The BIMA Project: Analysis of *O-C* Diagram on AO Vel

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Outline

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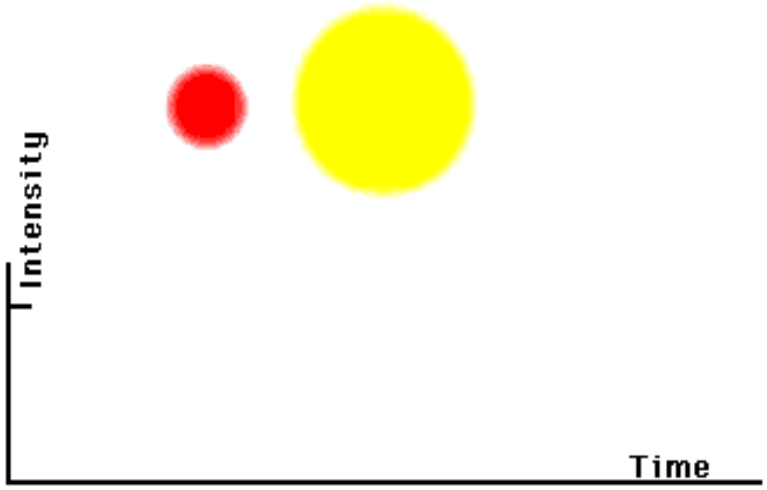
Acknowledgments

INTRODUCTION

Eclipsing Binaries' Minima (BIMA) Monitoring Project

A long-term observational project of eclipsing binaries.

- Bosscha Observatory. in June 2012
- National Astronomical Research Institute of Thailand (NARIT). Joined in December 2012



http://imagine.gsfc.nasa.gov/docs/teachers/hera_college/binary-model.html

to collect Time of Minimum data through photometric observations

to establish the orbital period of each system and its variations.

to built an open-database of eclipsing binaries' minima.

to improve our understanding on eclipsing binaries

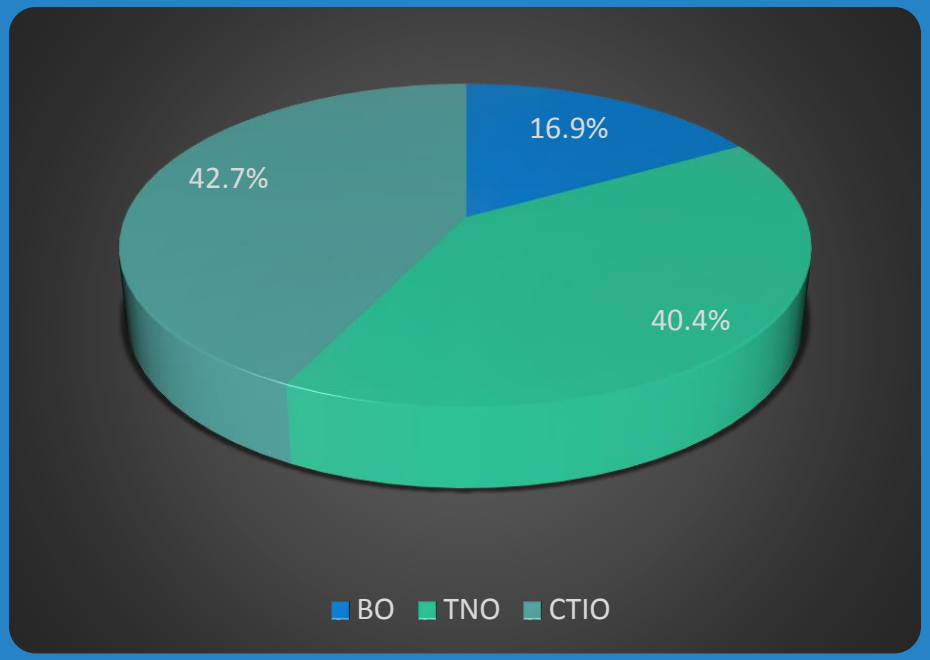
OBSERVATION: INSTRUMENTS

18°25'32''N
98°29'12'' E
2.4 m Ritchey-Chretien
0.5 m Schmidt-Cassegrain
Thailand National Observatory (TNO), Thailand

30°10'03.50'' S
70°48'19.40'' W
0.6 m Panchromatic Robotic Optical Monitoring and Polarimetry Telescopes (PROMPT-8), Chile

6°49'28''S
107°36'56'' E
0.203 m GAO-ITB Remote Telescope System,
Bosscha Observatory, Indonesia

RESULT (1) : STATISTICS



89 minima in total

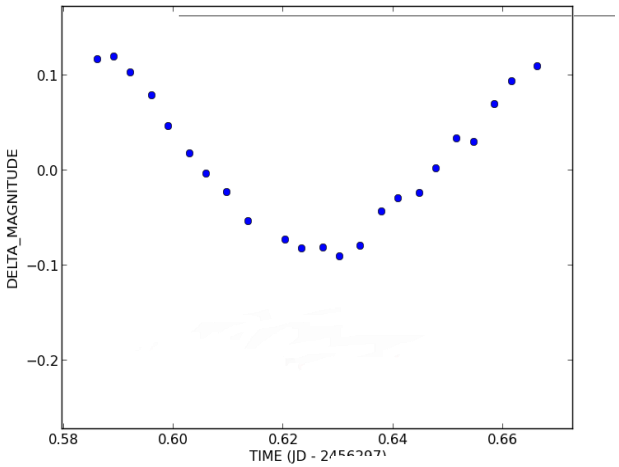
15 minima from BO

36 minima from TNO

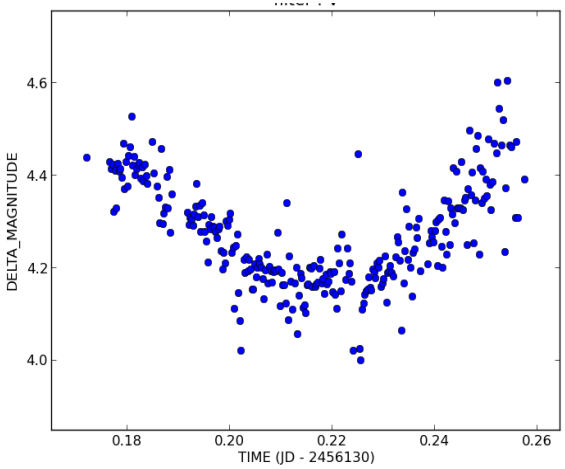
38 minima from CTIO

RESULT (2) : LIGHT CURVES

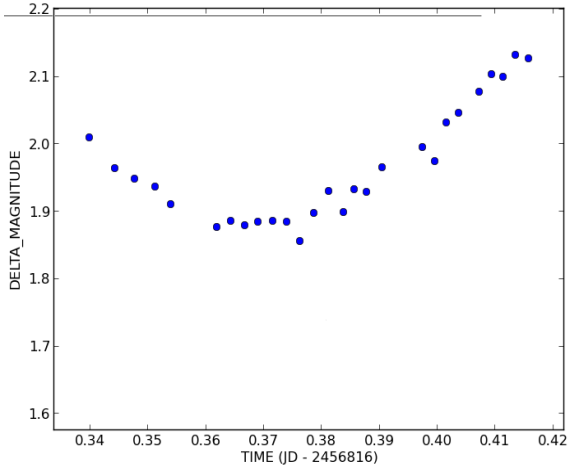
AB AND



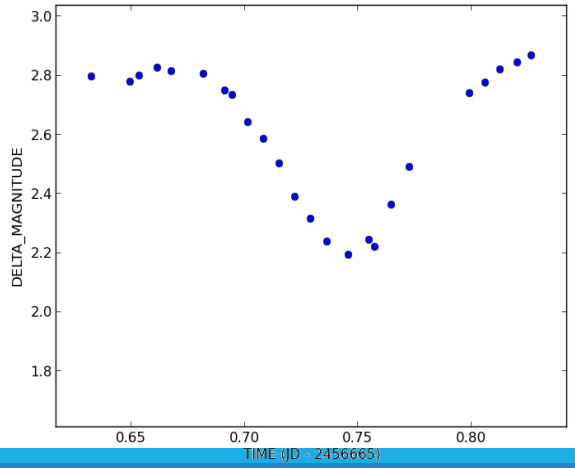
V566 OPH



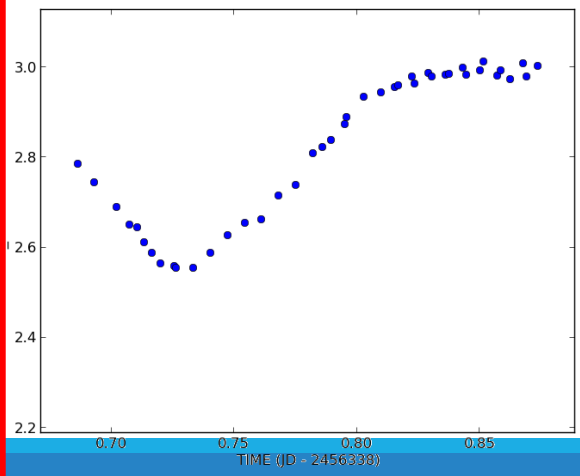
GO CYG



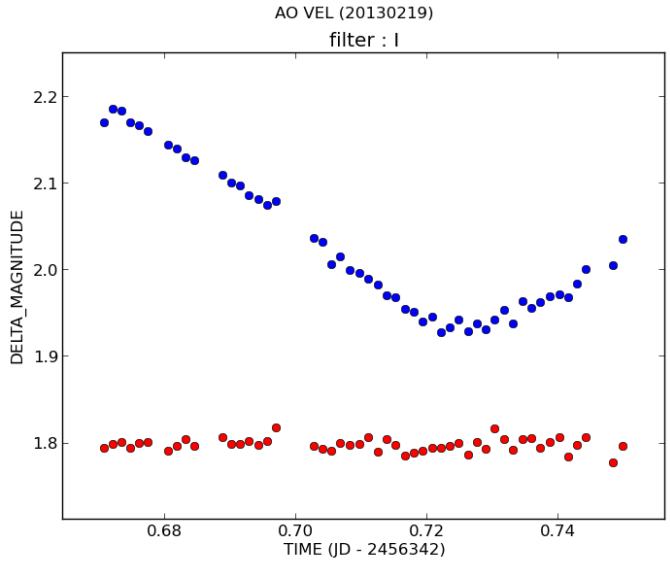
TU CMA

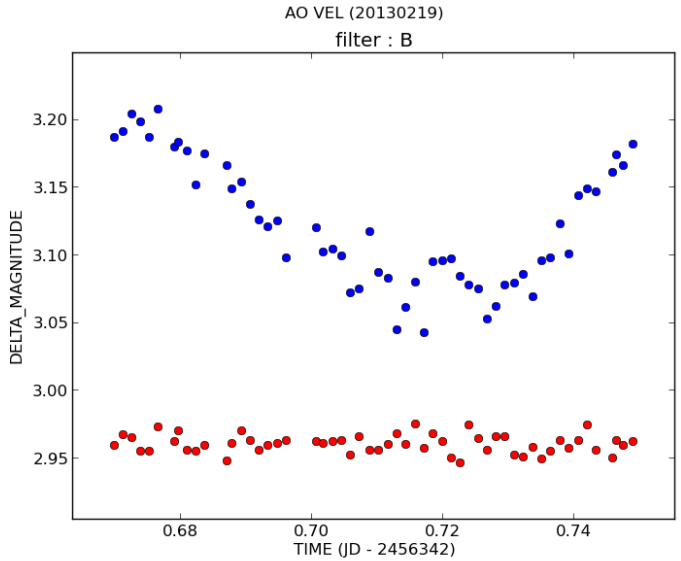


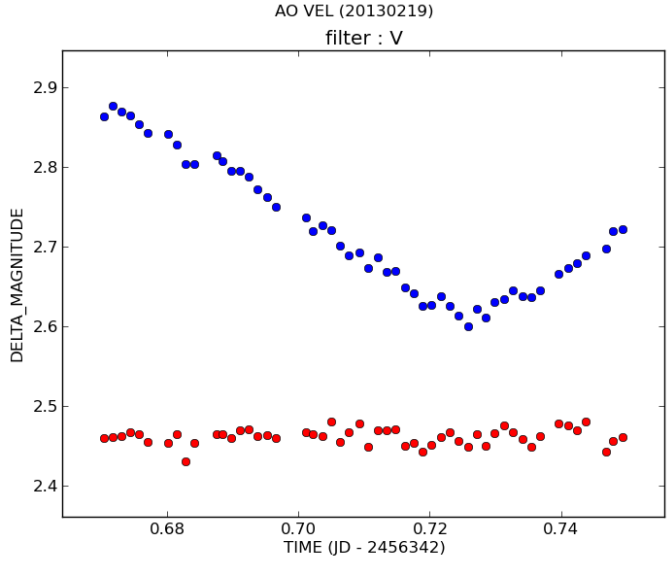
AO VEL

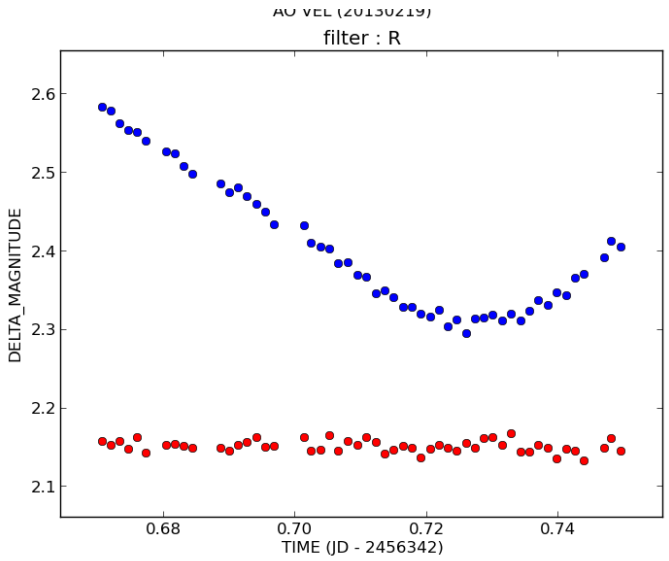


AO Vel Light Curves







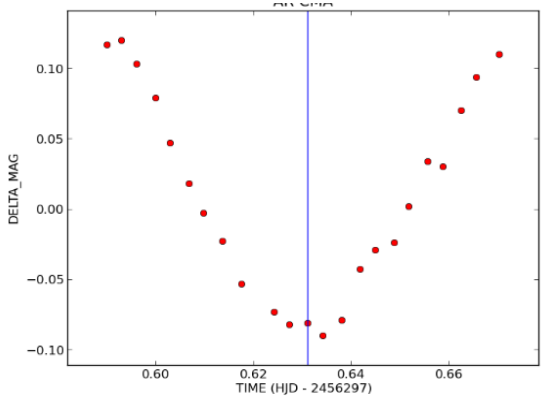


RESULT (3) : TIME OF MINIMUM

Kwee-van Woerden Method (1956)

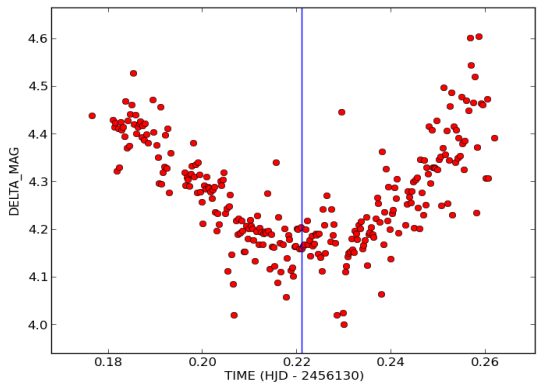
Custumed script using Python

AB AND



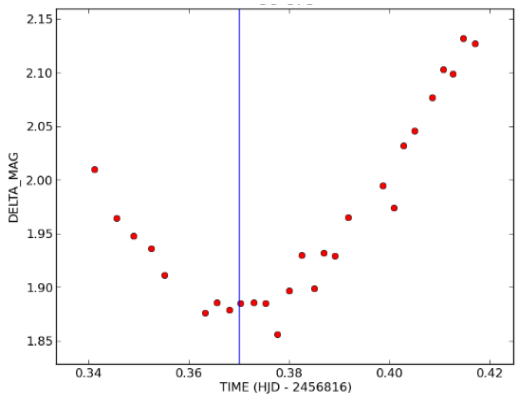
ToM = 2456297.631043 ± 1.6786 × 10^{-04}

V566 OPH



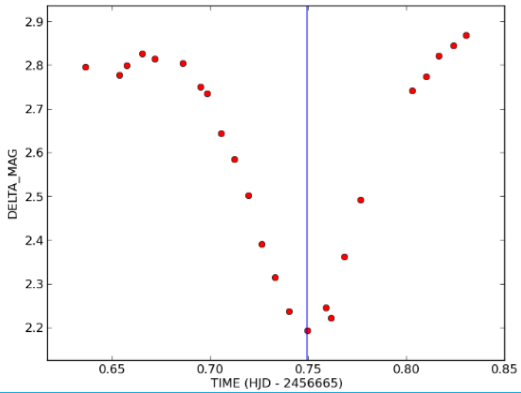
ToM = 2456130.221185 ± 6.6613 × 10^{-05}

GO CYG



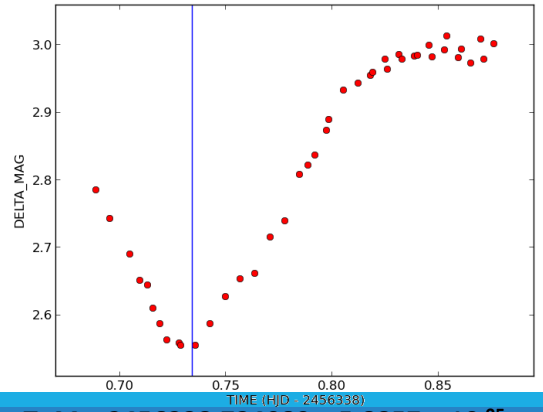
ToM = 2456816.369935 ± 1.9887 × 10^{-04}

TU CMA



ToM = 2456665.749283 ± 1.4572 × 10^{-04}

AO VEL



ToM = 2456338.734089 ± 5.8857 × 10^{-05}

RESULT (4) : *O*–*C* Diagrams

$$O-C = ToM_{observed} - ToM_{calculated}$$

Get $ToM_{Calculated}$ from a linear ephemeris

$$HJD_{\min} = E_0 + E \times P$$

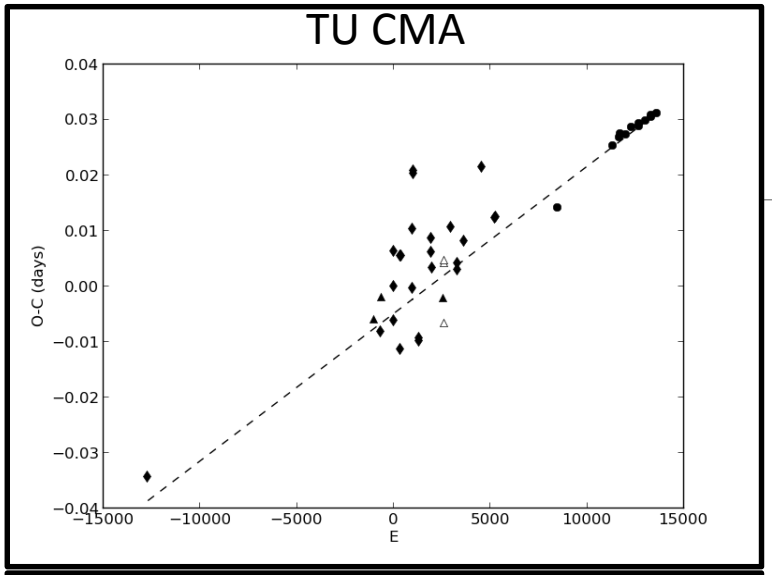
where :

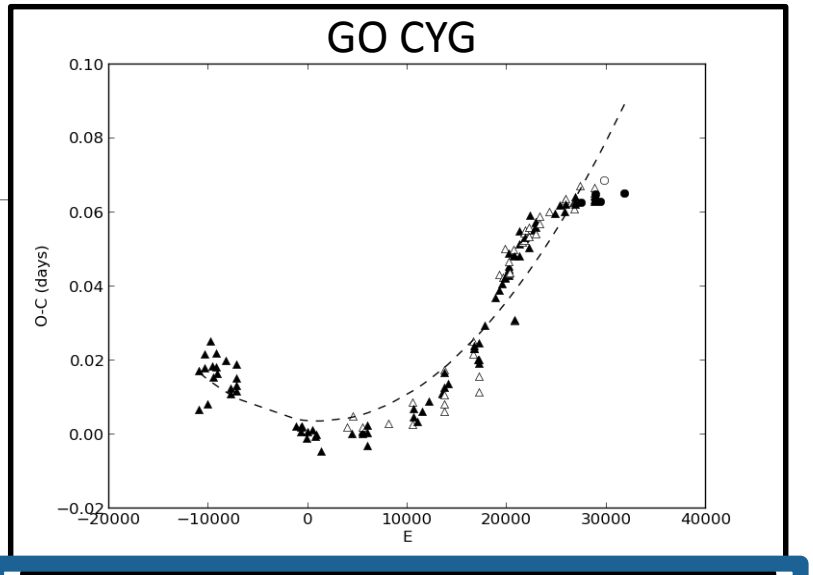
HJD_{min} = calculated ToM in HJD

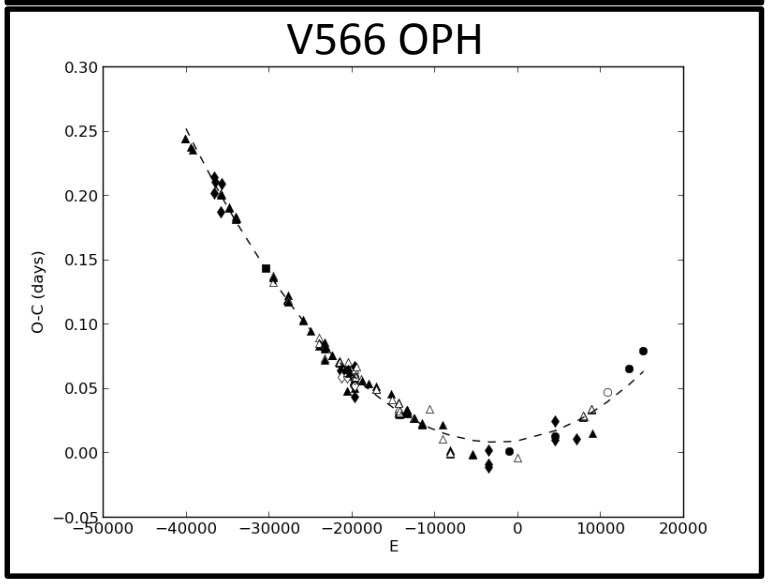
E_0 = initial epoch

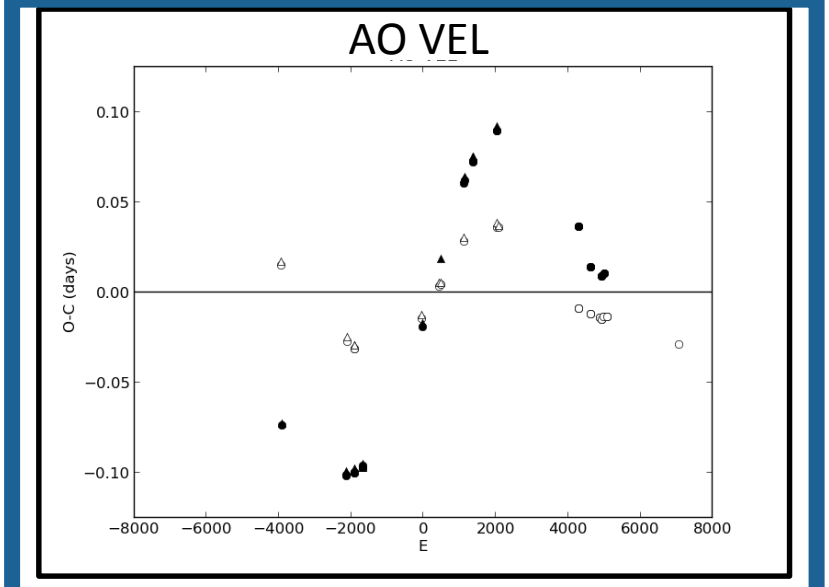
P = period

RESULT (5) : *O–C* Diagrams









AO Vel (HD 68826)

- Detached eclipsing binary (Algol Type)
- Discovered to be variable by Herztprung (1937). P = 1.58 day/
- Apsidal motion 50 years detected by Oosterhoff & van Houten (1949)
- *uvby* photometry by Grønbech (1987)
- Clausen et al. (1995) presented first photometric analysis.

α_{2000}	$8^h11^m53.9^s$
δ_{2000}	$-48^o44'46.0"$
Spectral Type	B9III/Ap
V_{max}	9.34

Analysis of *O-C* Diagram on AO Vel

We use linear ephemeris calculated by Clausen et al. 1995:

$$\text{Pri. Min.} = \text{HJD } 2445043.^{d}6806 + 1.^{d}584660 \times E$$

$$\text{Sec. Min.} = \text{HJD } 2445044.^{d}4587 + 1.^{d}584631 \times E$$

Apsidal Motion

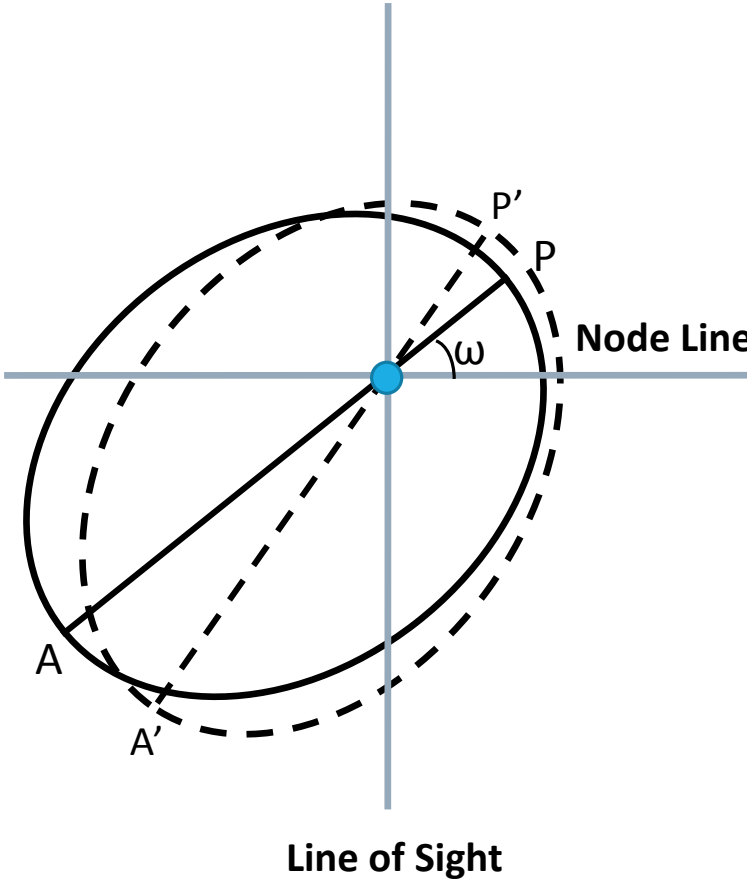
$$T = T_0 + P_s E + (j-1)\frac{P}{2} + (2j-3)A_1 \frac{eP}{2\pi}\cos\omega + A_2 \frac{e^2 P}{4\pi}\sin 2\omega -$$

$$-(2j-3)A_3 \frac{e^3 P}{8\pi}\cos 3\omega - A_4 \frac{e^4 P}{16\pi}\sin 4\omega +$$

$$+(2j-3)A_5 \frac{e^5 P}{32\pi}\cos 5\omega + A_6 \frac{e^6 P}{64\pi}\sin 6\omega$$

$$\omega = \omega_0 + \dot{\omega} E$$

T = observed time of minimum
T_0 = initial epoch
P_s = sidereal period
P = anomalistic period
e = eccentricity
E = cycle
A_n = constant (Gimenez & Bastero, 1995)
ω = periastron longitude
ω_0 = periastron longitude when E_0
$j = 1$ for primary minimum
$j = 2$ for secondary minimum

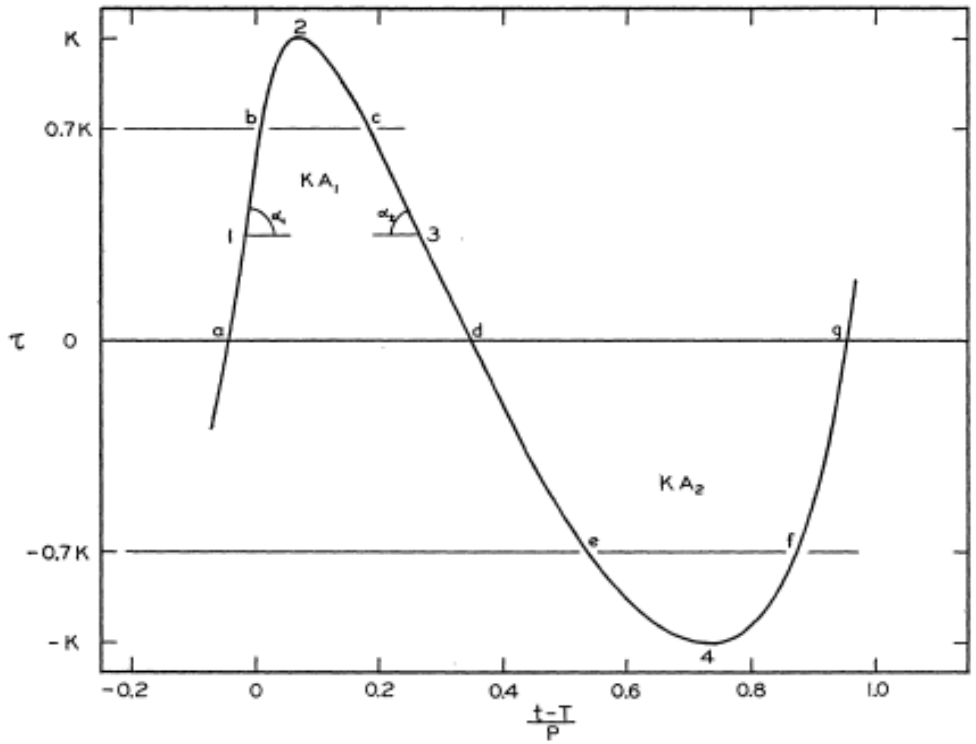


(Gimenez and Bastero, 1995)

Light Time Effect

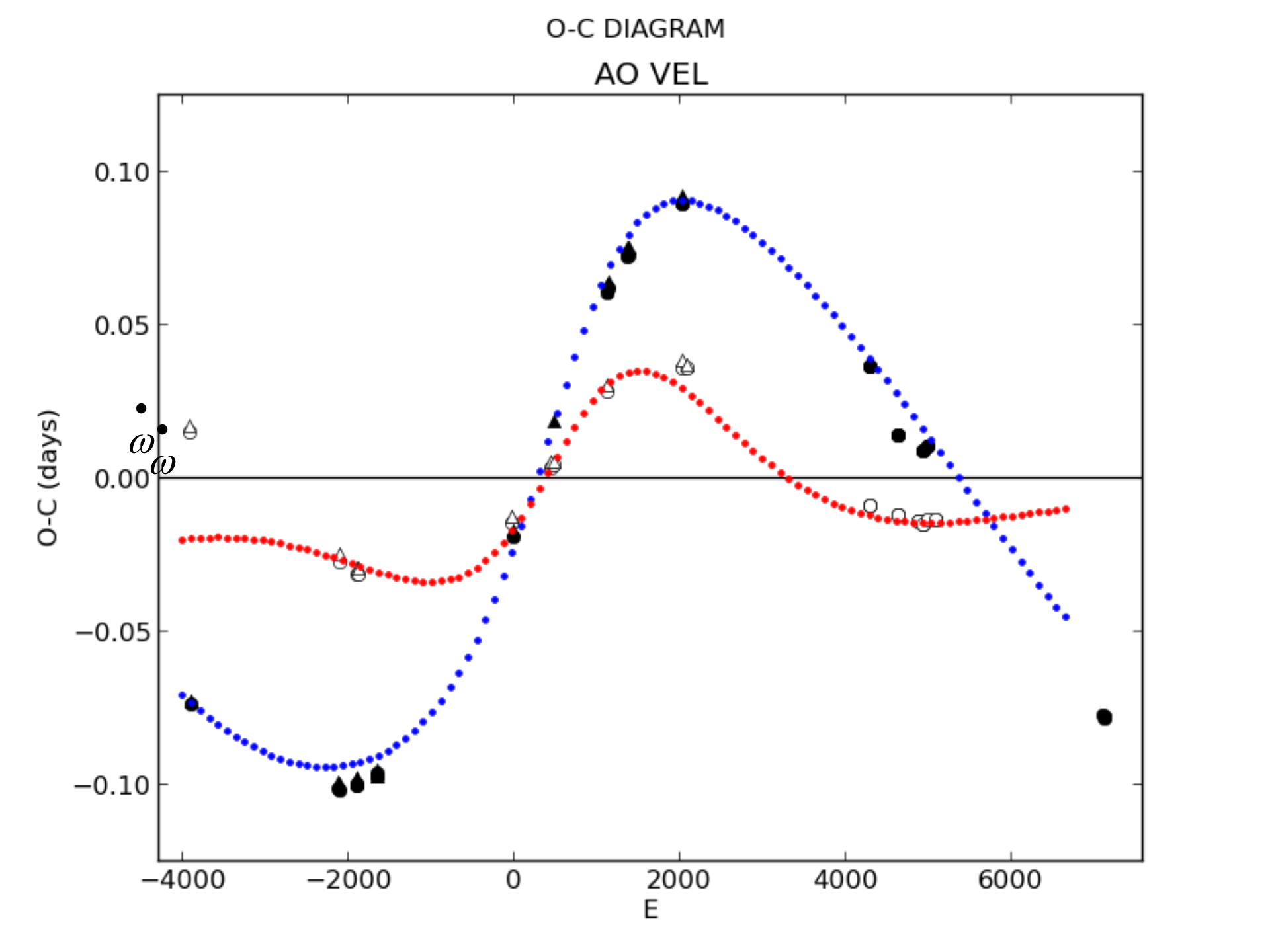
$$\tau = K \frac{1}{\sqrt{(1 - e^2 \cos^2 \omega}} [\frac{1 - e^2}{1 + e \cos \upsilon} \sin(\upsilon + \omega) + e \sin \omega]$$

$$K = \frac{1}{2}(\tau_{max} - \tau_{min}) = \frac{a \sin i \sqrt{(1 - e^2 \cos^2 \omega)}}{2.590 \times 10^{10}}$$



τ = difference of light distance to observer
K = semi amplitude of τ
e = eccentricity
υ = true anomaly
ω = periastron longitude
i = inclination

(Irwin, 1952)


O-C DIAGRAM
AO VEL
0.10
0.05
0.00
−0.05
−0.10
O-C (days)
ω
ω
−4000
−2000
0
2000
4000
6000
E

Result

Apsidal motion parameter:

$T_0 = 2445043.67$ $P_{sidereal} = 1.5846212$ days

$P_{anomalistic} = 1.4566882$ days $\omega_0 = 84.831$ deg

$\dot{\omega} = 0.0322$ day/cycle

Light Time Effect Parameter:

$T_0 =$ HJD 2446225.0 $P_3 = 12053.25$ days

Semi Amplitude $= 0.0618925$ days

$E_3 = -0.336653$ cycle

$\omega_3 = 0.45602$ deg

Acknowledgments

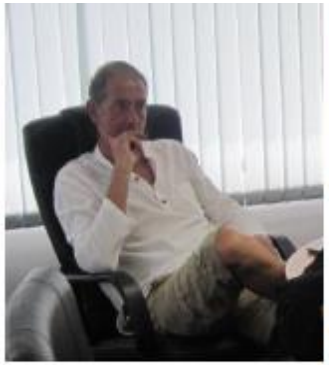
- Faculty of Mathematics and Natural Sciences, Institut Tekonologi Bandung
- Bosscha Observatory, Institut Teknologi Bandung
- Organizing Committee of EAYAM 2015












Thank You!