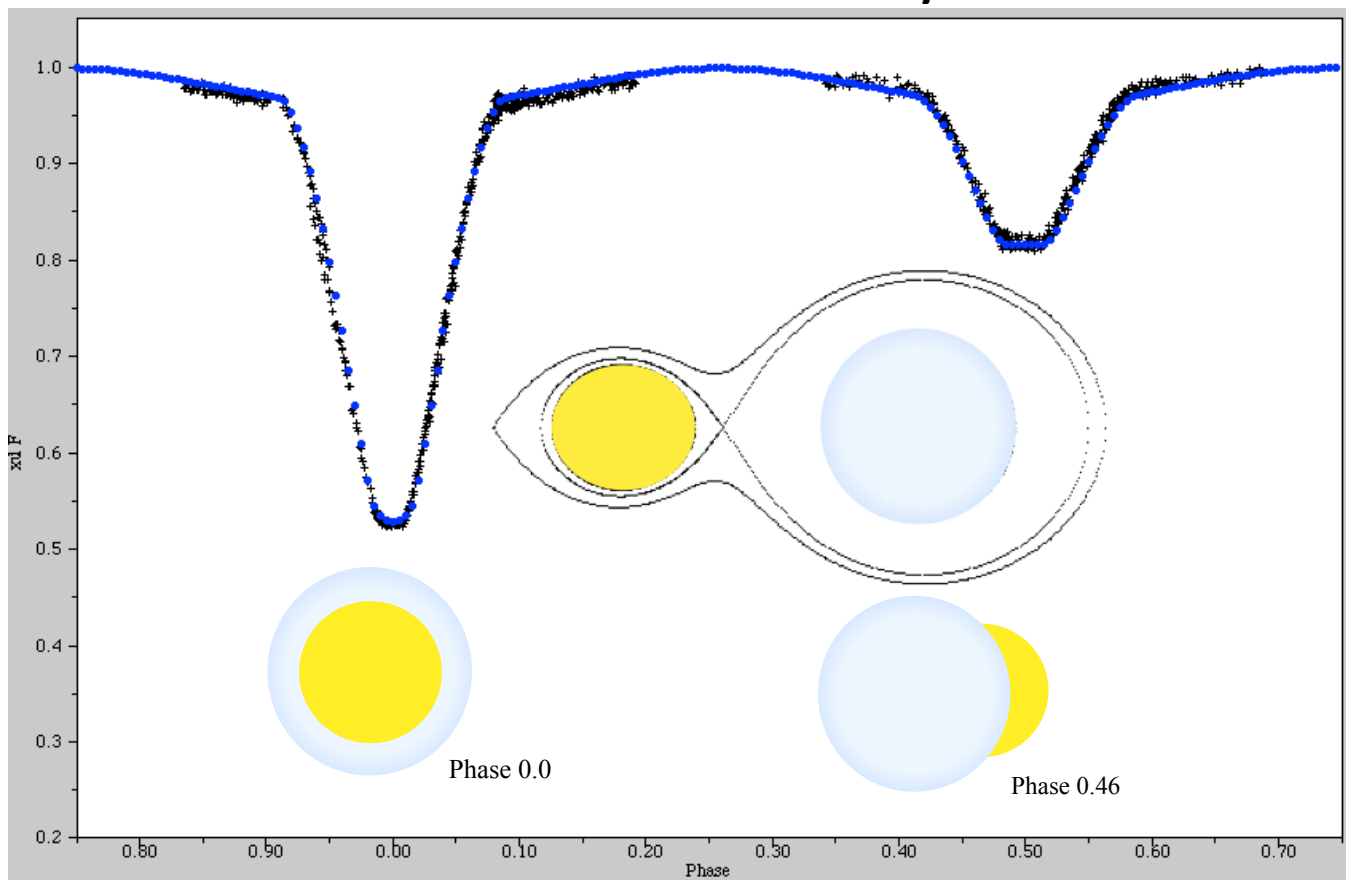
Search for Planets Around Detached Eclipsing Systems

A pro-am project working with Simon O'Toole – Australian
Astronomical Observatory



Variable Stars South

V0626 Sco – an EA binary



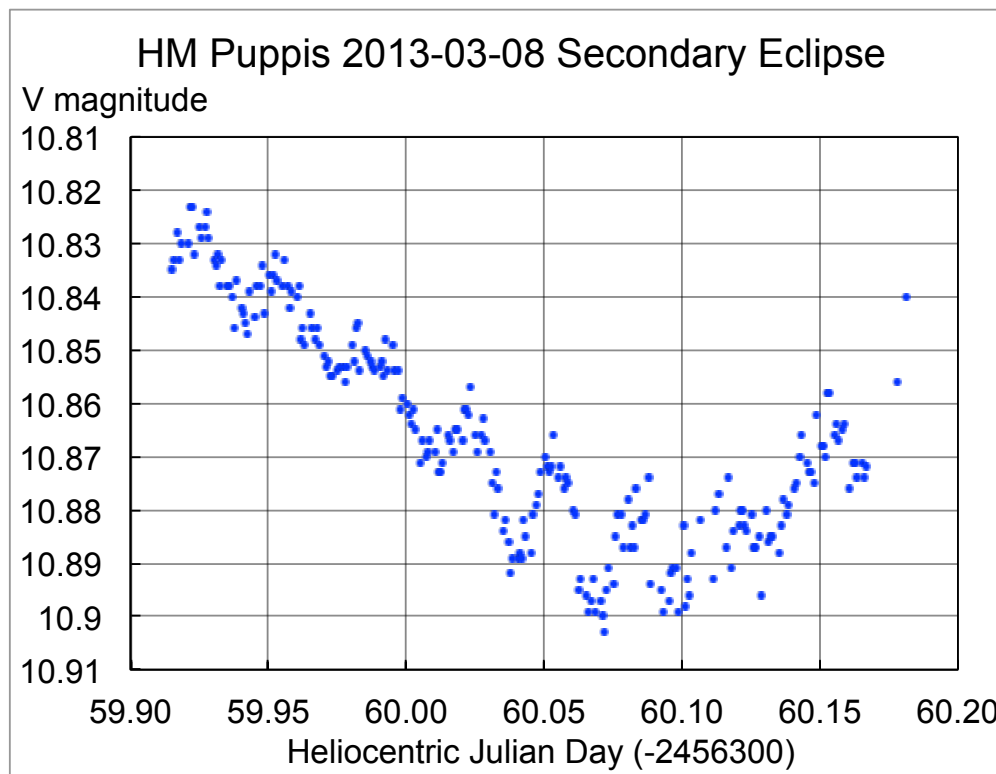
Light curve of V0626 Sco an EA binary with best fit line from Binary Maker 3 software – *David Moriarty*



Variable Stars South

Some EAs were found to have small oscillations similar to those of a delta Scuti star.

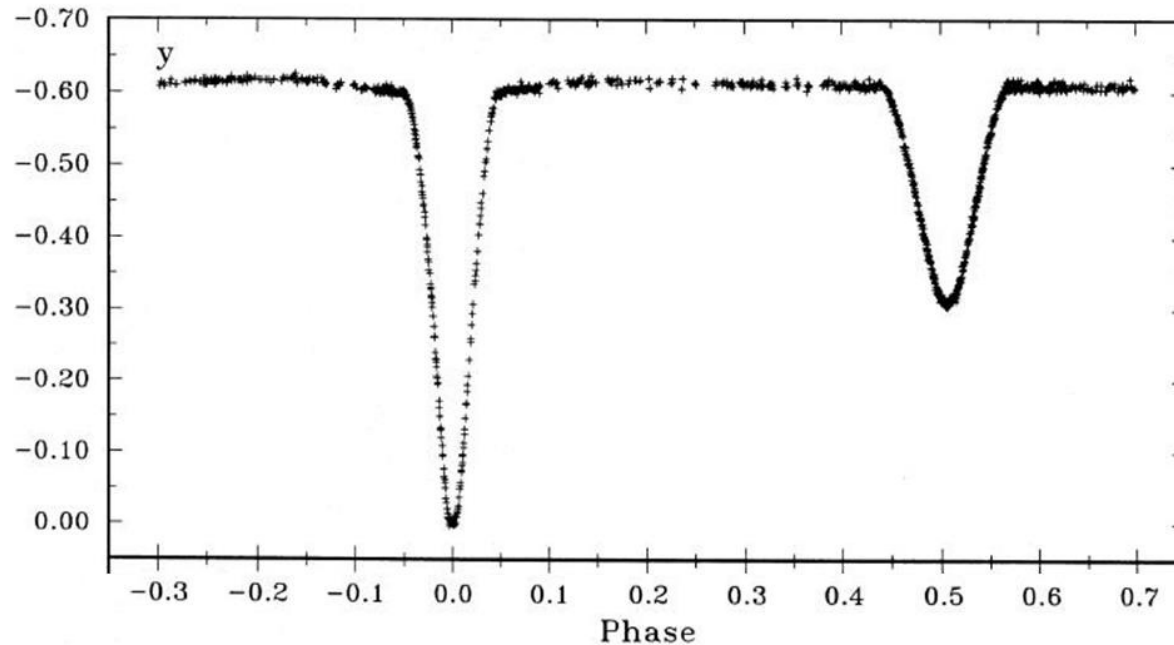
(David Moriarty)





Variable Stars South

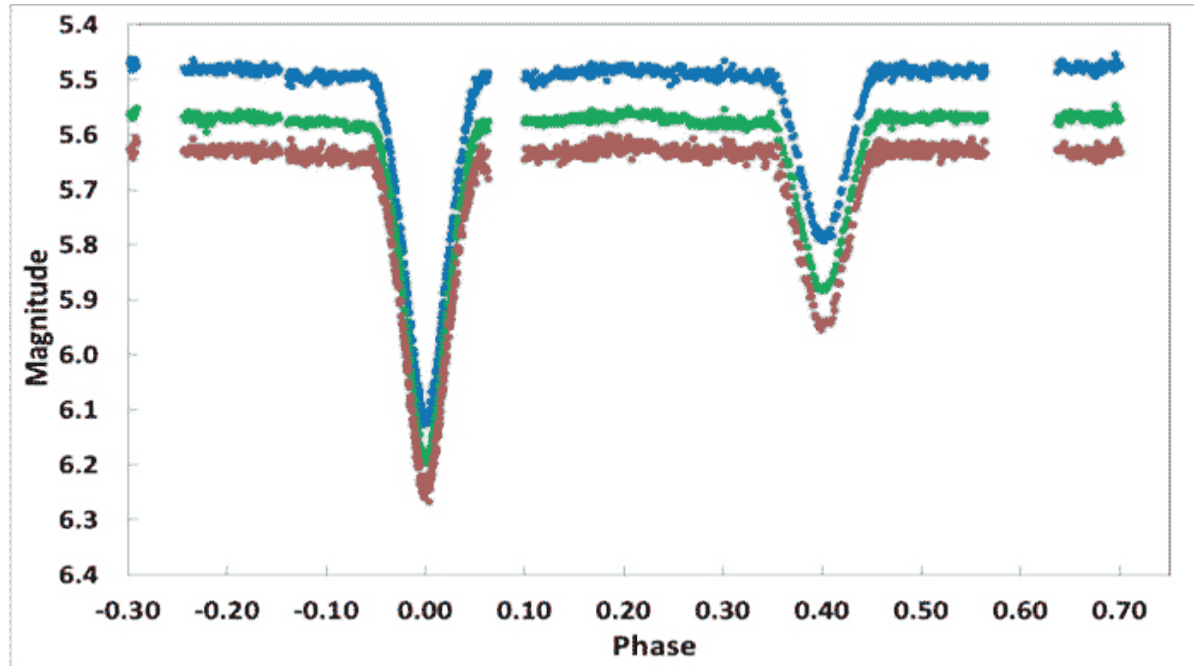
GG Lup (1993)



Light curve of eclipsing binary GG Lup 1985 (*Andersen J., Clausen J.V., Giménez A., 1993 A&A, 277, 439*)



Variable Stars South

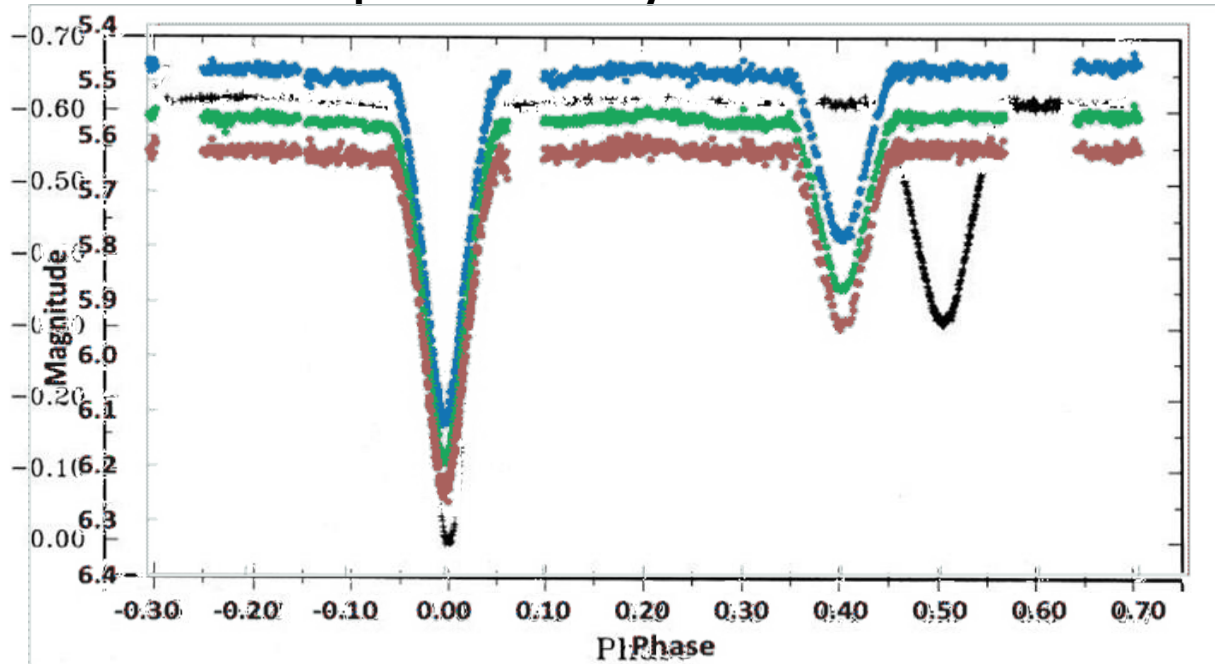


Light curve of eccentric eclipsing binary GG Lup 2015 (*Budding E., Butland R., Blackford M., MNRAS (April 21, 2015) Vol. 448 3784-3796*).



Variable Stars South

GG Lup - an EB binary





Variable Stars South



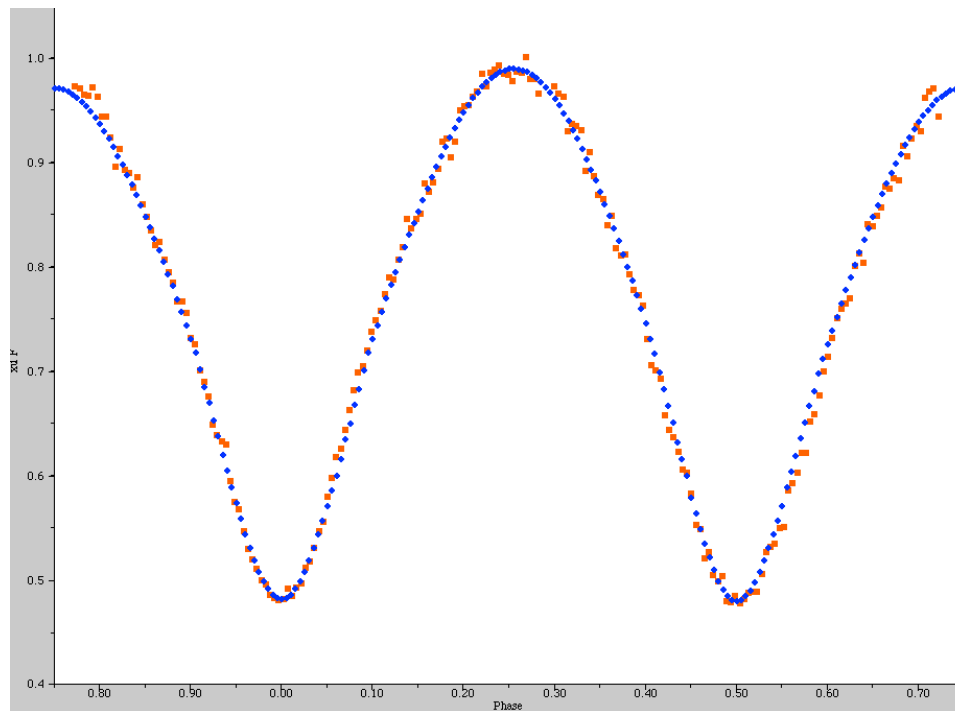
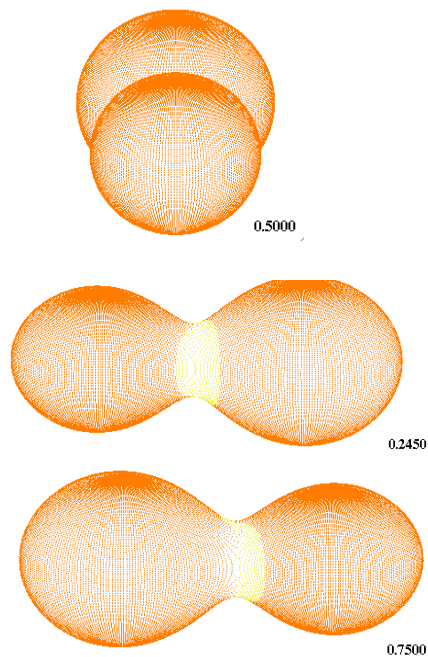
Mark Blackford's dual DSLR photometry system. Canon EOS 1100D with 200mm f2.8 lens (6.5° x 4.3°) Canon EOS 600D with 80mm f6 telescope (2.7° x 1.8°)

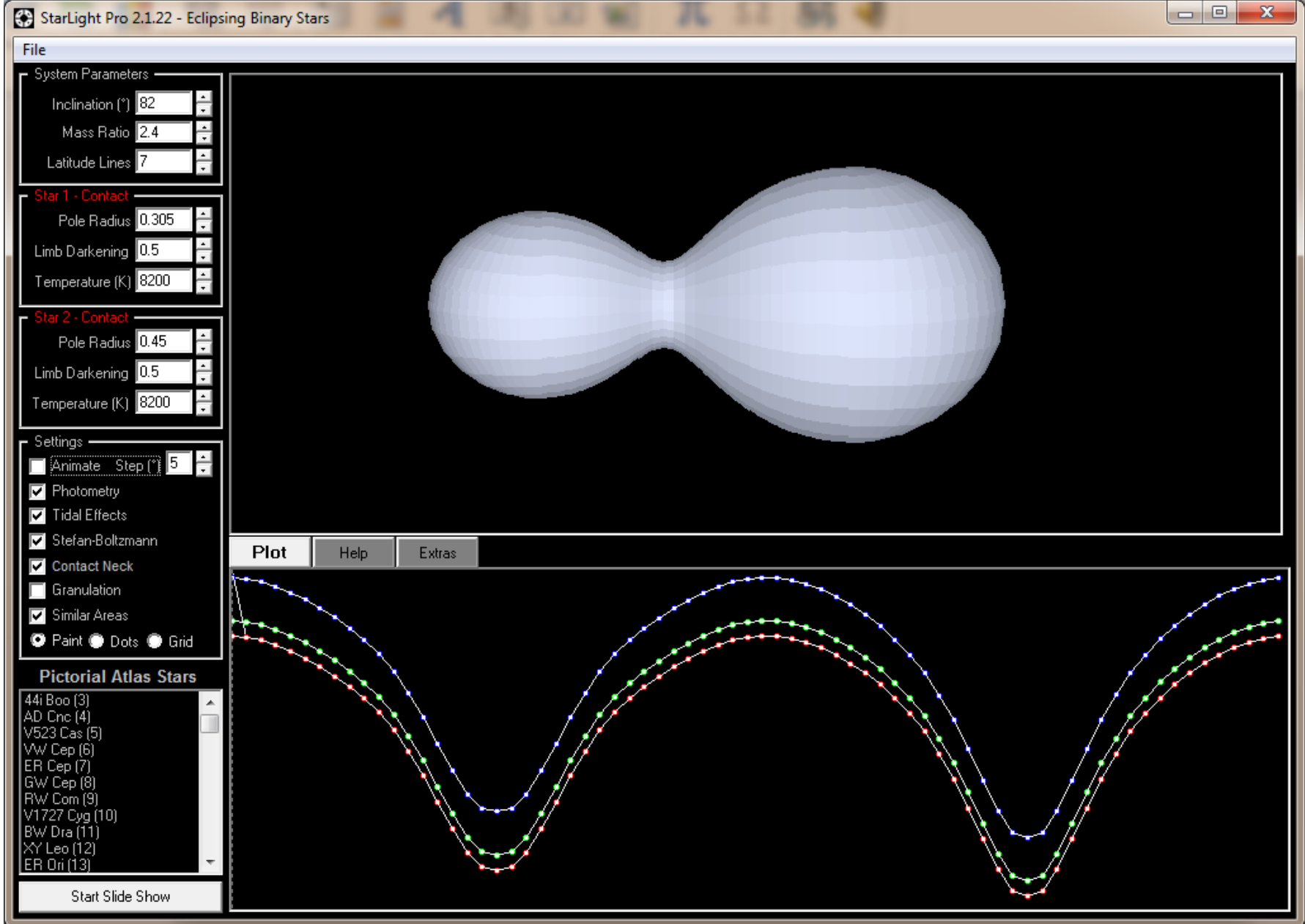


Variable Stars South

EW binaries have quite short periods of 6 – 24 hours

RV Gruis – a contact binary $p=6.2$ hrs.





<http://www.midnightkite.com/binstar/StarLightPro.exe>



Variable Stars South

Other projects

- **Near IR photometry of Betelgeuse**
 - Too bright for professionals
 - Three pulsation periods: 2335, ~300, ~150 days
 - Diameter changes
 - Spectral type changes
 - Candidate for type II Supernova – mass $20M_{\odot}$
 - Many effects only visible in J & H bands (near IR)



Variable Stars South

Other projects

- **Photometry of Red (M) Dwarfs**
 - 75% of stars in Milky Way
 - Faint, small and old (maybe as old as the Galaxy)
 - Project – long-term monitoring of variability, rotation and colour of selected RDs
 - Rotation periods 0.5 to 38 days
 - Bright ones suitable for DSLRs
 - Nine super-earths in habitable zone found from 102 southern RDs

(Bonfils, X. *et al*, 2013. *Astronomy & Astrophysics* **549**, A109)

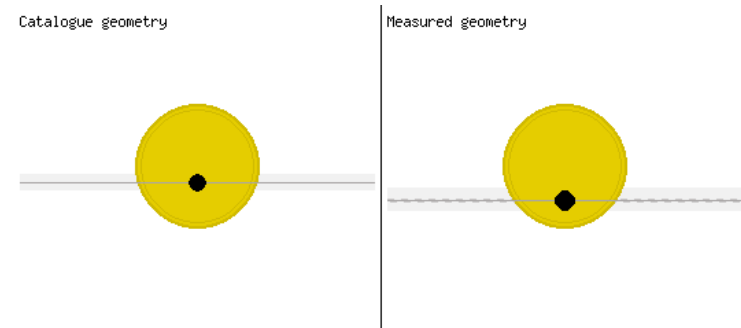
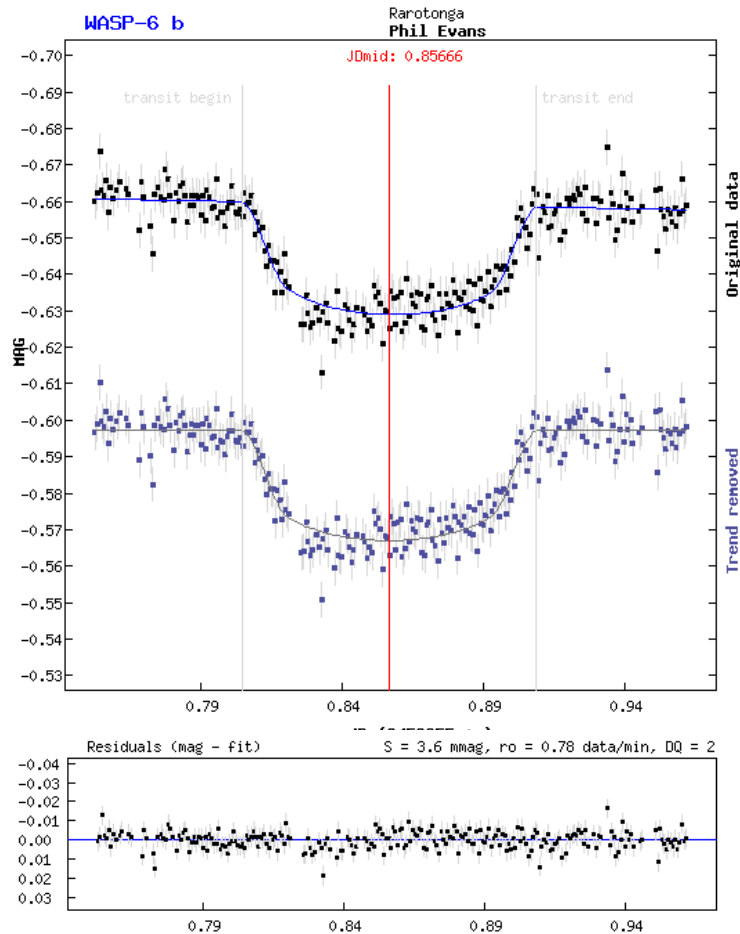


Variable Stars South

www.variablestarsouth.org



Variable Stars South



Exoplanet Transit Database

<http://var2.astro.cz/ETD/predictions.php>