Observing techniques, instrumentation and science for metre-class telescopes II
Conference

Tatranská Lomnica, Slovakia
September 24 — 28, 2018

Observations of Slightly Studied CBS with Period Variations

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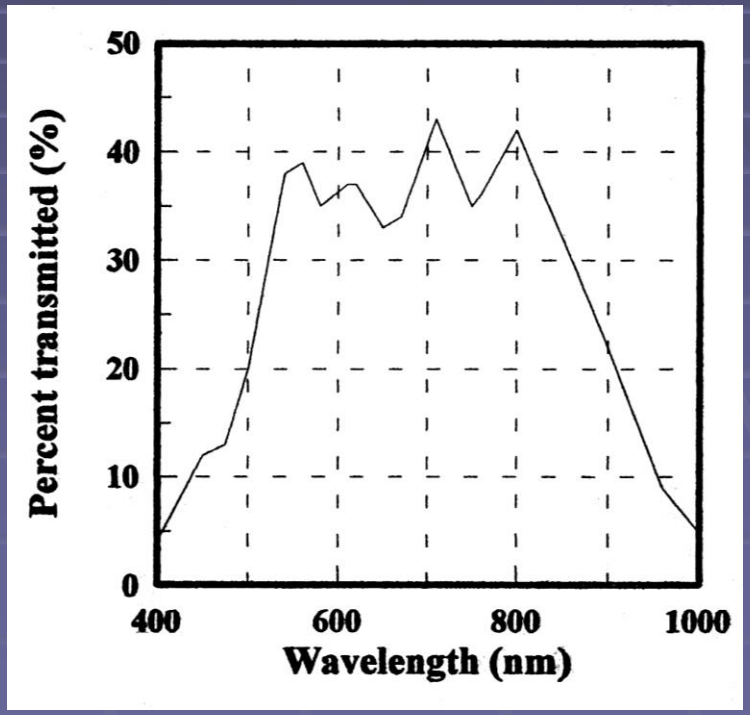
Nikifor Dmitrievish Kalinenkov, founder of Observatory, named after his name

Kalinenkov Astronomical Observatory
(V.O.Suchomlinsky Mykolaev National University)

Mykolaev, Ukraine

Telescope ZTS-702

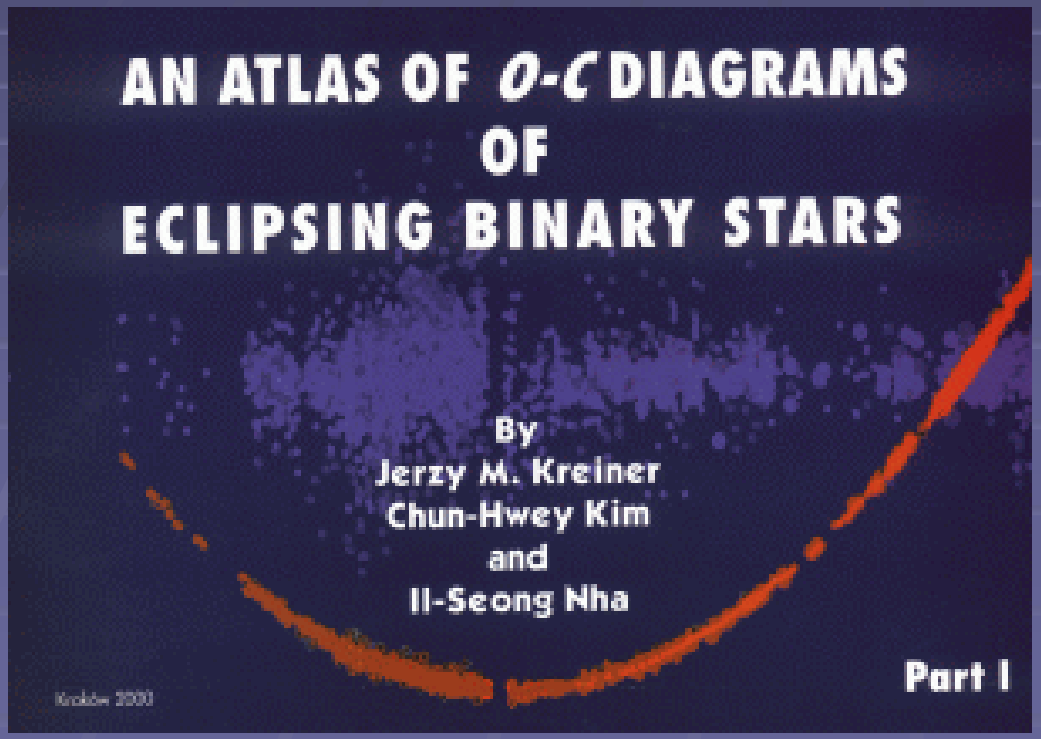
Diameter	702 *мм*
Focus (primary)	2806 *мм*
Camera	SBIG CCD ST-7
Scale	0.67"/p
Field	5'×8'
Filters	VRI



Period variations in binary systems are explained either due to change of large axis in the system, either due to change of mass of system or due to both these factors.

Possible reasons in the close binary system: mass loss and mass transfer.

Kreiner J. M., Kim Ch-H, Nha I.-S. An Atlas of O-C Diagrams of Eclipsing Binary Stars. Krakow, 2000. *http://www.as.ap.krakow.pl/o-c*



Stars were included in the "Atlas..." provided they satisfied 3 criteria:

1) at least 20 minima had been timed;
2) these minima spanned at least 2,500 cycles;
3) the 2,500 cycles represented no fewer than 40 years.

Taking into account possibilities of our telescope ZTS-702 we chose from the «Atlas…» for our observational program about 150 binary systems with the a small amount of the known time minima located in the constellations Aquila, Auriga, Andromeda, Cassiopeja, Pegasus, Cygnus, Cepheus.

The aim of observations is determination of the new parameters of binary systems based on full-period light curve and the analysis of O - C variations.

The program stars were studied mainly during preparation of bachelor' and master' theses.

Exposure time was selected from 60 to 180s (S/N >15)

The results of investigation of Program binaries such as CU Peg, V 609 Aql, BM UMa, V 859Cyg and V841 Cyg were published.

var2.astro.cz/EN/brno/

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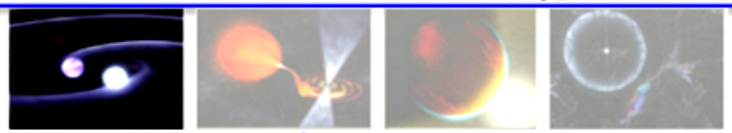
Variable Star and Exoplanet Section

of Czech Astronomical Society



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MEDUZA - intrinsic variables
TRESCA - exoplanets
HERO - high energy objects

OBSERVERS LOG
User-defined objects

ABOUT US
Leadership

B.R.N.O. Project - Eclipsing Binaries

Welcome to B.R.N.O. web page about eclipsing binaries!

Acronym B.R.N.O. means *Brno Regional Network of Observers* and points to historical connection between eclipsing binary observers and Brno Observatory.

Observing eclipsing binaries has long tradition in Czech republic, started in 1960. Main observation result is time of minimum.

It is possible to observe both visually and with CCD camera. Times of minima and research papers were published mostly in "Contributions of Observatory and Planetarium of Nicholas Copernicus in Brno" and in our bulletin Perseus. Recently, data are published only in electronical journals - like IBVS (Information Bulletin on Variable Stars) or OEJV (Open European Journal on Variable Stars).

- *Project contact person:* **Bc. Luboš Brát**, brat@pod.snezkou.cz

- **B.R.N.O. Contributions #37, Times of minima** (2009-2011) **NEW**
- **B.R.N.O. Contributions #36, Times of minima** (2008-2009)

No user logged in
- LOGIN -
Observer registration

> **Minima predictions** <

> **Exoplanet transits** <

New minima in B.R.N.O.:

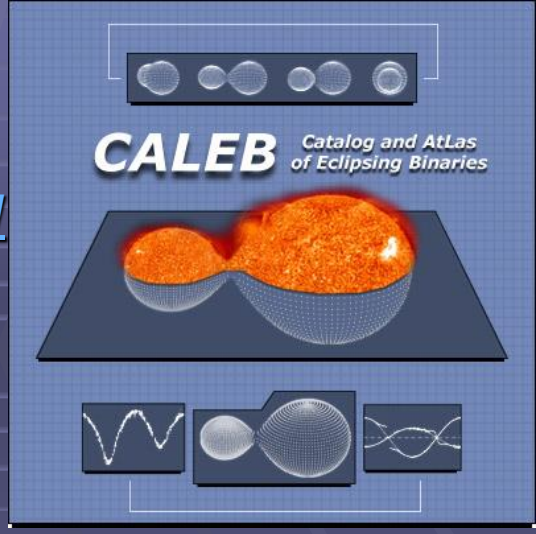
OO Aql (Mašek M.)
KW Eri 1° (Durantini Luca H., Artola R.)
KW Eri 2° (Durantini Luca H., Artola R.)
ST Ind (Durantini Luca H., Artola R.)
UCAC4 625-070678 Lyr (Mašek M.)
BW Del (Mašek M.)
V0481 Peg (Nosáľ P.)
MO Dra (Marian Urbaník)
SY Hor (Quiñones C, Pignata R.)
NT Cas (Marian Urbaník)

New transits in TRESCA:

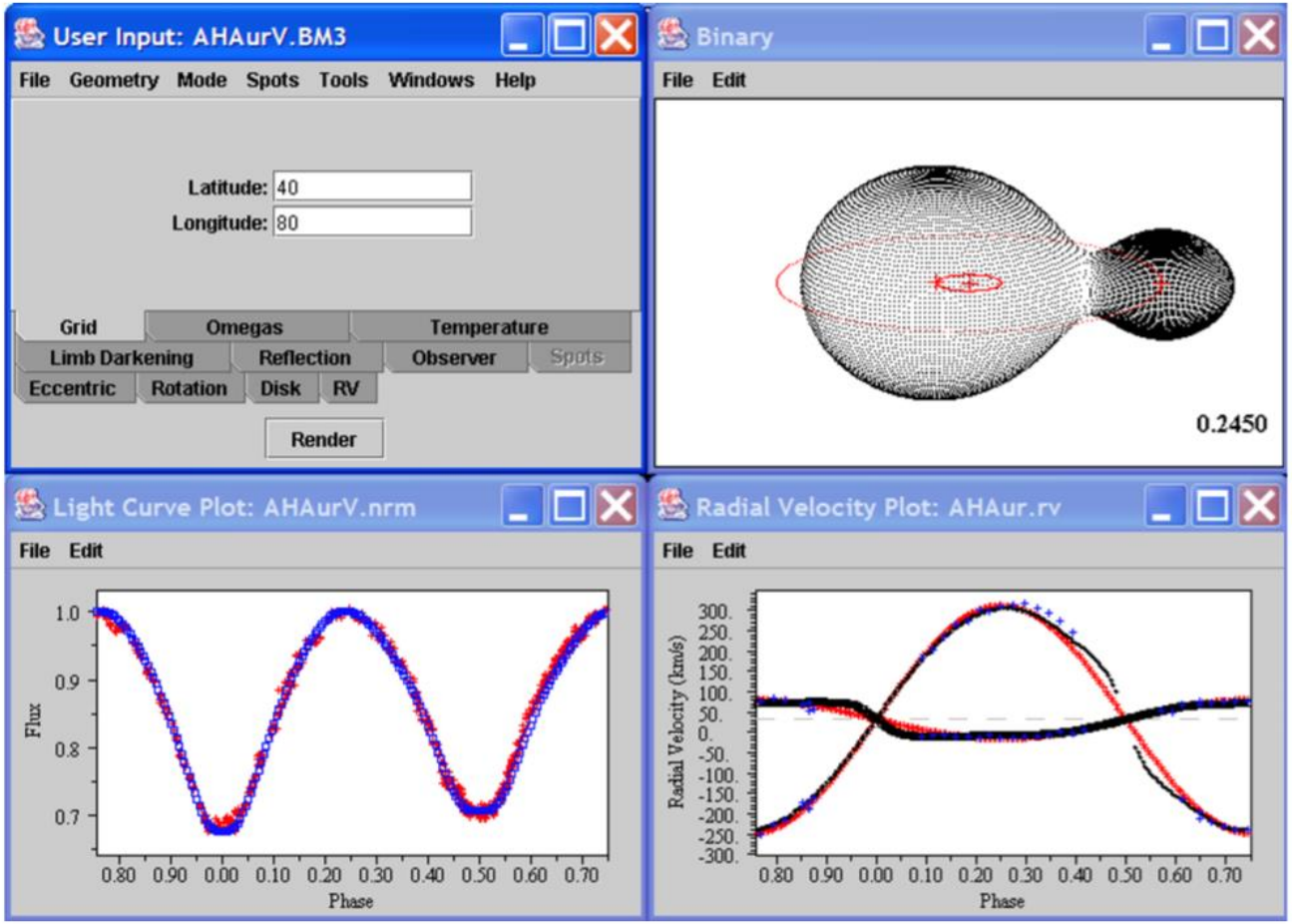
TrES-5 b (V. Hentunen)
WASP-10 b (D. Néel)
HD189733 b (O. Mazurenko)
Kepler-5 b (D. Jean-Christophe, D. Marwane)

We used additionally data from B.R.N.O. project: http://var2.astro.cz/EN/brno/

The papmeters od CBS we calculated using Binary Maker 3
http://www.binarymaker.com/
by David Bradstreet



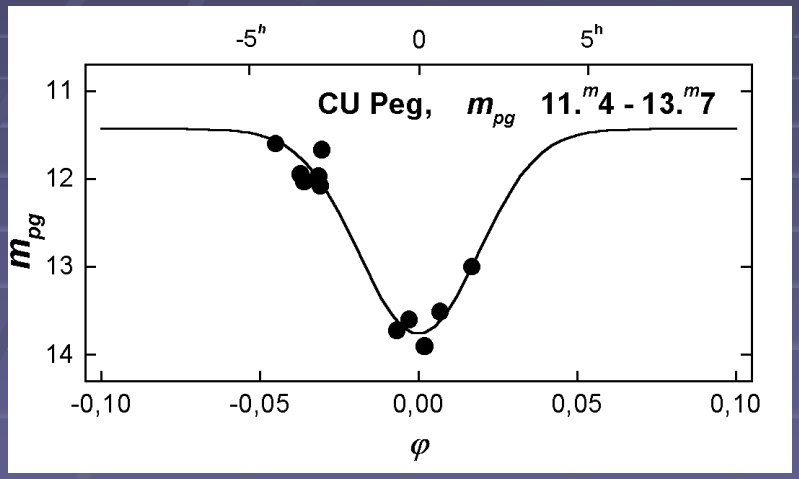
and CALEB data:
http://caleb.eastern.edu/



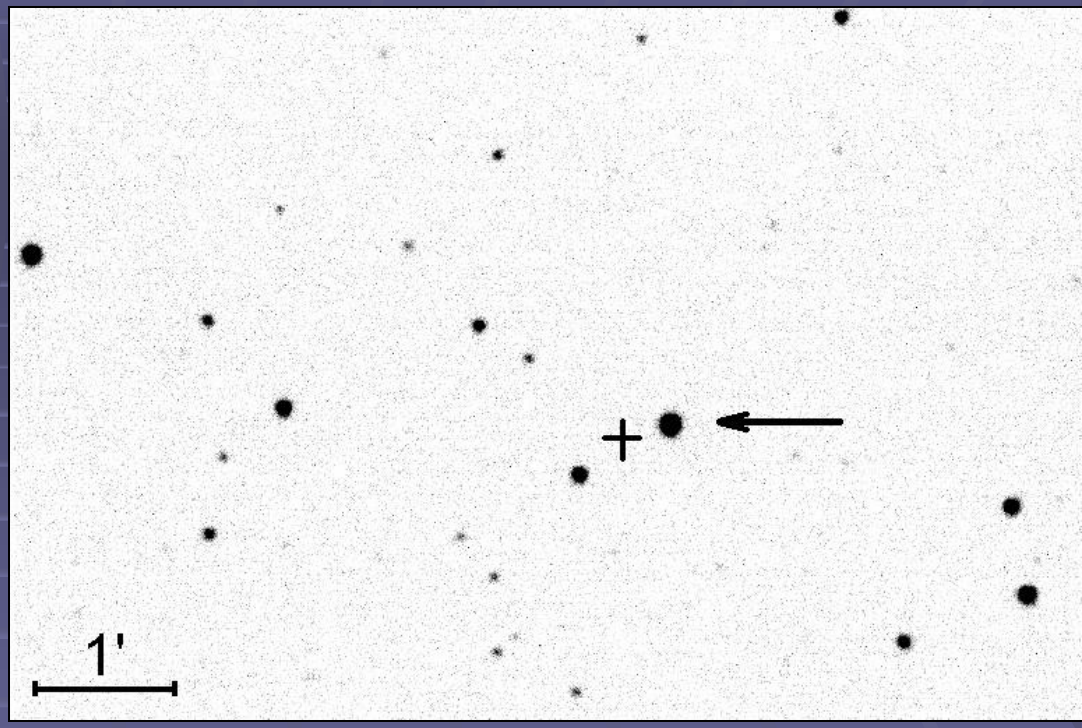
CU Peg

$\Delta\, m_v$ = 12^m.06 – 14^m.76,
R.A.=21^h 47^m 47^s, Dec.= +27°15′.4

Min I = 2434221.392+ 3.880196E
Only 16 time minima



The mean light curve based
on Odessa Observatory patrol plates.



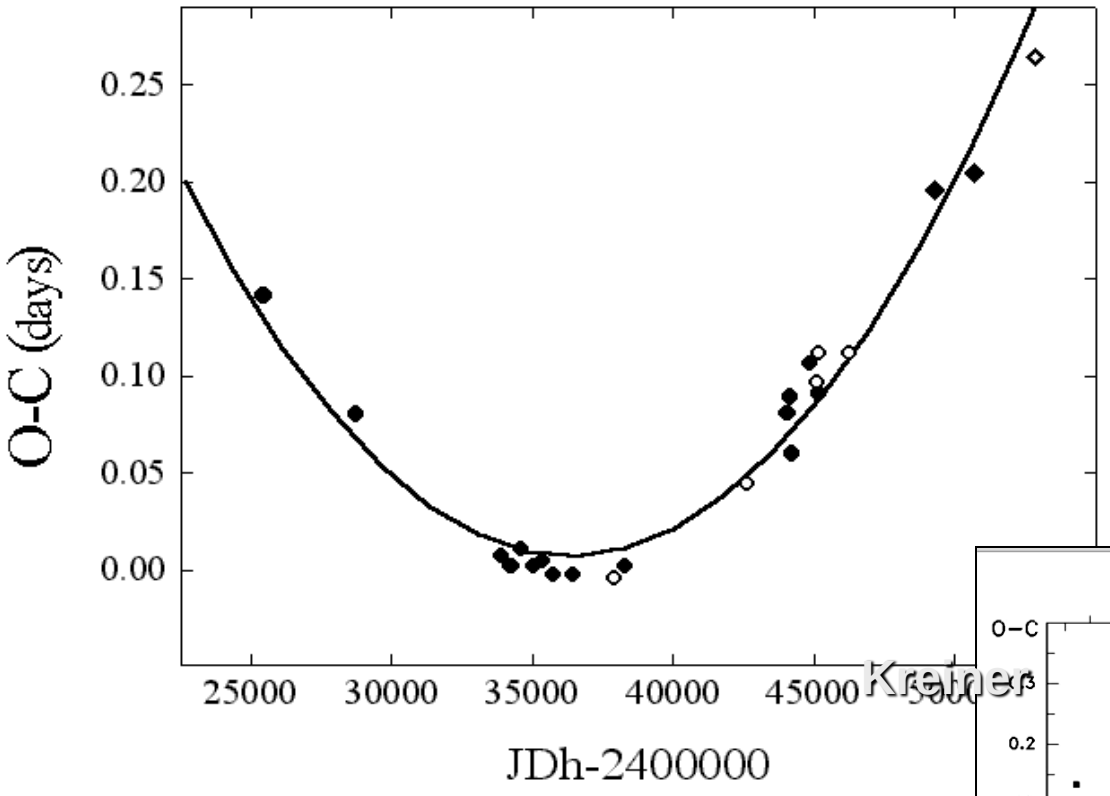
One our frame with
CU Peg region

Refined coordinates:

R.A.$_{2000.0}$ = 21^{h}47^{m}44^s.62,

Dec.$_{2000.0}$= 27°15'24".7

Odessa 7-camera astrograph archive covers 1957-1998 and contains about 84000 astroplates in *pg* nad *pv* bands.



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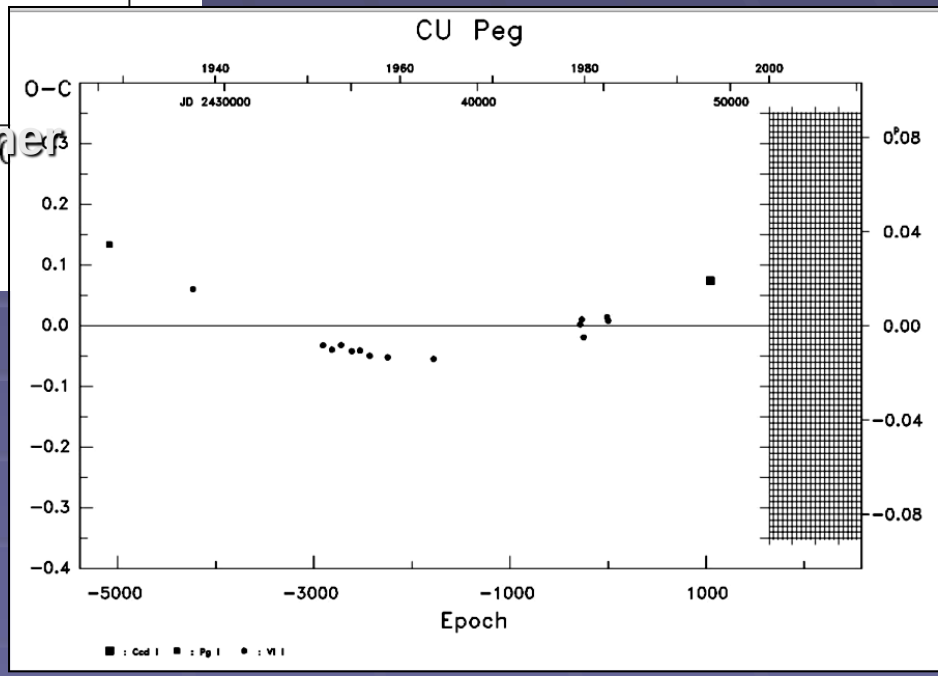


The parabolic period change has been clearly seen.

Open circles presents 6 our time minima.

$dP/dt = 1.38 \times 10^{-6} d/year$,

mass transfer from less massive component.

V609 Aql

Δ ***mv*** **=** $11^m.7 - 12^m.1$,

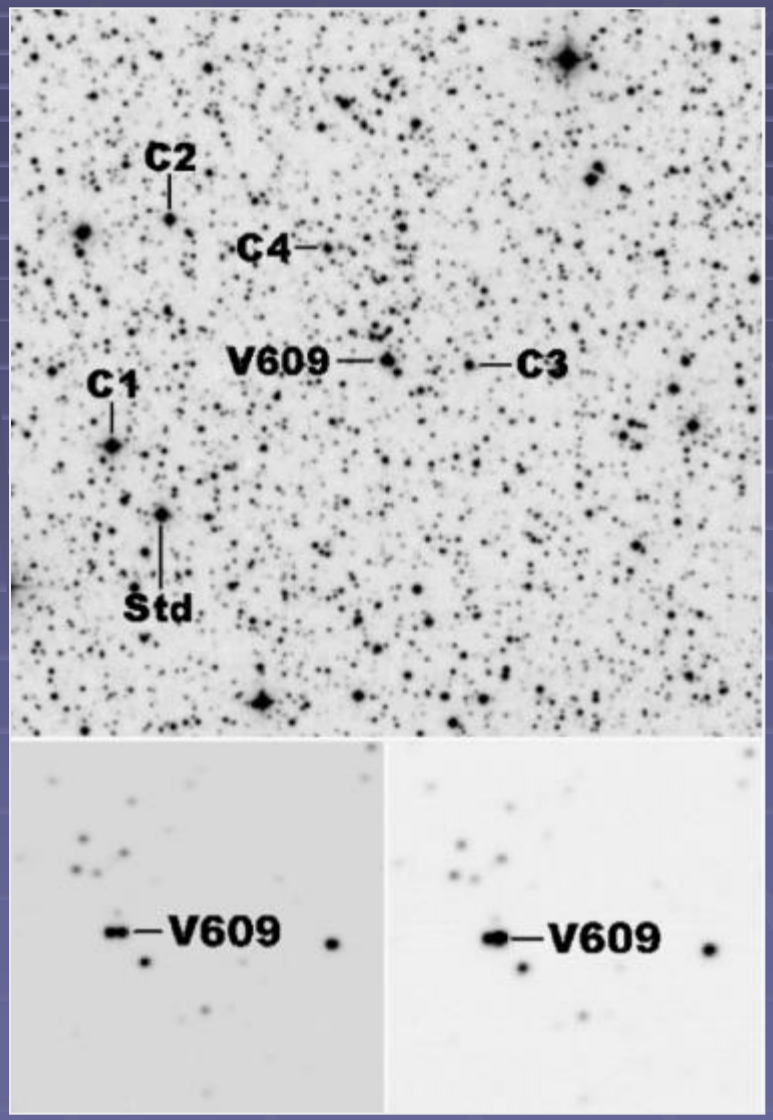
R.A.=20^h 09^m $58^s.77$, Dec.= +14°38'14".7

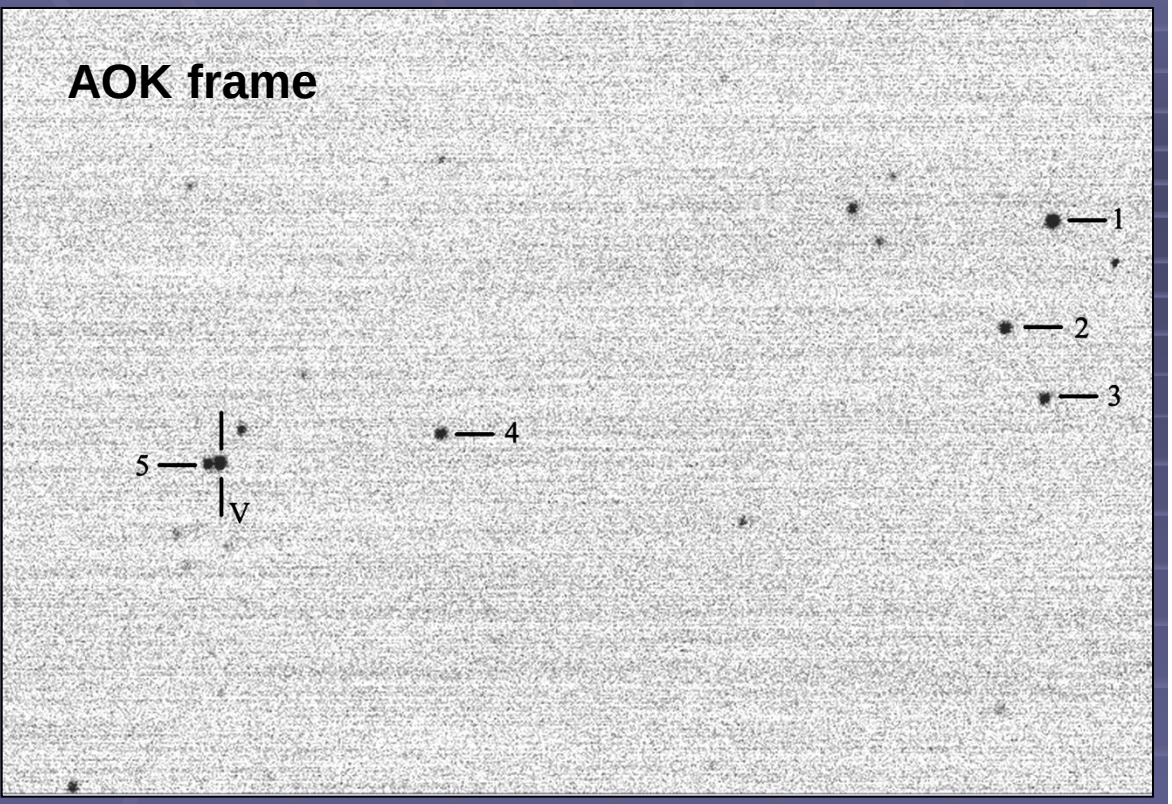
Min I = 2429365.7284 + 0.79656390 E

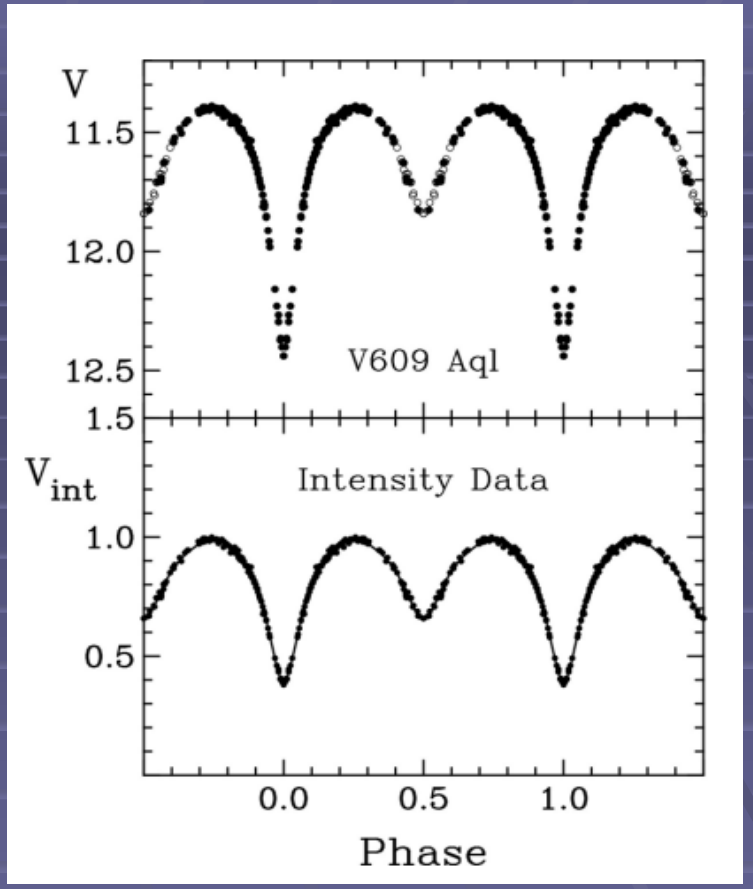
Only 19 time minima

A finder chart for the field centered on V609Aql from the red image of the Palomar Observatory Sky Survey (top). The field of view measures 15'× 15'and shows the location of the variable, the adopted reference star, and four check stars used for the observations. The lower portion of the figure displays two enlargements from CCD images of V609 Aql at phases 0.9998 (lower left) and 0.8700 (lower right).

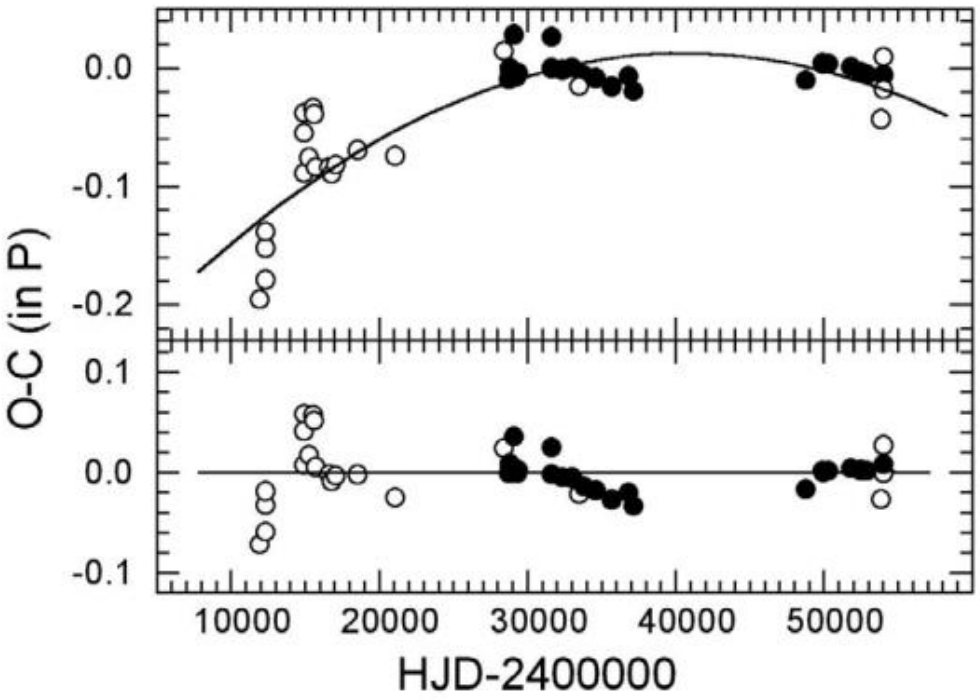
21 nights between 22 September and 18 December 2006 using a Celestron 28-cm SchmidtCassegrain telescope at the Abbey Ridge Observatory, an automated facility located at a dark site outside of Halifax, Nova Scotia, Canada



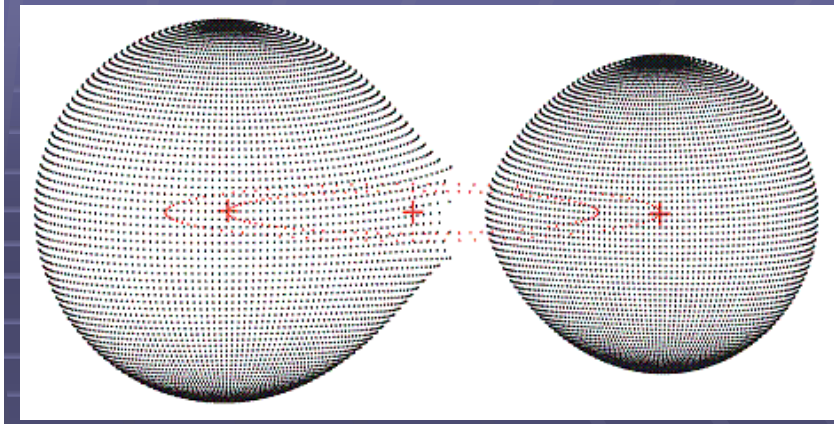




V-band observations (including mirrored data) for V609 Aql (upper) corrected for contamination by a companion of V= 12.35. Open circles represent the Nikolaev observations normalized to the Abbey Ridge data. The same data are plotted as intensities (lower) along with the best-fitting model light curve.



Contact system



A model for the V609 Aql system at phase 0.25 from Binary Maker 3.

Additional estimates for times of light minimum in V609 Aql (open circles), both primary and secondary minima, were obtained through visual scanning of plates in the **Harvard College Observatory Photographic Plate Collection**, using suitable reference stars in the field for comparison

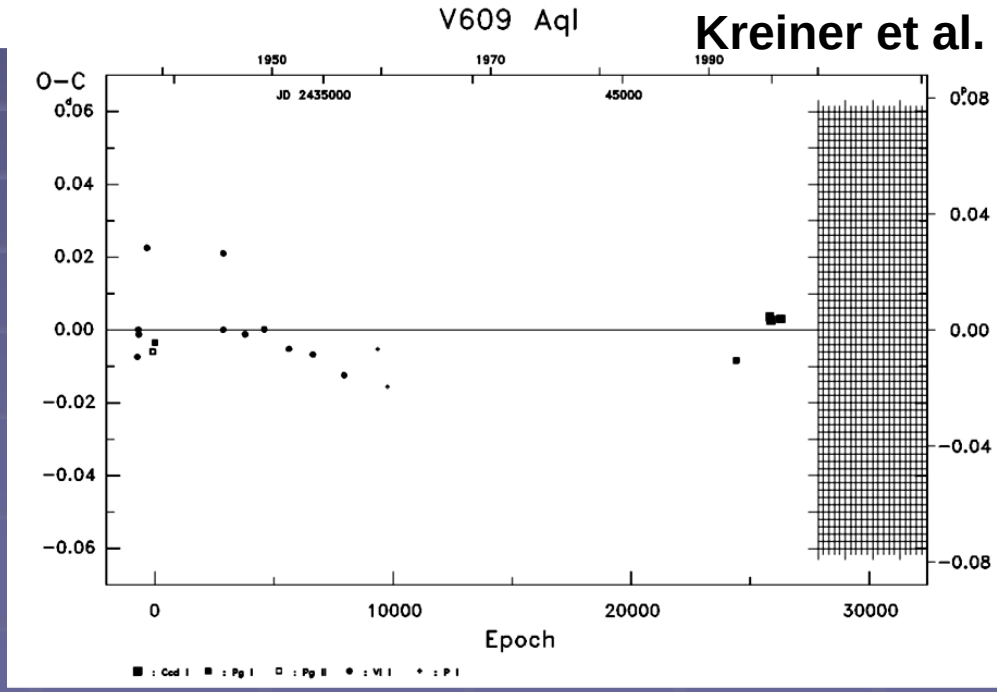
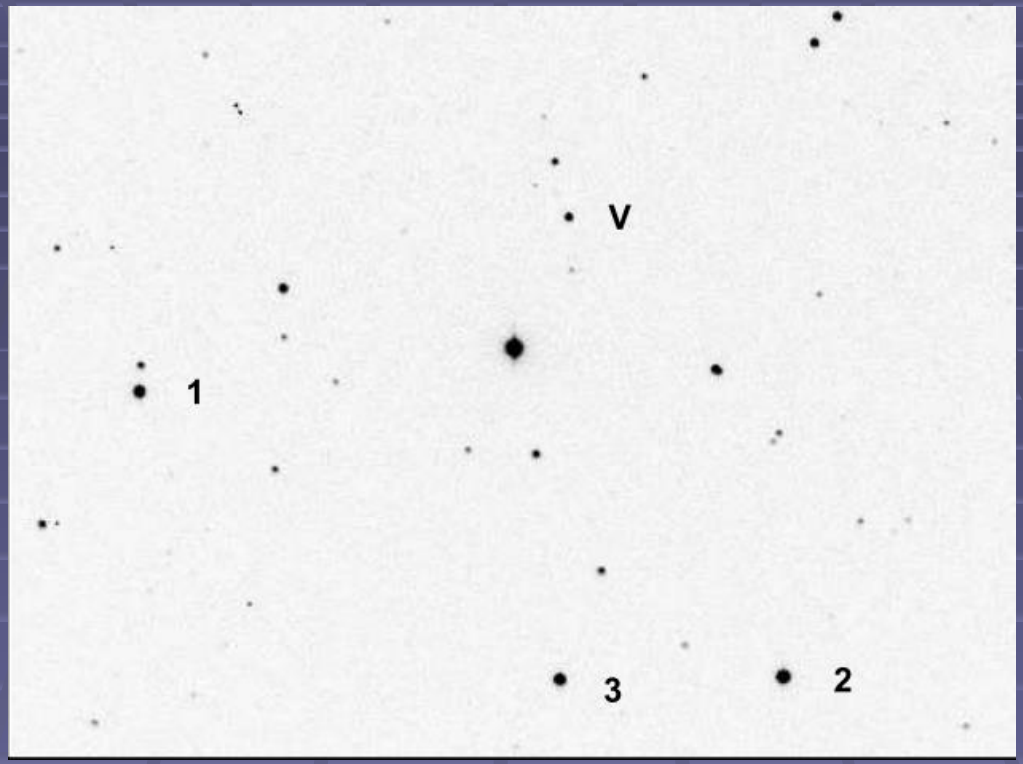


TABLE VI

Derived System Parameters for V609 Aql

Parameter	Ishtchenko & Leibowitch (1955)	Brancewicz & Dworak (1980)	This Paper
V	…	…	11.40
ΔV_1	…	…	1.04
ΔV_2	…	…	0.44
B	11.7	…	…
ΔB_1	0.4	…	…
ΔB_2	0.2	…	…
Separation	…	4.97 $R_\odot$	4.39 $R_\odot$
R_1	…	1.49 $R_\odot$	1.84 $R_\odot$
R_2	…	1.24 $R_\odot$	1.47 $R_\odot$
RL_1	…	74%	113%
RL_2	…	71%	98%
L_1	…	2.34 $L_\odot$	2.70 $L_\odot$
L_2	…	1.43 $L_\odot$	0.80 $L_\odot$
T_1	…	5870 K	6050 ±25 K
T_2	…	5680 K	5000 ±25 K
M_1	…	1.49 $M_\odot$	1.05 $M_\odot$ (adopted)
M_2	…	1.10 $M_\odot$	0.74 ±0.02 $M_\odot$
M_1/M_2	…	0.74	0.70 ±0.02
$Sp.T._1$	…	F8	F8-F9
$Sp.T._2$	…	…	K2-K3
i	…	…	84°.8 ±0°.2

BM UMa



Δ ***mv*** **=** $14^m.4 - 15^m.3$,

R.A.=$11^h\ 11^m\ 18^s$, Dec.= +46°25'24"

Min I = 2444292.3413 + 0.2712222 E

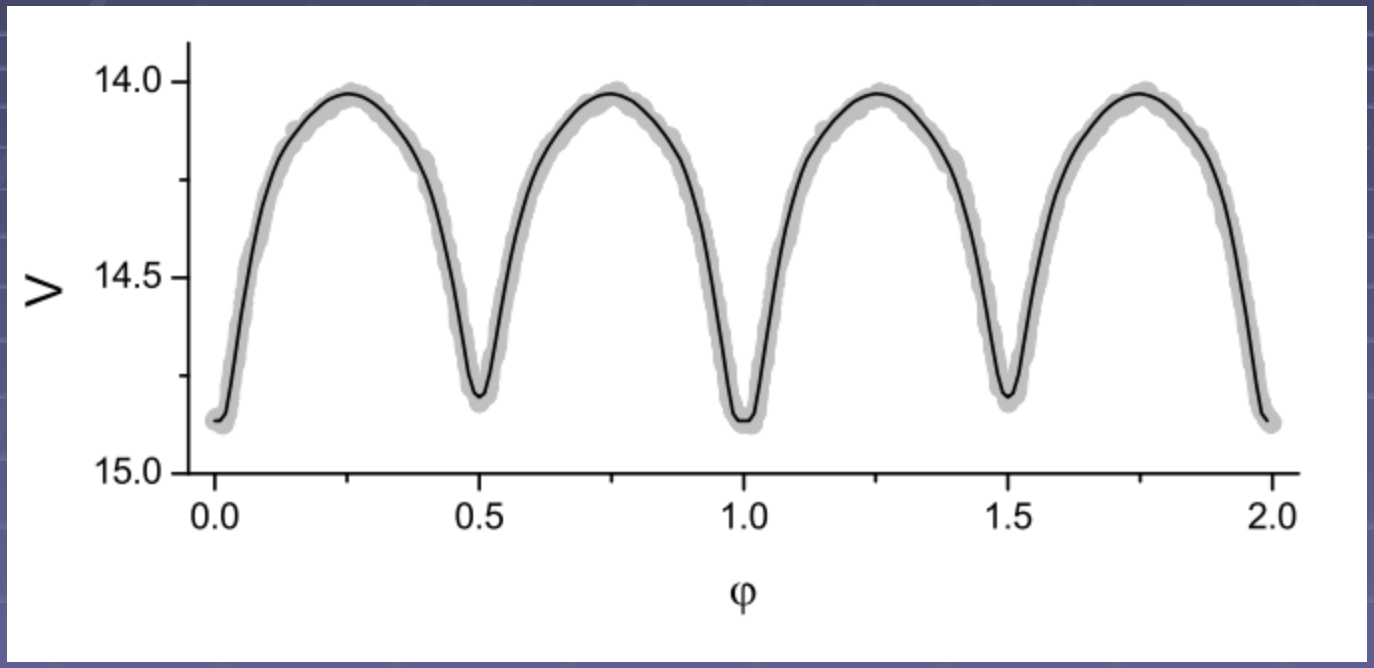
Only 34 time minima

and 37 years of observations.

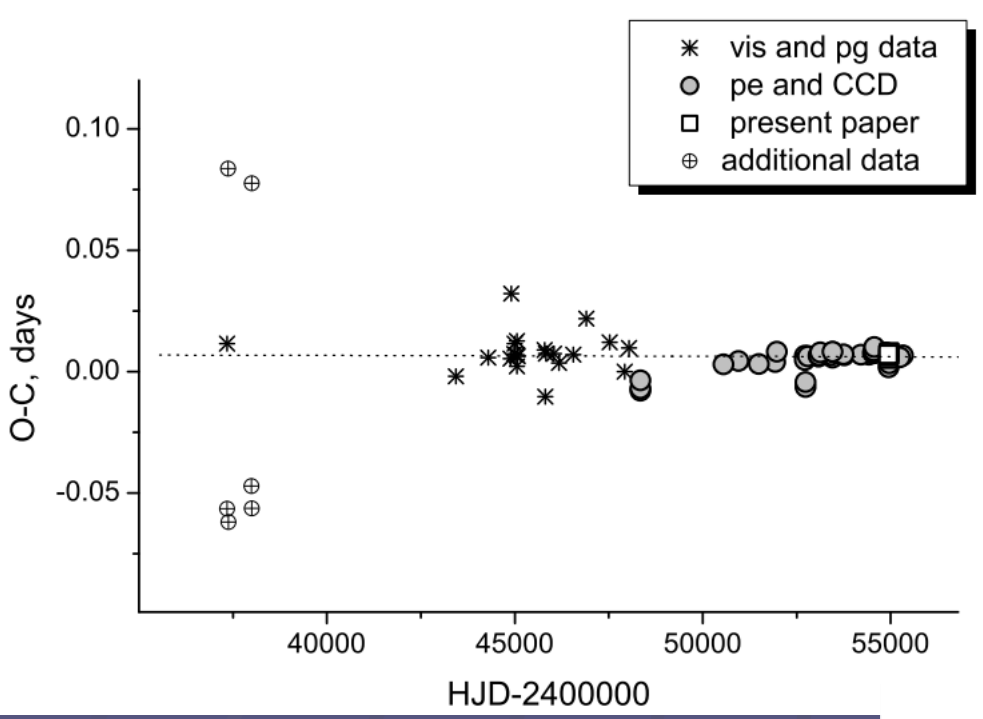
Table 1. The reference stars

Star	$\alpha_{2000.0}$	$\delta_{2000.0}$	V
1	168°.00166	+46°.37723	$12^m.486$
2	167°.74274	+46°.30769	$12^m.020$
3	167°.83080	+46°.30388	$12^m.905$

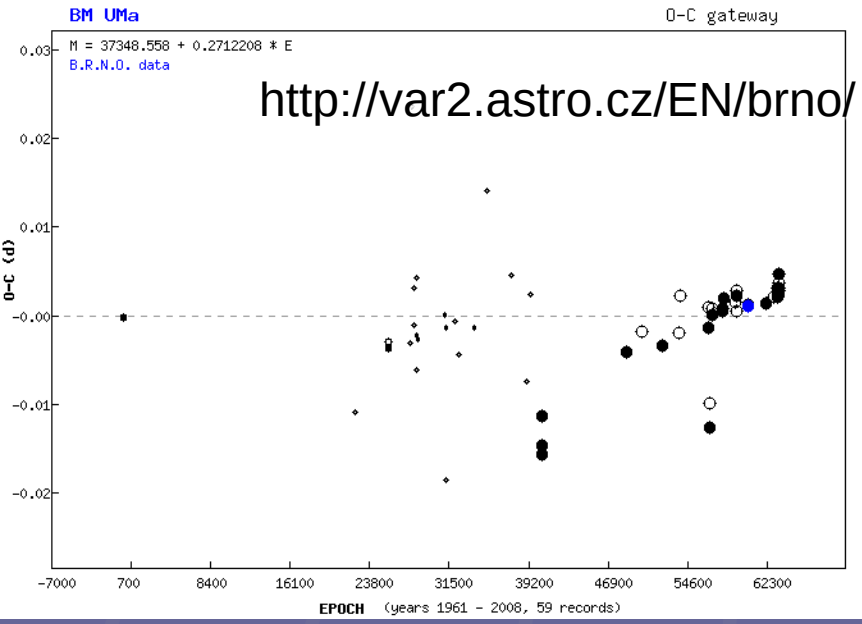
An anlysis is presented of the light curve and O{C variations in the eclipsing system BM UMa, based upon 9 nights of V-band observations (JD 2454933 to 2454961) using two robotic remotely controlled telescopes at Tzec Maun Observatory (USA) along with observations made with the RK-600 telescope of Odessa Astronomical Observatory.

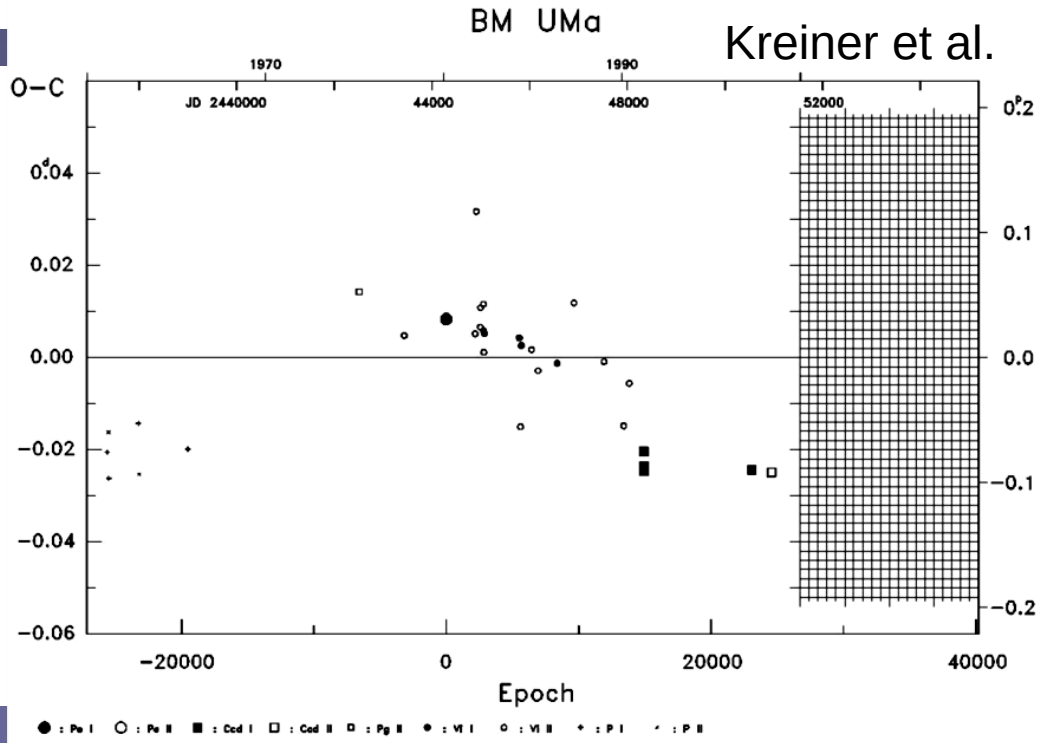


With the aid of Binary Maker 3.0 and its Catalog and Atlas of Eclipsing Binaries" (Bradstreet & Steelman 2003), we generated a synthetic light curve for BM UMa. A best-fitting model was obtained for a contact system with a fill-out factor of -11% of the Roche lobe for both components with parameters: mass ratio 0.59, inclination angle 89°, and effective temperatures of 4250 K and 4400 K.



Our best fit based on all 76 tabulated times of light minimum is:
HJDminI = 2447927:382 + 0:2712209E
with standard deviation of the period value SD = 5.7×10^{-7}.
The ephemeris exhibits no linear or quadratic tendencies in the O - C variations





V841 Cyg

Δ ***mv*** = $11^m.1 - 11^m.3$,

R.A.=$19^h\ 22^m\ 18^s.4$, Dec.= +28°41'08"

Min I = 2434629.425 + 0.76113618 E

Only 28 primary time minima

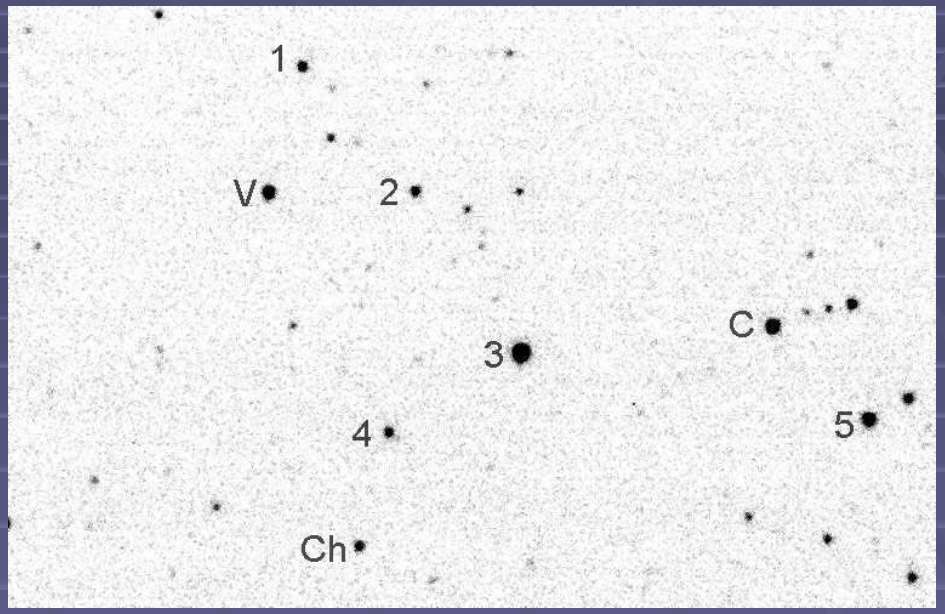
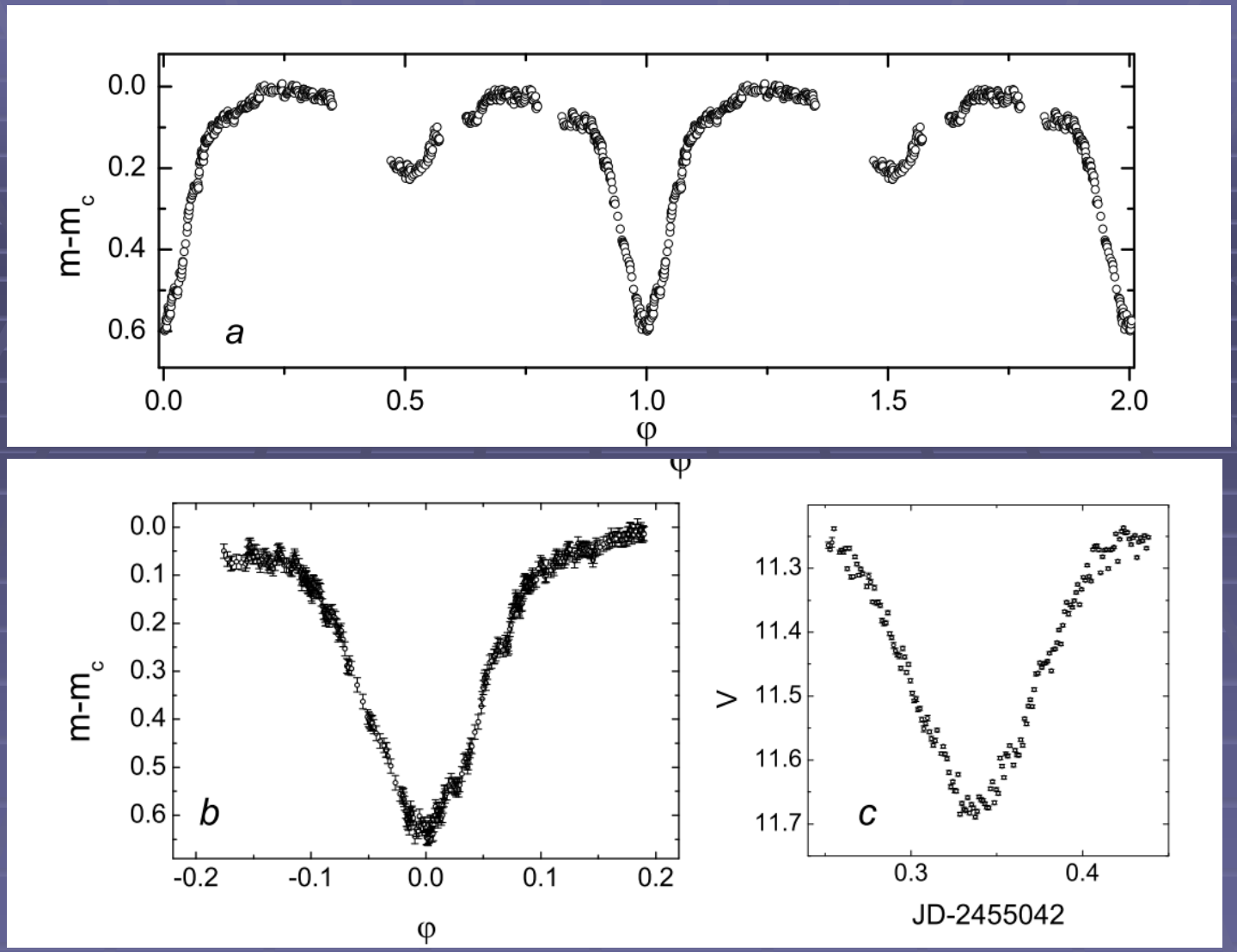
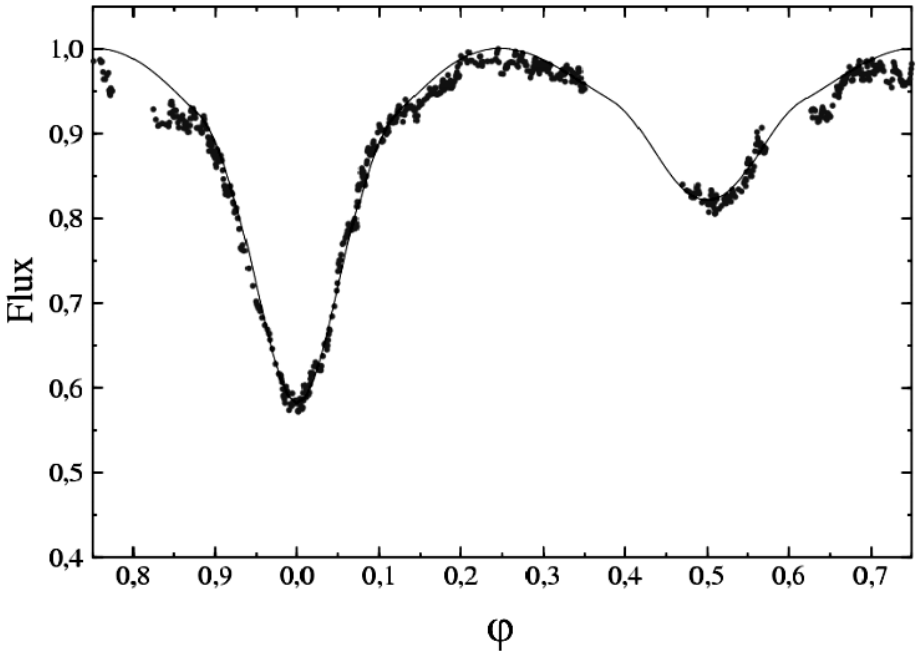


Table 1: The reference stars for V841 Cyg frame.

N	RA_{J2000}	Dec_{J2000}	TASS 4	V	SD
1	$19^h22^m17^s.70$	$+28°42'13''.8$	1788884	$12^m.658$	$0^m.154$
2	19 22 12.06	+28 41 20.0	3488546	12.973	0.091
3	19 22 06.97	+28 40 06.0	1788858	10.268	0.163
4	19 22 11.78	+28 39 13.4	1788868	13.021	0.202
5	19 21 51.40	+28 40 03.8	1788805	11.434	0.095

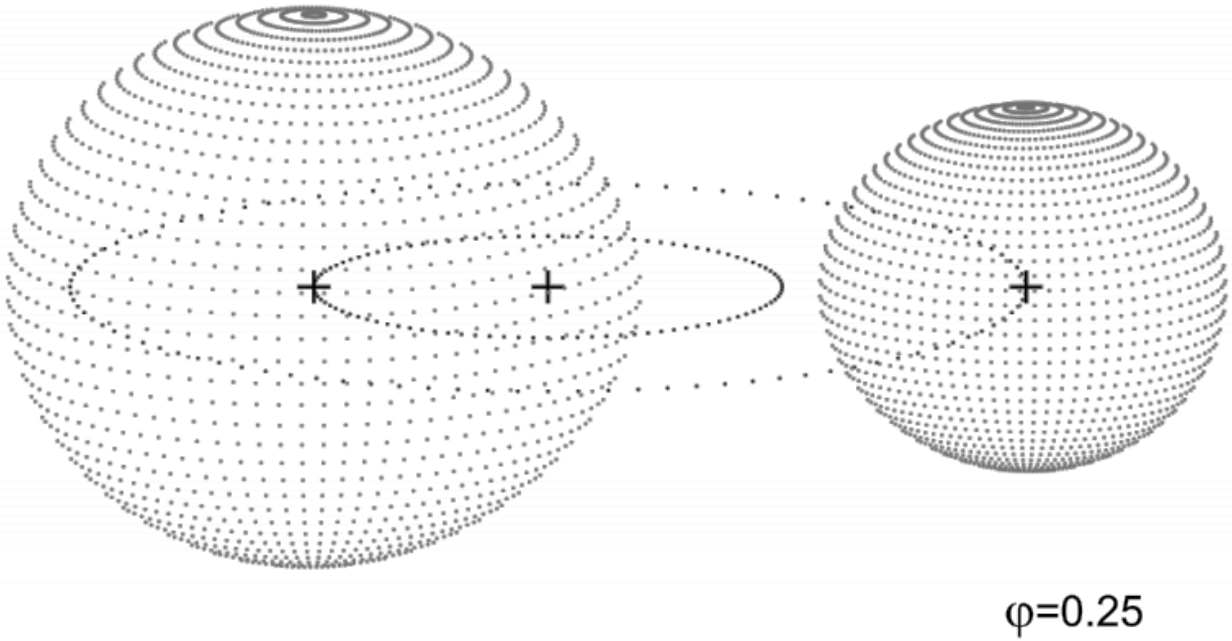


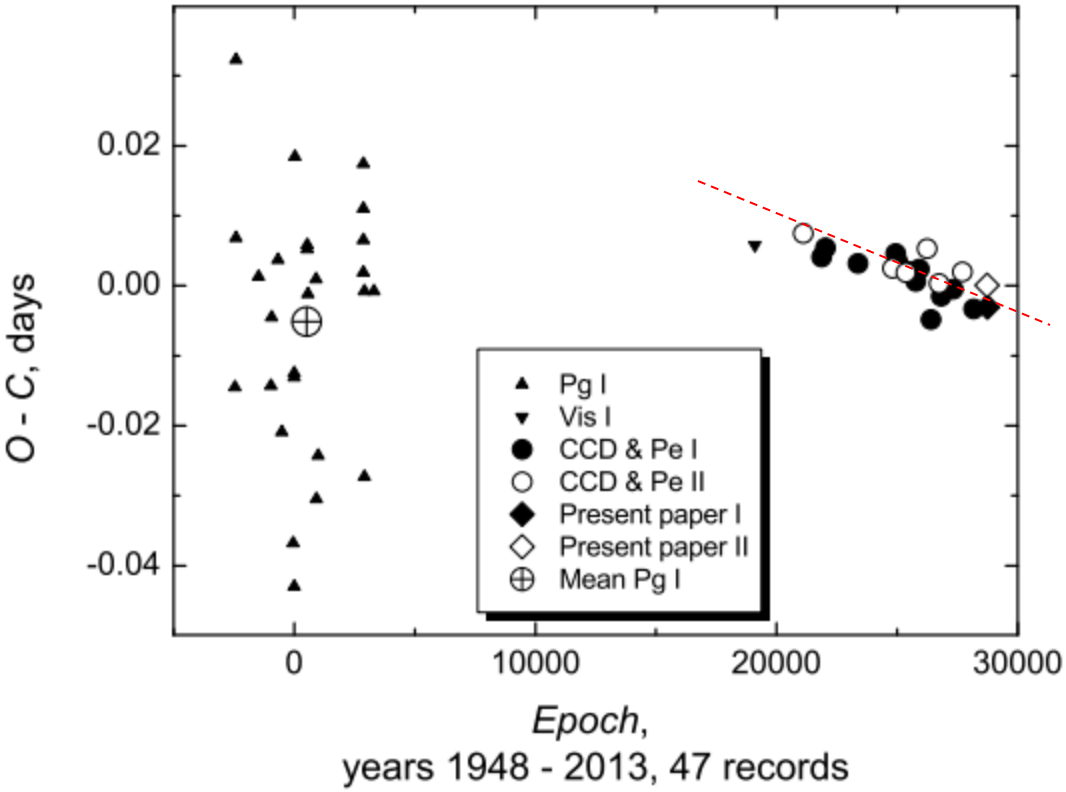
The light curve of V841 Cyg (a) and features of magnitudes variations in primary eclipse according our measurements (b) and **Ogmen** (AAVSO) observations (c). Error bars for magnitudes are shown on lower panel.



Parameters of the eclipsing binary system V841 Cyg. It contains form A6V+G5V stars with mass ratio about 0.49.; they fill own Roshe lobes on 95% and 92% correspondingly and both components are deformed. The distance between components is about $5R_{\odot}$, the distance between component surfaces is about $1{:}4R_{\odot}$.

The depths of light minima in V-band are $0^{m}.53$ and $0^{m}.20$.





V841 Cyg classification as is NCB system, without significant mass transfer.

We calculated the O - C values for out time minima using B.R.N.O. database modified ephemeris and compared the results with “O - C Gateway” data.

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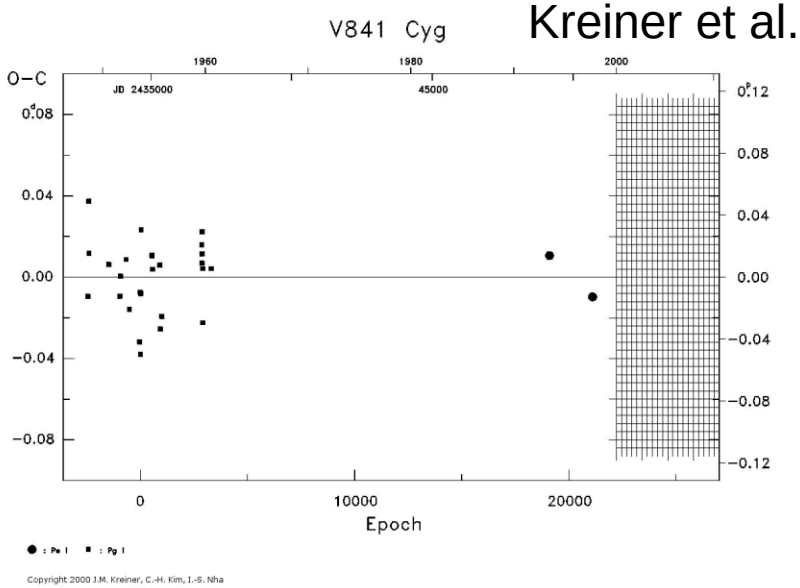
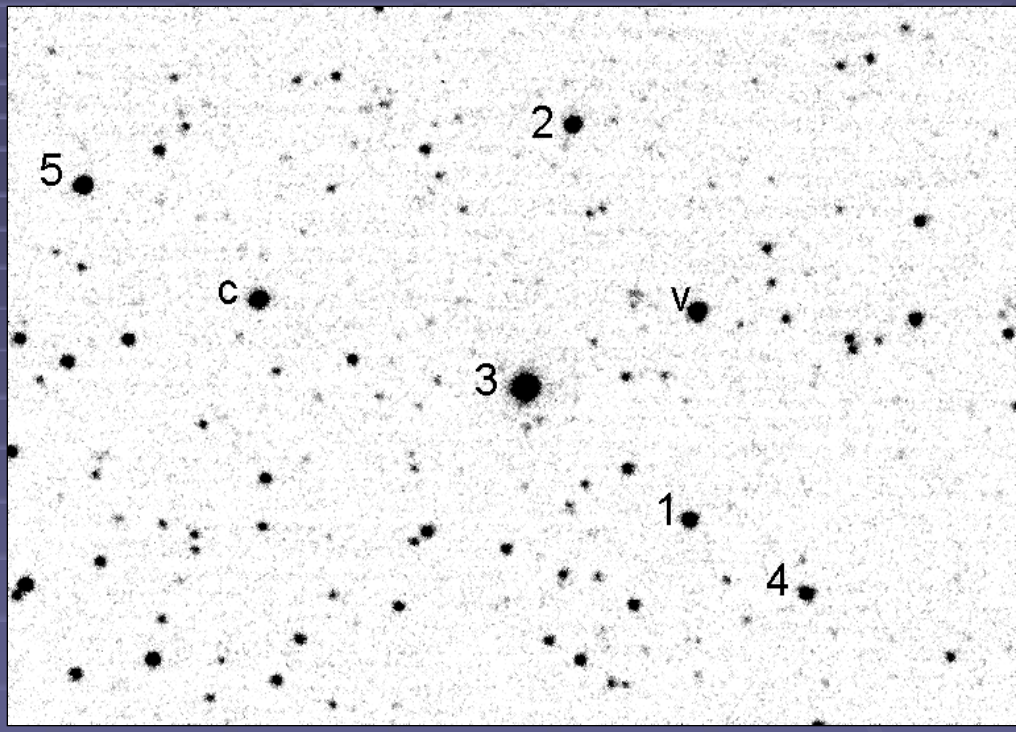


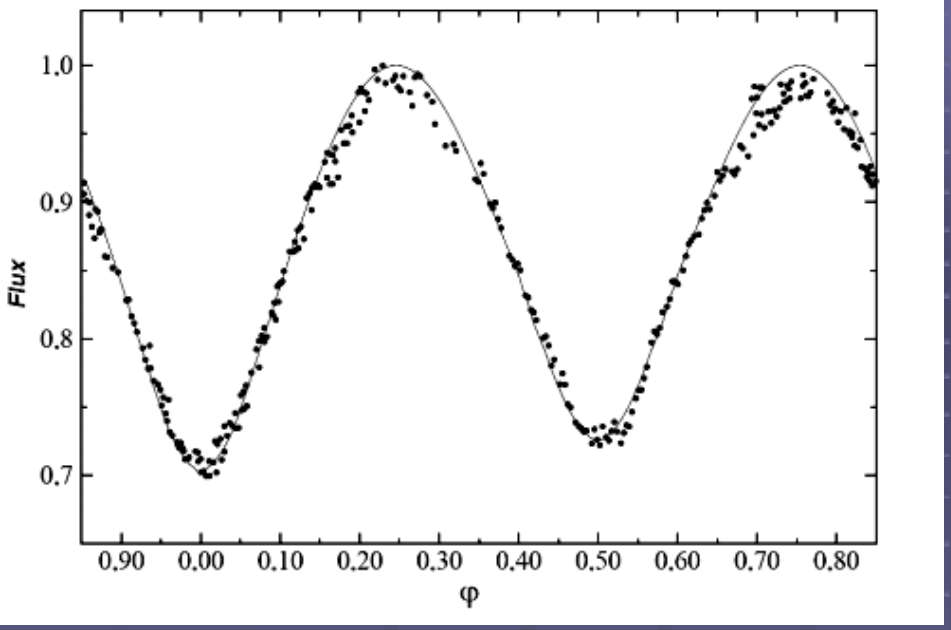
V859 Cyg

Δ ***mv*** = $11^m.7 - 12^m.1$,
R.A.=$19^h\ 27^m\ 12^s.7$,
Dec.= +28°56'50".
Min I = 2434629.4119 + 0.40499999 E
Only 17 time minima,

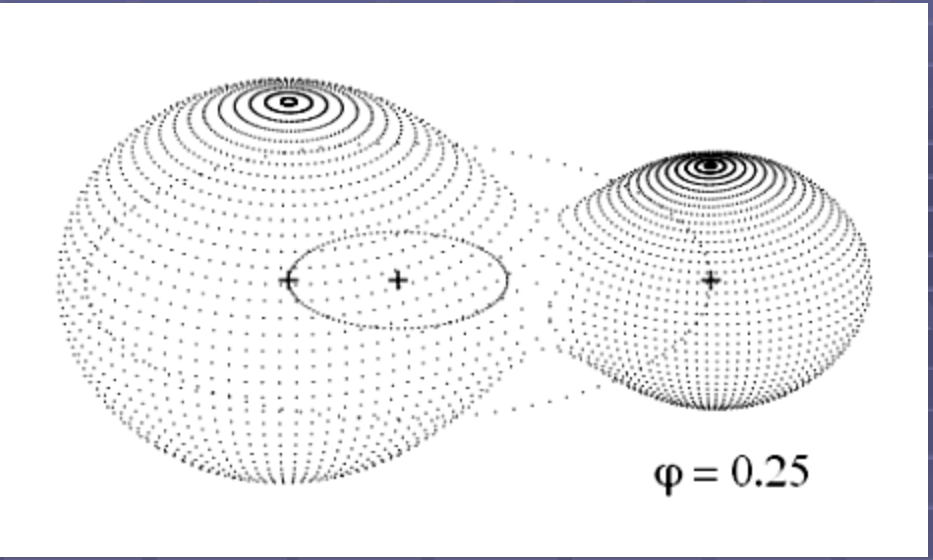


CCD frame of V724 Aql and reference stars (Photometric Catalog TASS Mark IV)

№	RAJ2000 h:m:s	DEJ2000 d:m:s	TASS4	Vmag m	SD m	Sp
c	19 27 29.36	+28 56 39.7	1839447	11.901	0.101	G5III
1	19 27 12.83	+28 55 12.9	1839414	12.841	0.178	
2	19 27 17.86	+28 58 12.9	3136596	12.478	0.112	
3	19 27 19.00	+28 56 08.3	1805867	9.709	0.058	G5V
4	19 27 08.16	+28 54 40.6	3136587	13.500	0.332	
5	19 27 36.24	+28 57 27.6	1839453	11.915	0.099	F5IV

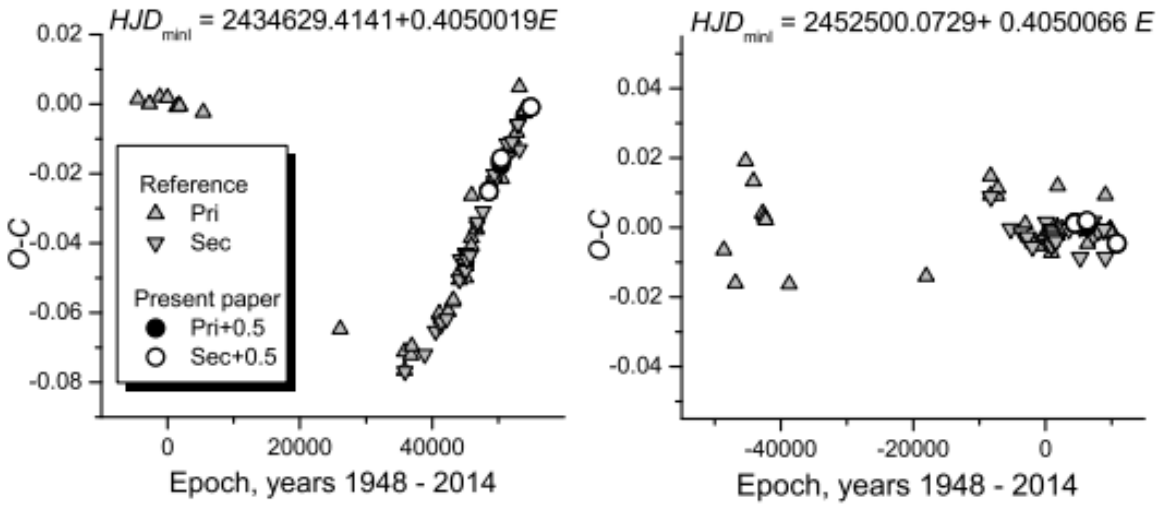


Overcontact system



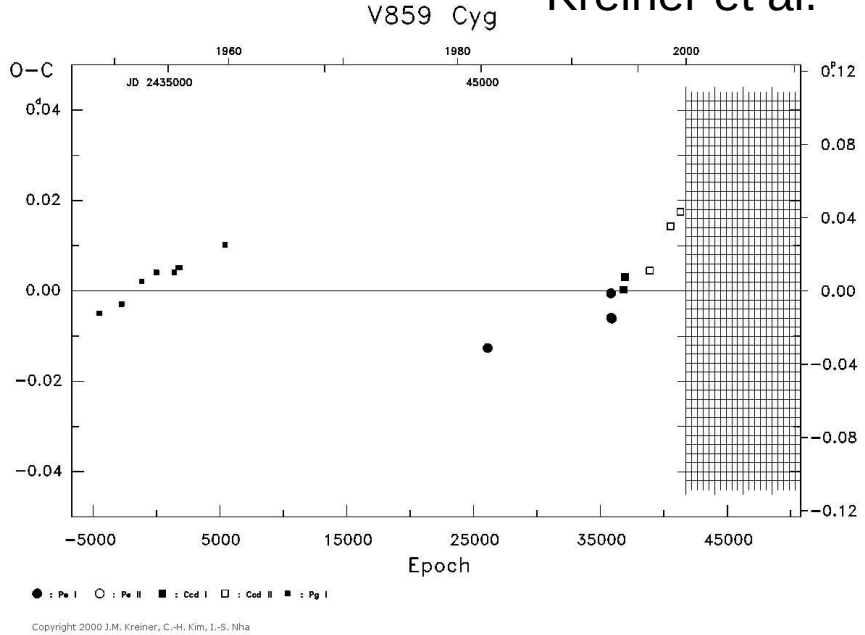
GEOMETRY=SPHERICAL
MASS_RATIO=0,350000
INPUT_MODE=OMEGA_POTENTIALS
OMEGA_1=2,450303
OMEGA_2=2,450303
WAVELENGTH=5500,000000
TEMPERATURE_1=7200,000000
TEMPERATURE_2=6900,000000
GRAVITY_1=0,320000
GRAVITY_2=0,320000
LIMB_1=0,486000
LIMB_2=0,486000
REFLECTION_1=0,500000
REFLECTION_2=0,500000

THIRD_LIGHT=0,000000
INCLINATION=64,000000
NORM_PHASE=0,260000
PHASE_INCREMENT=0,010000
USE_ADVANCED_PHASE=FALSE
HAS_SPOTS=FALSE
HAS_DISK=FALSE
ROTATION_F1=1.0
ROTATION_F2=1.0
PSEUDOSYNC=TRUE
LONG_OF_PERIASTRON=0,000000
ECCENTRICITY=0.0
ZERO_POINT_OF_PHASE=0.0
USER_NORM_FACTOR=1.0



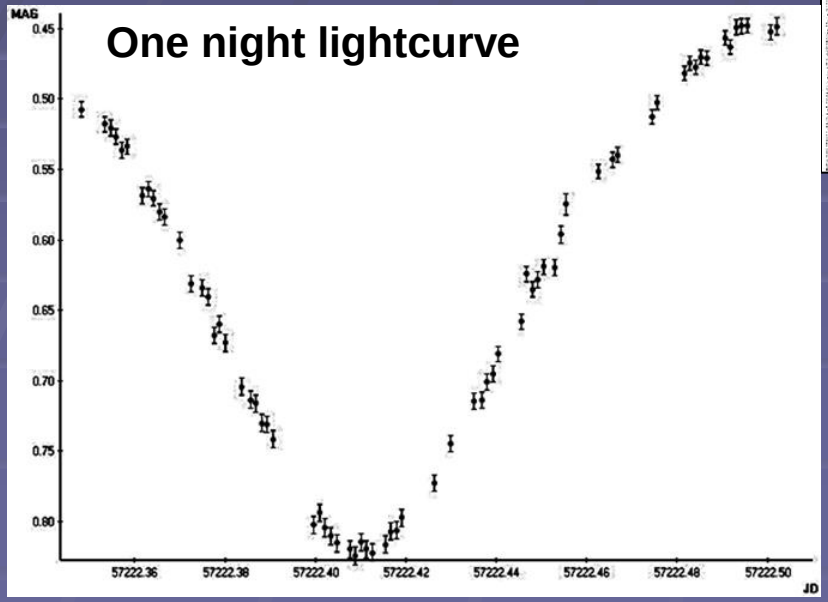
O - C variations of V859 Cyg system in 1948 -- 2014 according to O - C Gateway, B. R.N.O. (left panel) and Kreiner (2004) elements.

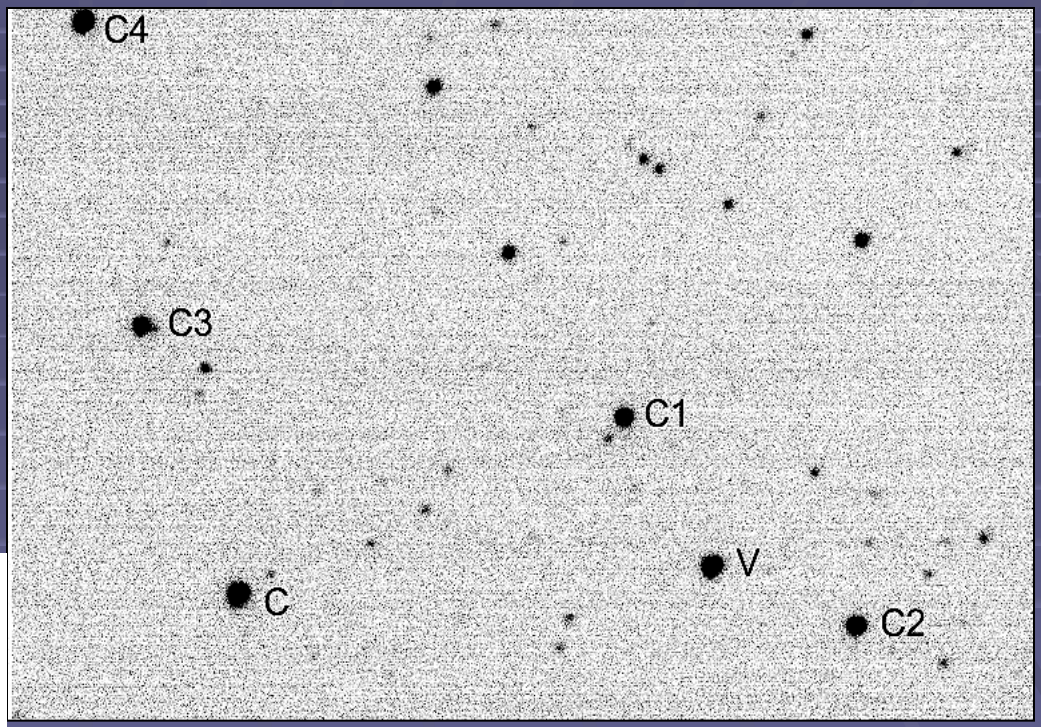
Kreiner et al.



V724 Aql

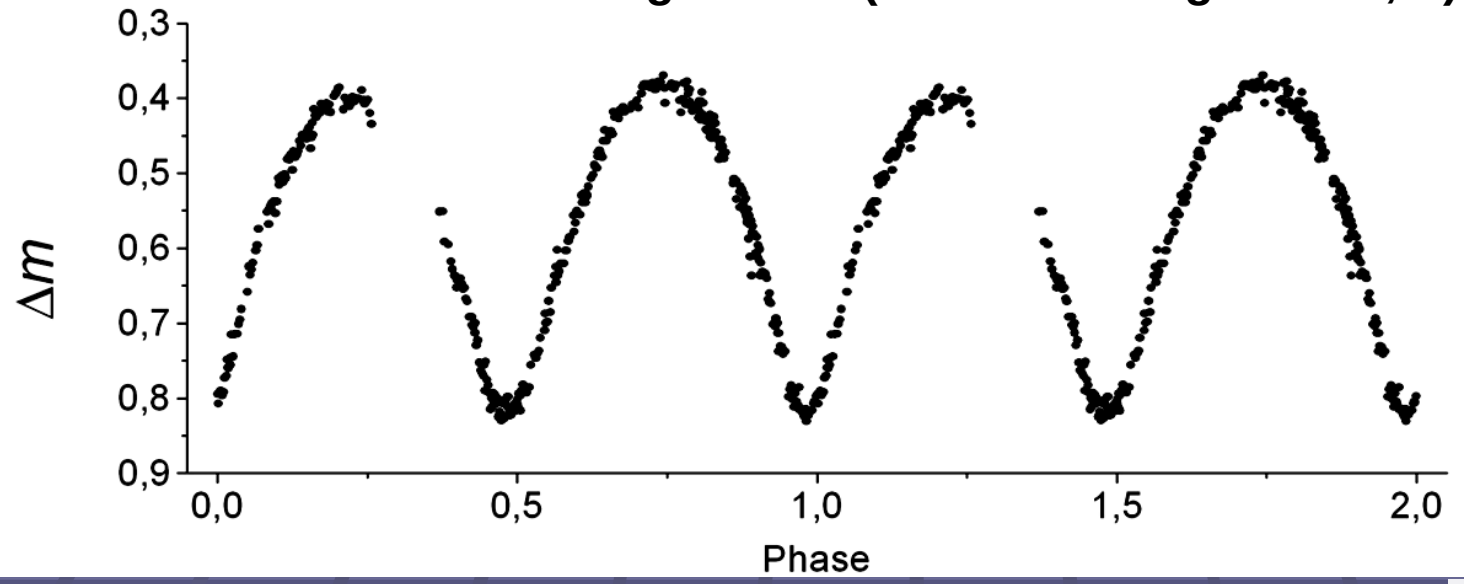
Δ ***mv*** = $11^m.1 - 12^m.4$,
R.A.=19^h 56*m* 48*s*,
Dec.= +1°06'00".
Min I = 2436818.6890 + 0.51759948E
Only 21 time minima,
no data for secondary minimum





CCD frame of V724 Aql and reference stars (Photometric Catalog TASS Mark IV (in V, 2015) and APASS (in V, R, I, 2018), corrected according to Lupton (2005).

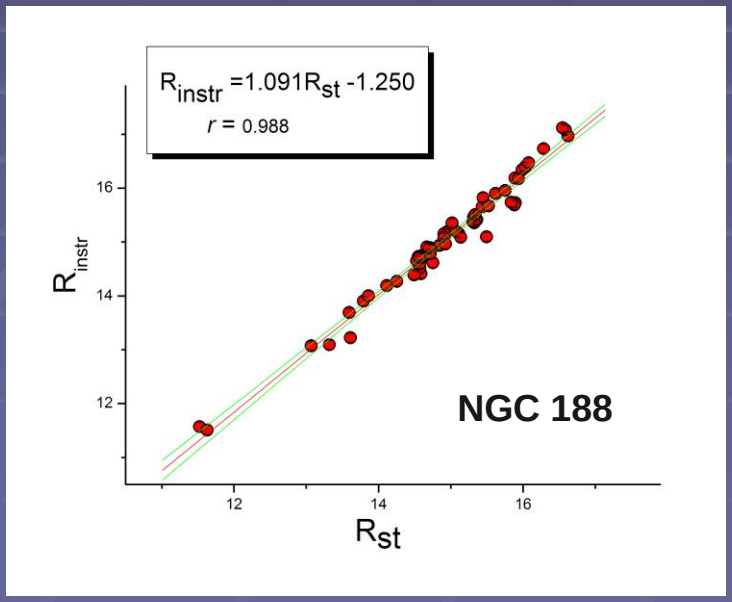
Season 2015 lightcurve (in relative magnitudes, V)



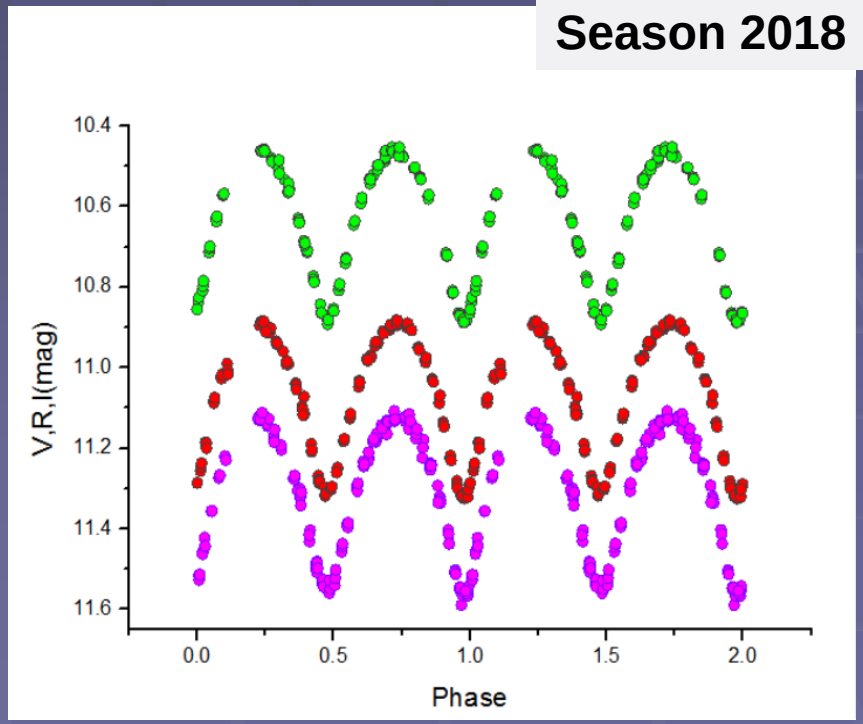
$m_I = 11{,}54^m$
$m_{II} = 11{,}54^m$

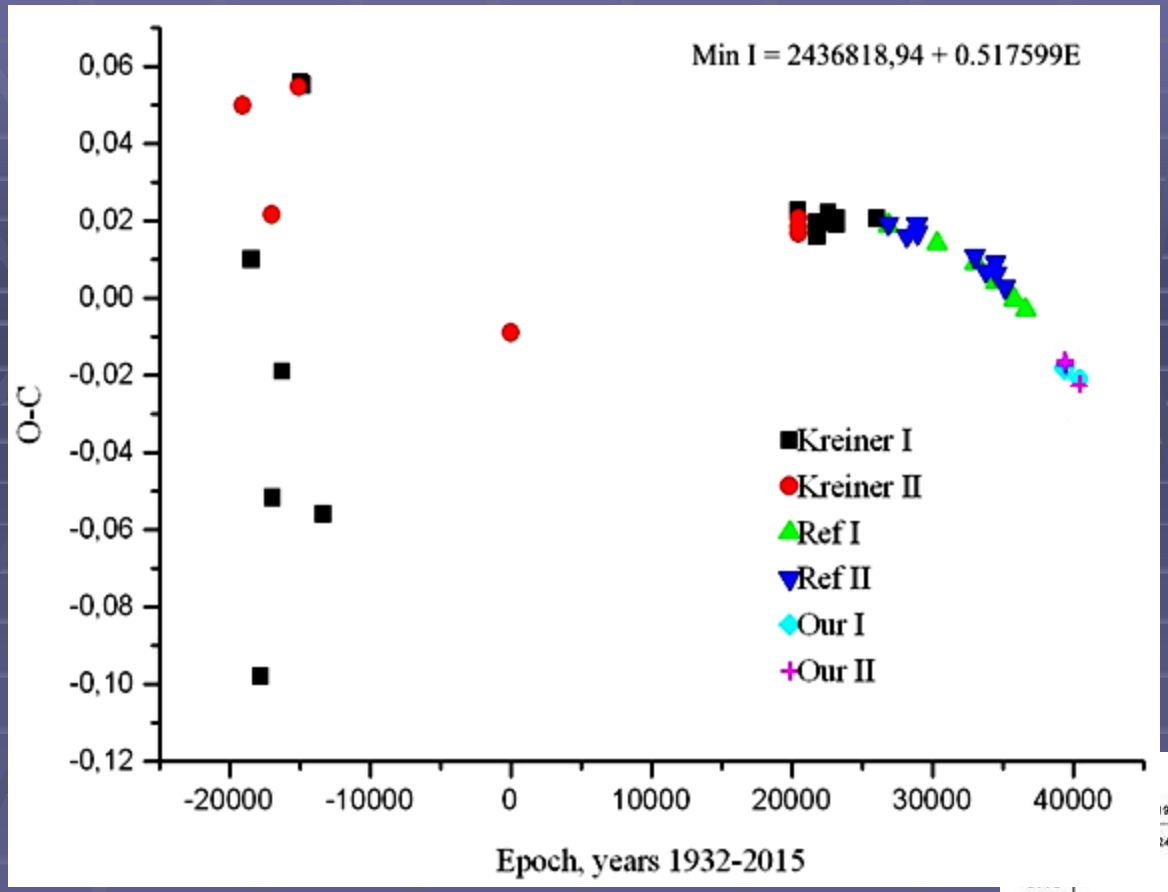
$m_{max} = 11.12^m$

$\Delta m = 0{,}42^m$



Season 2018

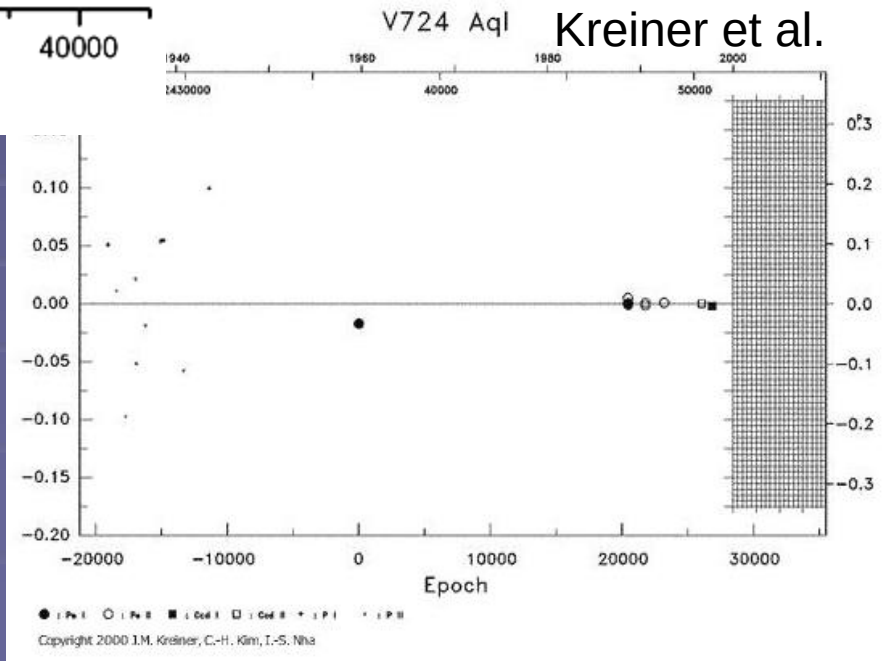




Time minima, JDh
2457210.5106 pri
2457215.4300 sec
2457222.4162 pri
2457243.3793 sec

2458339.37204 pri
2458340.40718 pri
2458344.28898 sec

O - C variations of V724 Aql system using all data set/ Parabolic trend?



Kreiner et al.

Summary

We show the useful of small telescope for study of variable stars and, in particularly close binary system in magnitude range from 11^m, where the number of insufficiently explored stars is great.

We show the necessity of study of full light curves for CBS.

For our program' stars we obtained more than 40 new time minima, and:

CU Peg – new time minima, mass transfer estimation;
V609 Aql – new time minima, mass transfer estimation, parameters of components;
BM Uma – new time minima, parameters of components, adjusted period;
V841 Cyg – new time minima, parameters of components;
V859 Cyg – new time minima, replace of primary and secondary minima, parameters of components, adjusted period;
V724 Aql – new time minima, to be continued….

Reference

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Dakujem!