
OGLE & MW by Yuri Beletsky

Tracking ellipsoidal binaries

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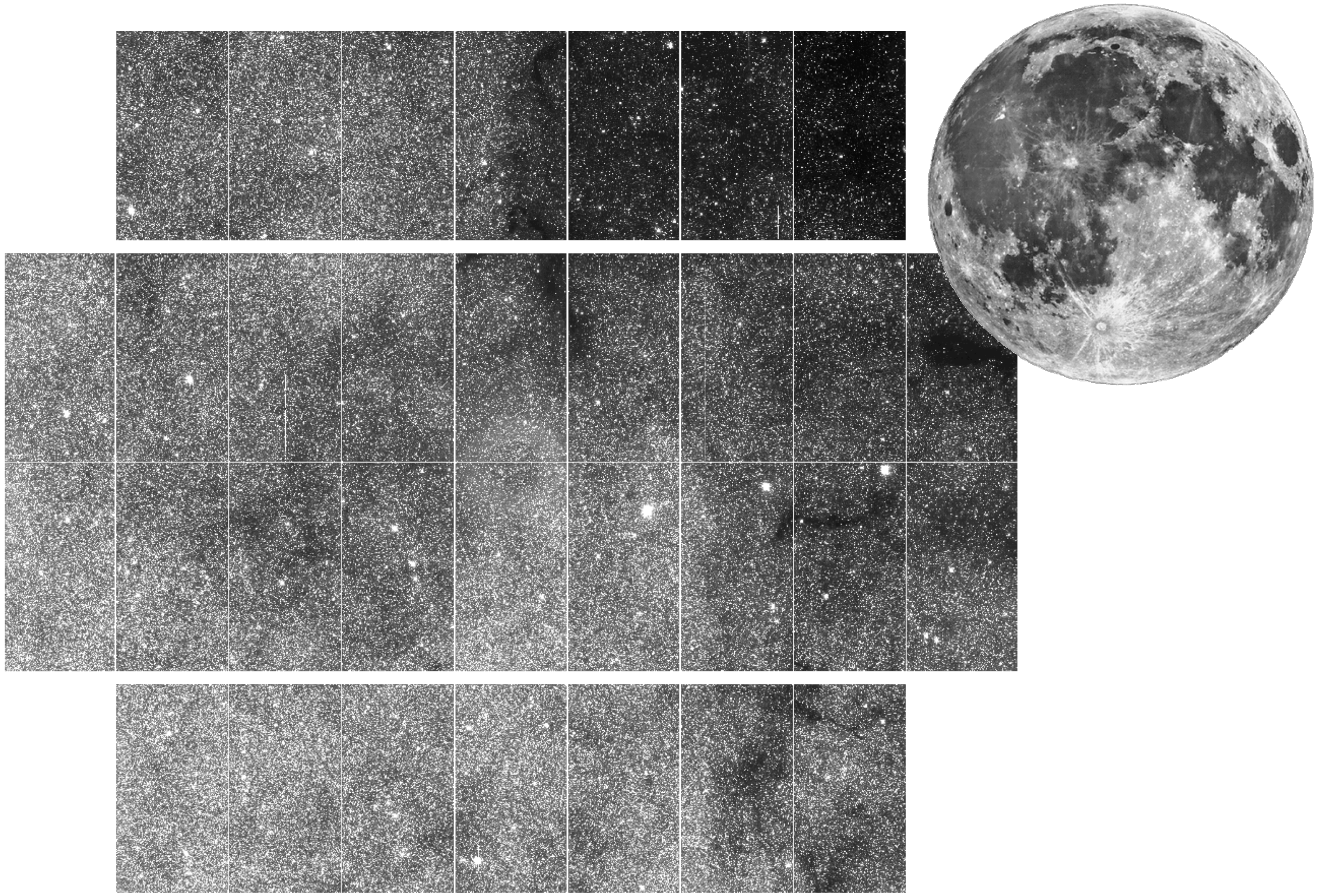
OGLE

Optical Gravitational Lensing Experiment

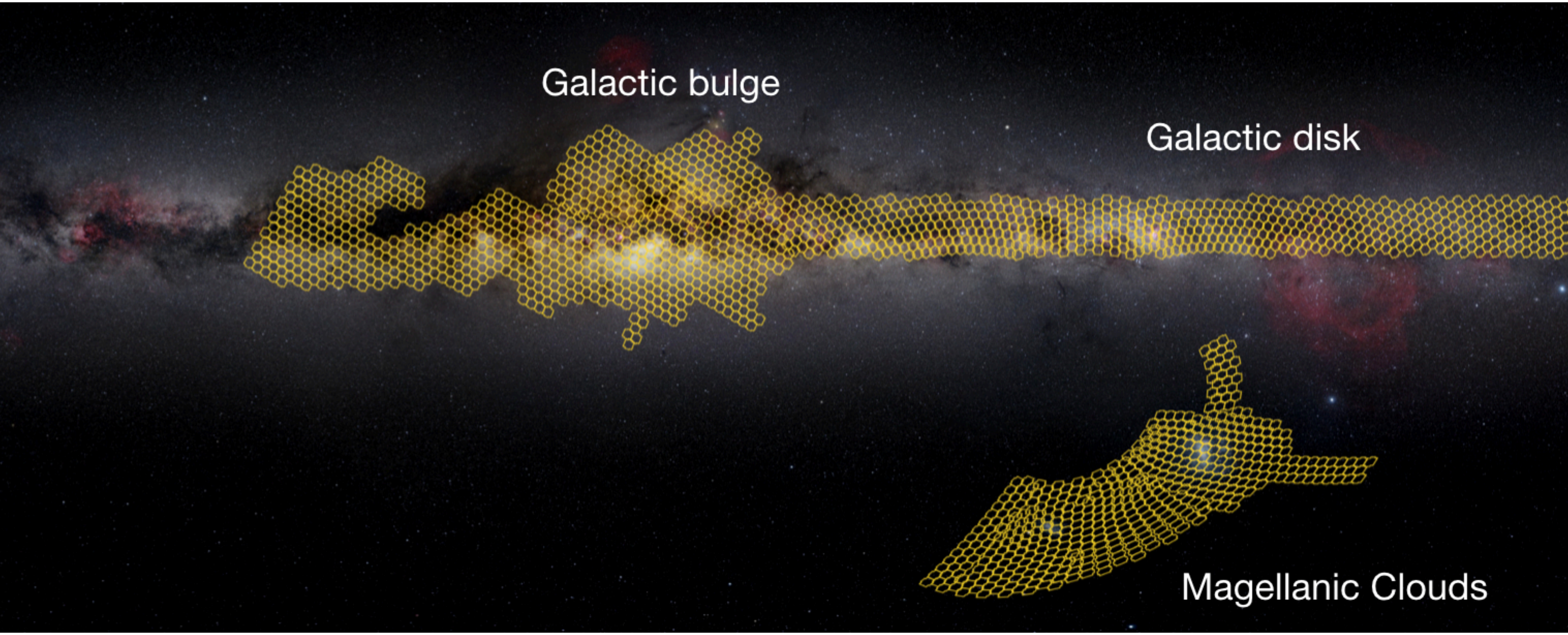
1.3-m telescope,
Las Campanas



Field of view: 1.4 deg^2

~6 000 000 stars in this picture

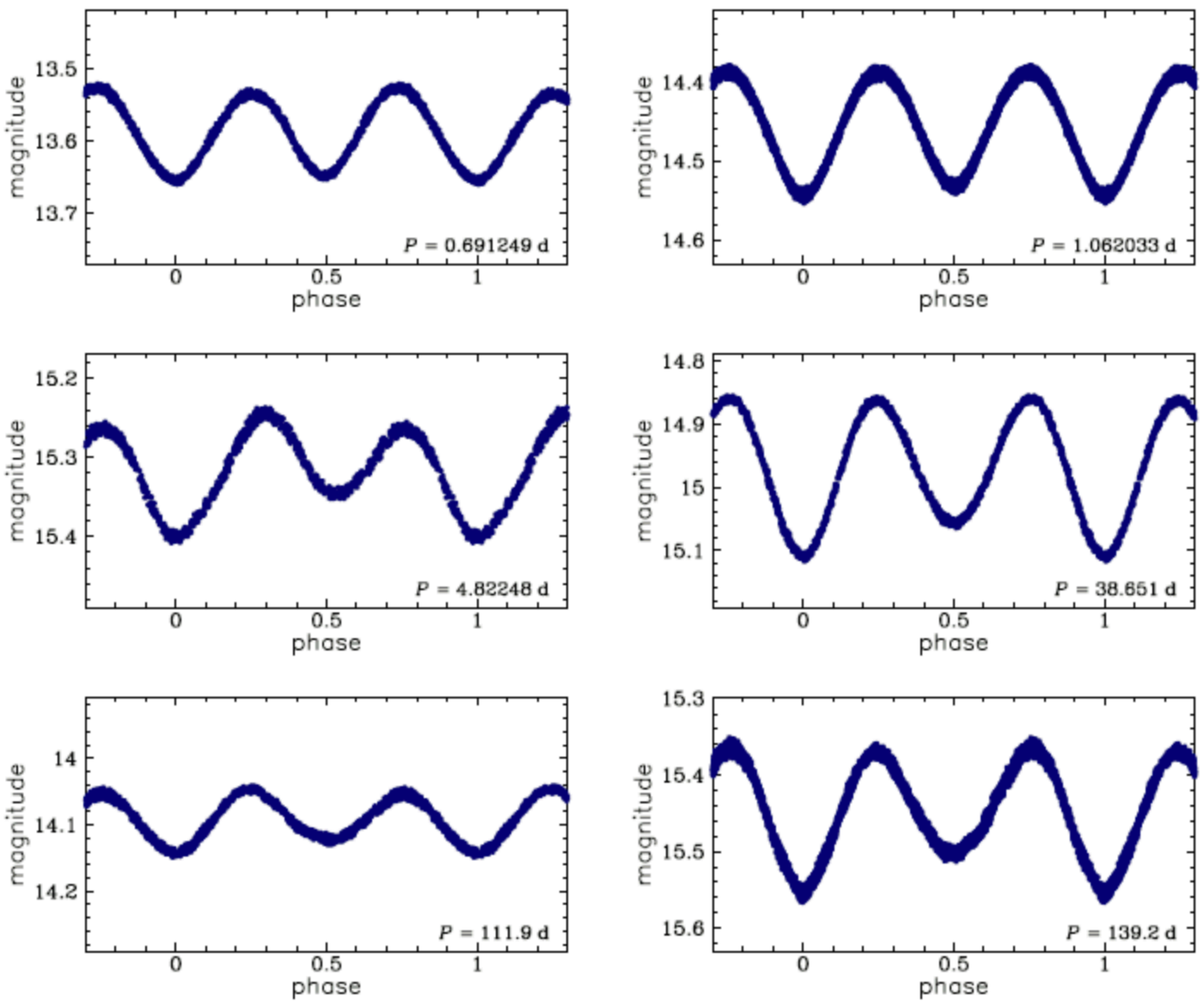
OGLE-IV sky coverage



2 billion stars monitored

Udalski et al., 2015

OGLE ellipsoidal systems



26 564

1 159	**25 405**
Magellanic Clouds	**Galactic bulge**
Pawlak et al. 2016	Soszyński et al. 2017

P: 0.08 - 636.71 d

I_{amp}: 0.008 - 1.209 mag

Dormant compact objects in binaries

large RV modulation

large ellipsoidal modulation
induced by tidal interaction

astrometry

Dormant compact objects in binaries

large RV modulation

large ellipsoidal modulation induced by tidal interaction

astrometry

Minimum mass ratio

photometric amplitude
M, R estimation
i = 90°

minimum mass ratio
MMR

photometric amplitude **only**
primary fills the Roche lobe
i = 90°

modified minimum mass ratio
mMMR

mMMR < MMR < actual MR

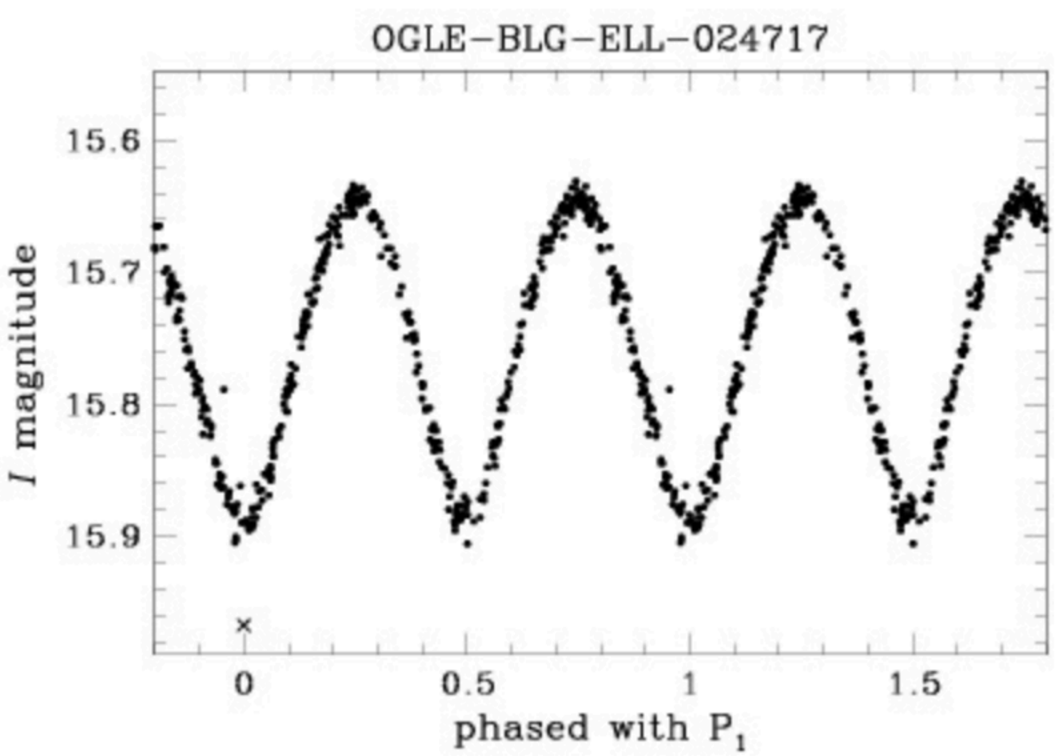
Gomel, Faigler & Mazeh, 2021a

dormant compact objects search in binaries

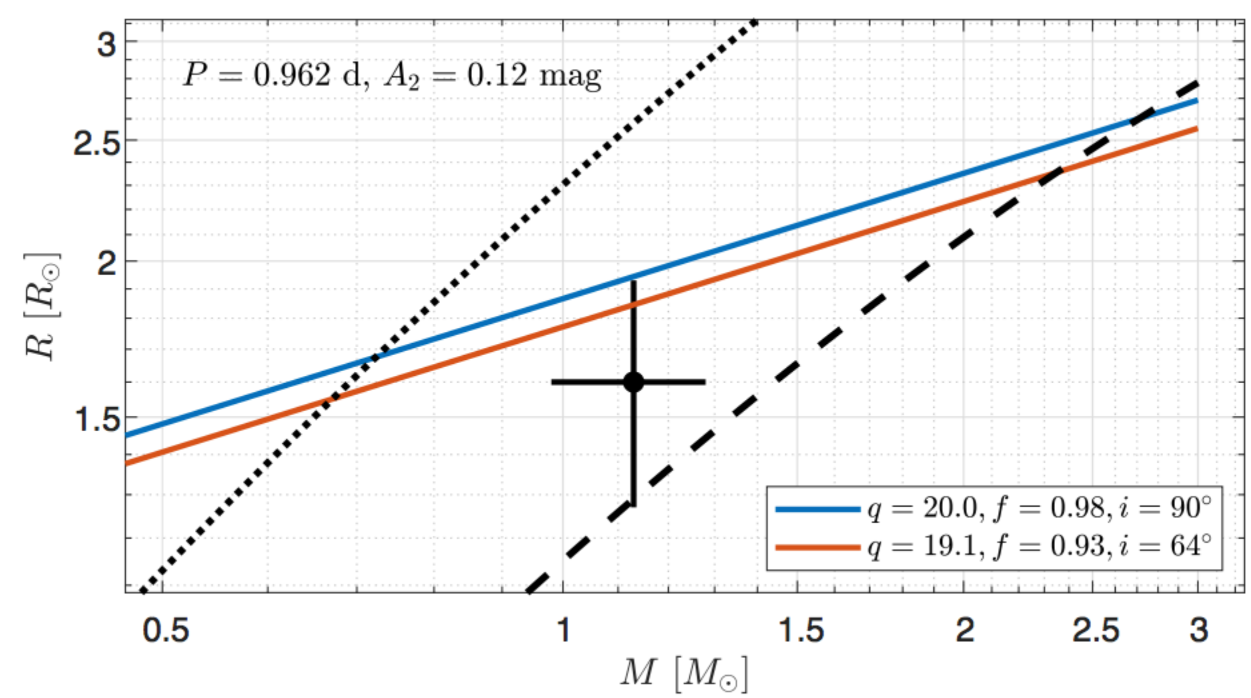
24 405 ellipsoidals toward GB

10 956 short-period P< 2.5 d

136 MS stars with large modulations



P = 0.9621 d
mMMR ~ 2.2



M_1 = 1.13 +- 0.16 Ms (from MIST)
M_2 ~ **3.7** Ms

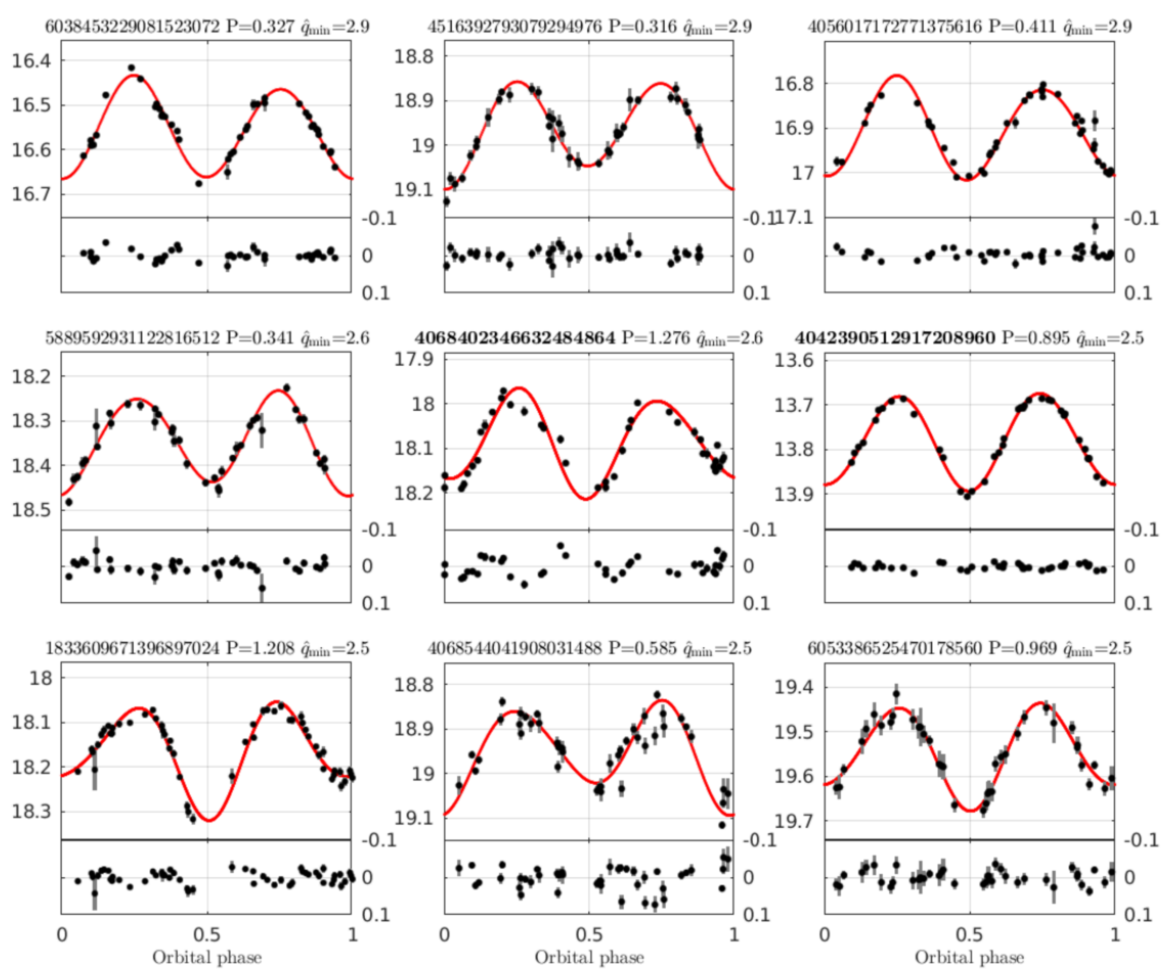
Gomel et al. 2021b
Soszyński et al. 2016

Ellipsoidals in Gaia DR3

22 914 short-period ellipsoidal

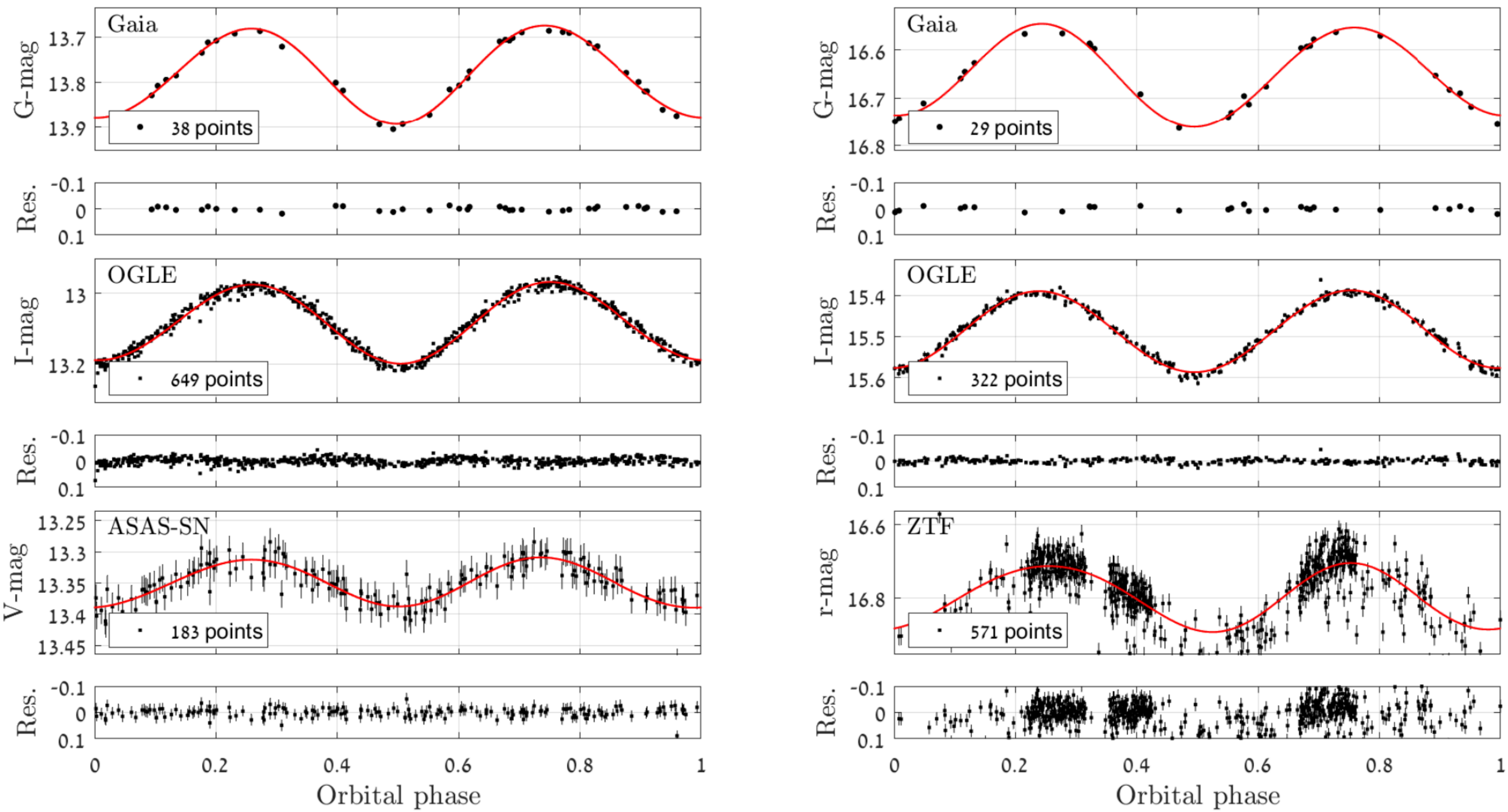
6306 candidates **262 best candidates**

- observed variability due to ellipsoidal modulation
- sources too faint for Gaia RV measurements
- to confirm the true nature follow-up is needed



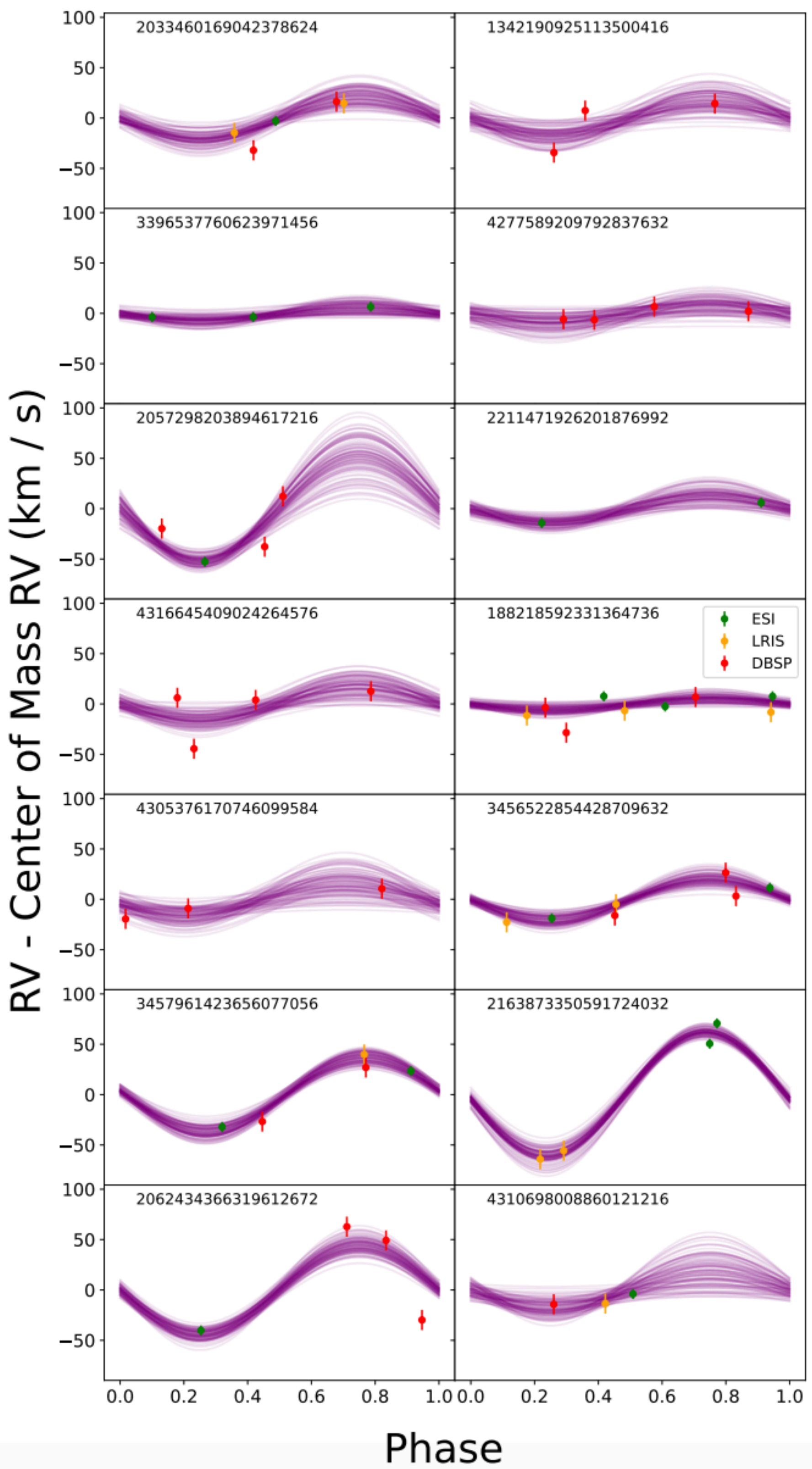
Gomel et al. 2022

Archival data



Gomel et al. 2022

Follow up



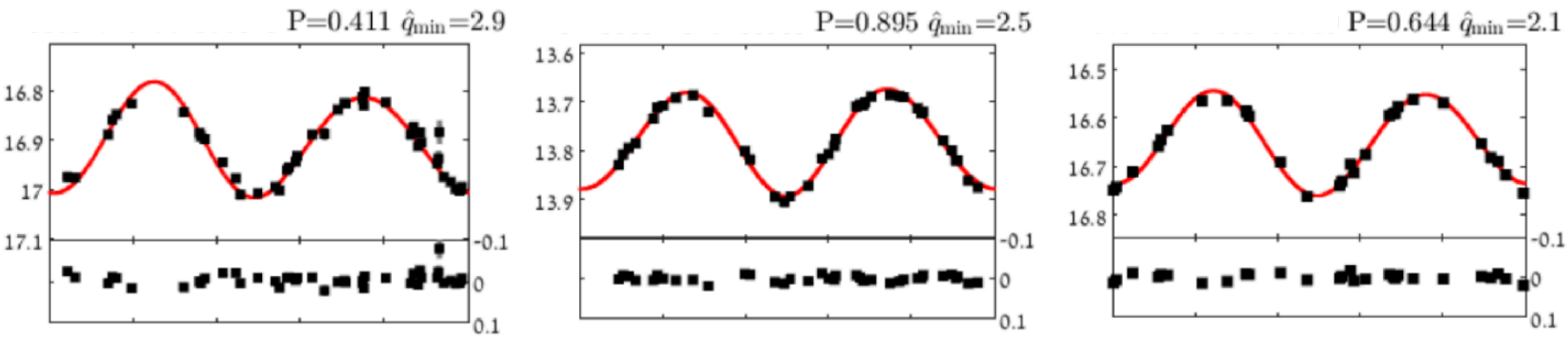
RV follow-up of 14 candidates

minimum companion masses of ≤ **0.5 Ms** in all cases

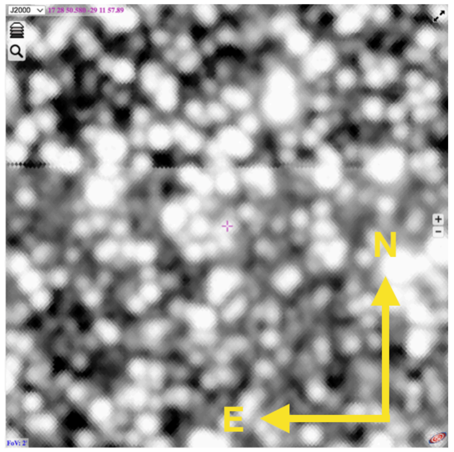
unequal-mass contact binaries with starspots

Nagarajan et al. 2023

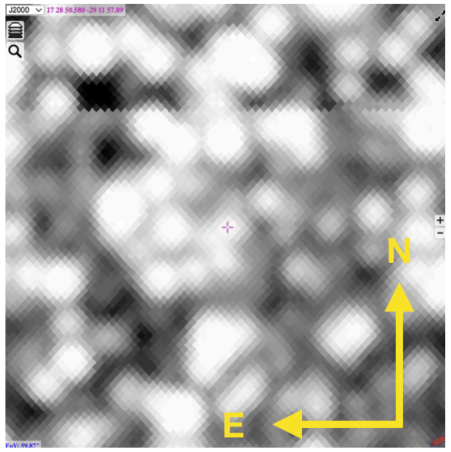
Follow up with ESO/XSHOOTER & SALT/HRS



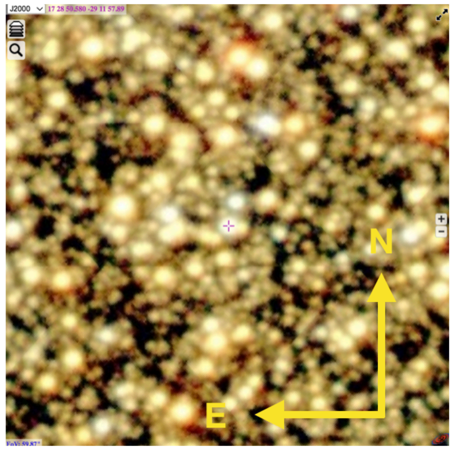
Unlike previous studies (e.g. Thompson et al. 2019, Jayasinghe et al. 2021),
all selected systems consist of **main-sequence stars**,
which makes the search for compact objects much more promising (e.g. El-Badry & Rix 2022).



FOV 2' x 2', 2MASS



FOV 1' x 1', 2MASS



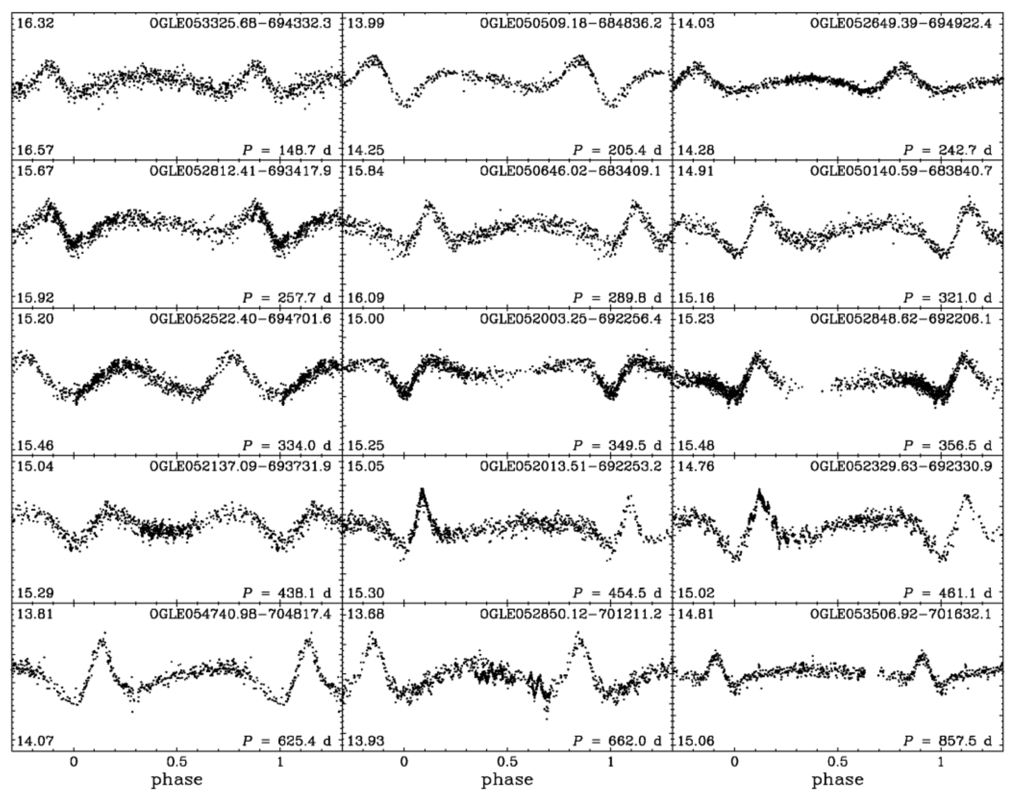
FOV 1' x 1', DECam

Eccentric ellipsoidal variables

Eccentric ellipsoidal variables

eccentric ellipsoidal variables (EEVs) → **heartbeat stars**

at **periastron**: tidal interactions → stellar deformation → brightness variations



OGLE ellipsoidals collection

Soszyński et al. 2004

An explanation of such variables was proposed by B. Paczyński (2004, private communication) who suggested that these objects may be ellipsoidal systems with significant eccentricity of the orbits.

Eccentric ellipsoidal variables

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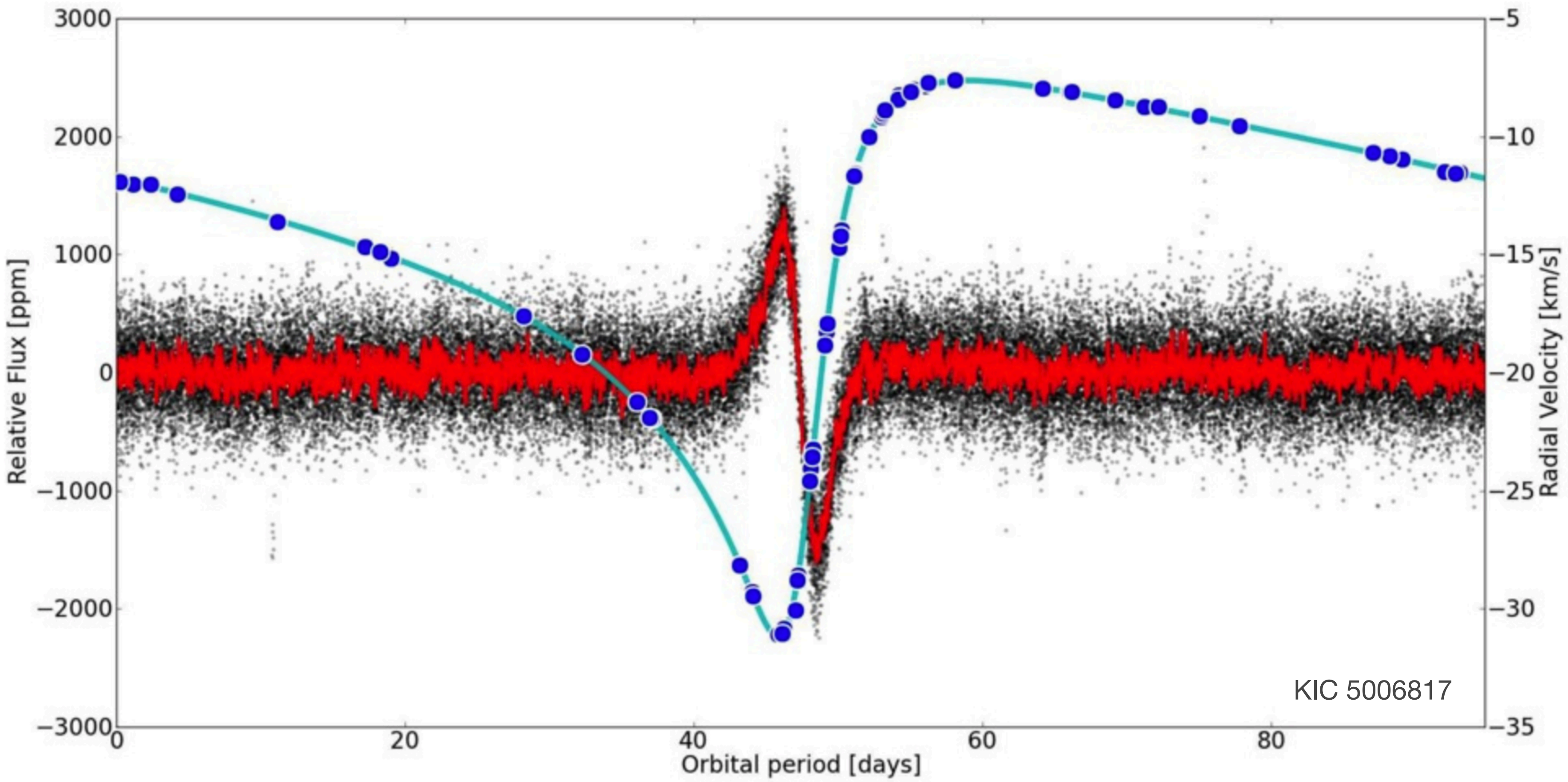


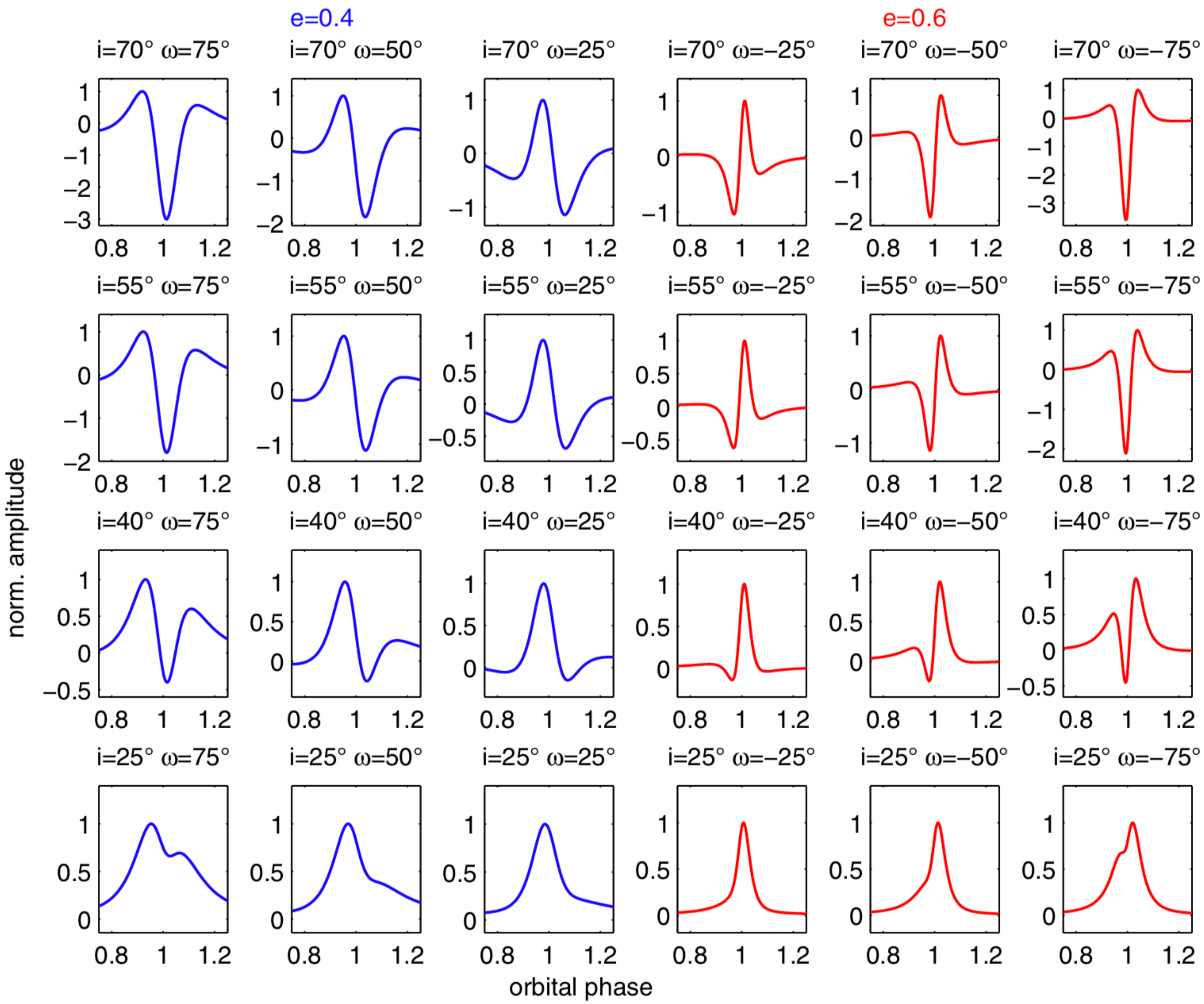
Beck et al. 2014

rich oscillation spectrum allows for **detailed seismic analysis** (modeling effects of rotation)

Shape of HB

shape: i, ω, e

amplitude: M1, M2, separation at the periastron



Thompson et al. 2012

EEVs collections

Kepler

~170 systems with small amplitude (<1 mmag)
Thompson et al. 2012, Beck et al. 2014, 2018,
Kirk et al. 2016, Guo et al. 2019, Hambleton et al. 2016, 2018

BRITE

~a few OB-type
Pablo et al. 2017, Pablo et al. 2019

TESS

~20 OB-type
Kołaczek-Szymański et al. 2021

OGLE

~1000 systems, mostly RGs
Wrona et al. 2022a,b

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TEO studies

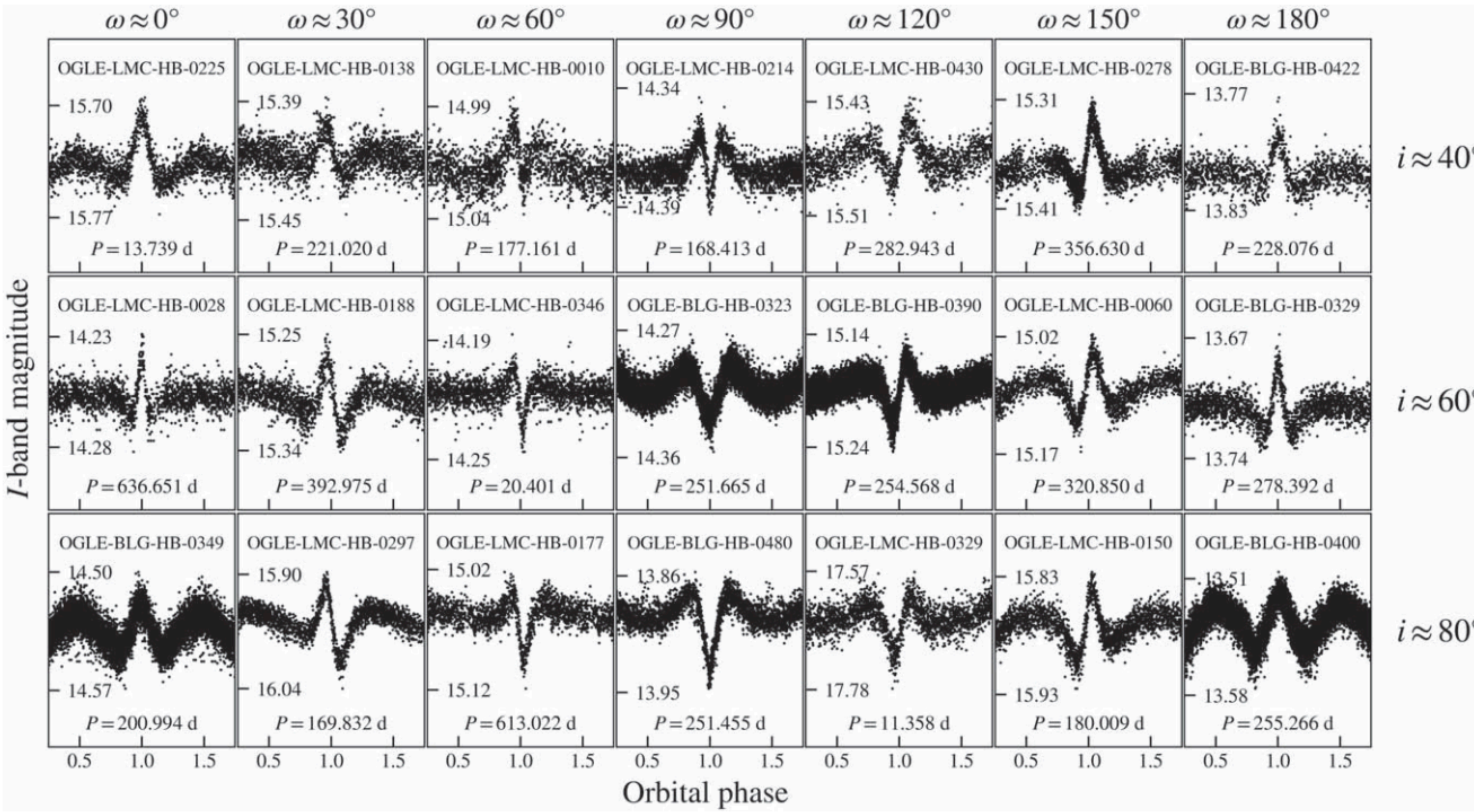
↓

tidally excited oscillations

↓

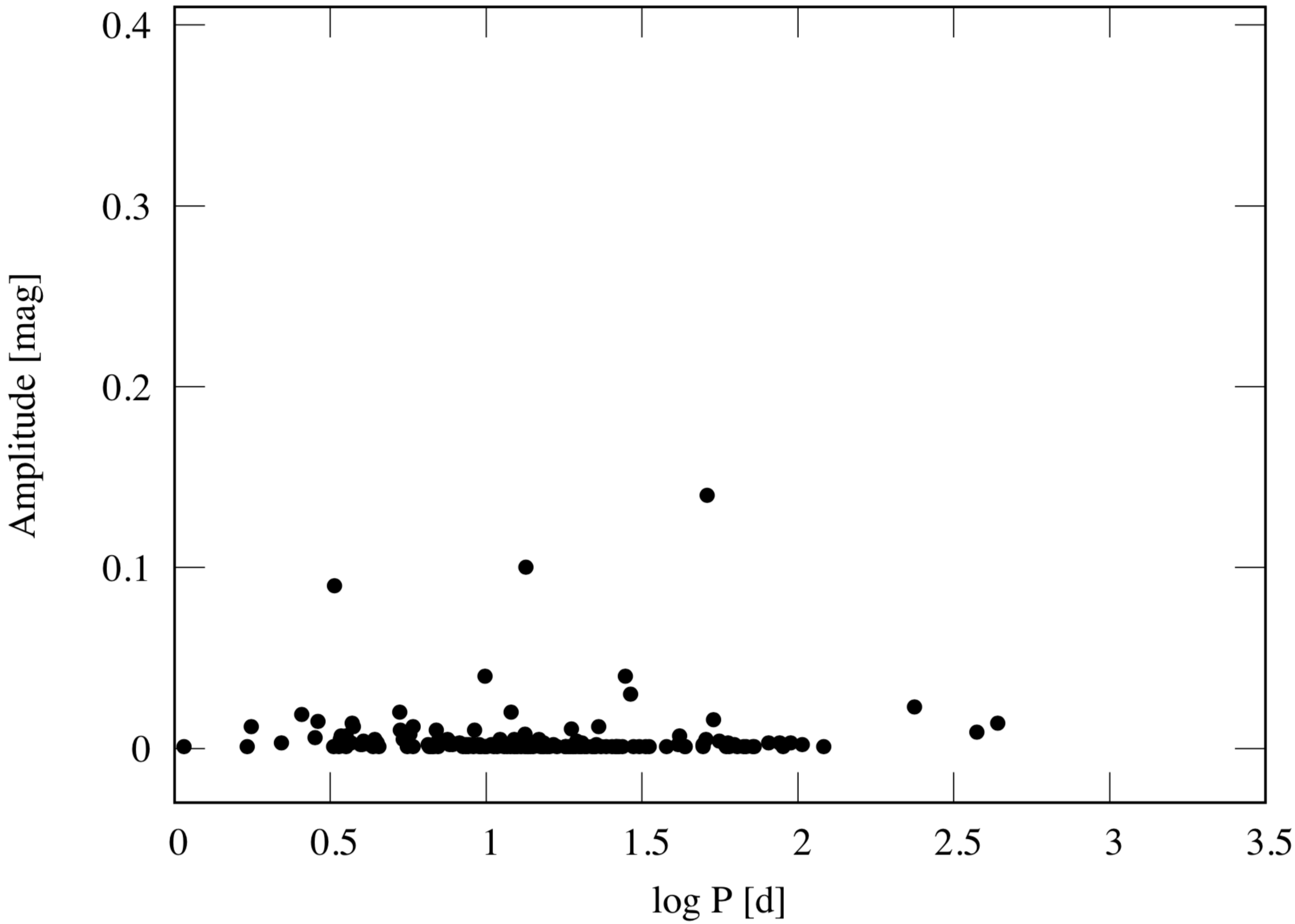
result of tidal forcing
(Fuller 2017)

OGLE search for EEVs



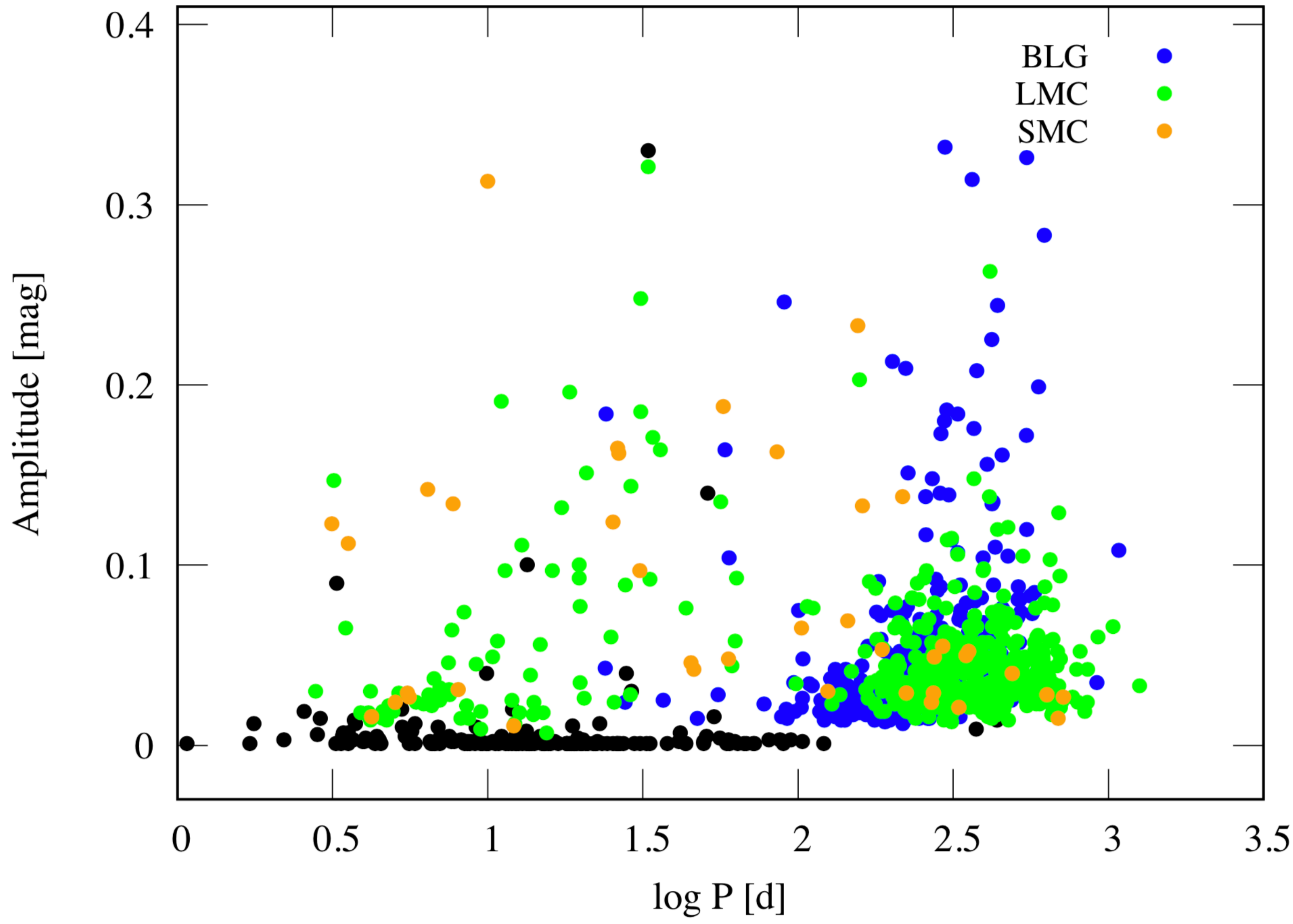
Wrona et al. 2022A, 2022B

EEVs



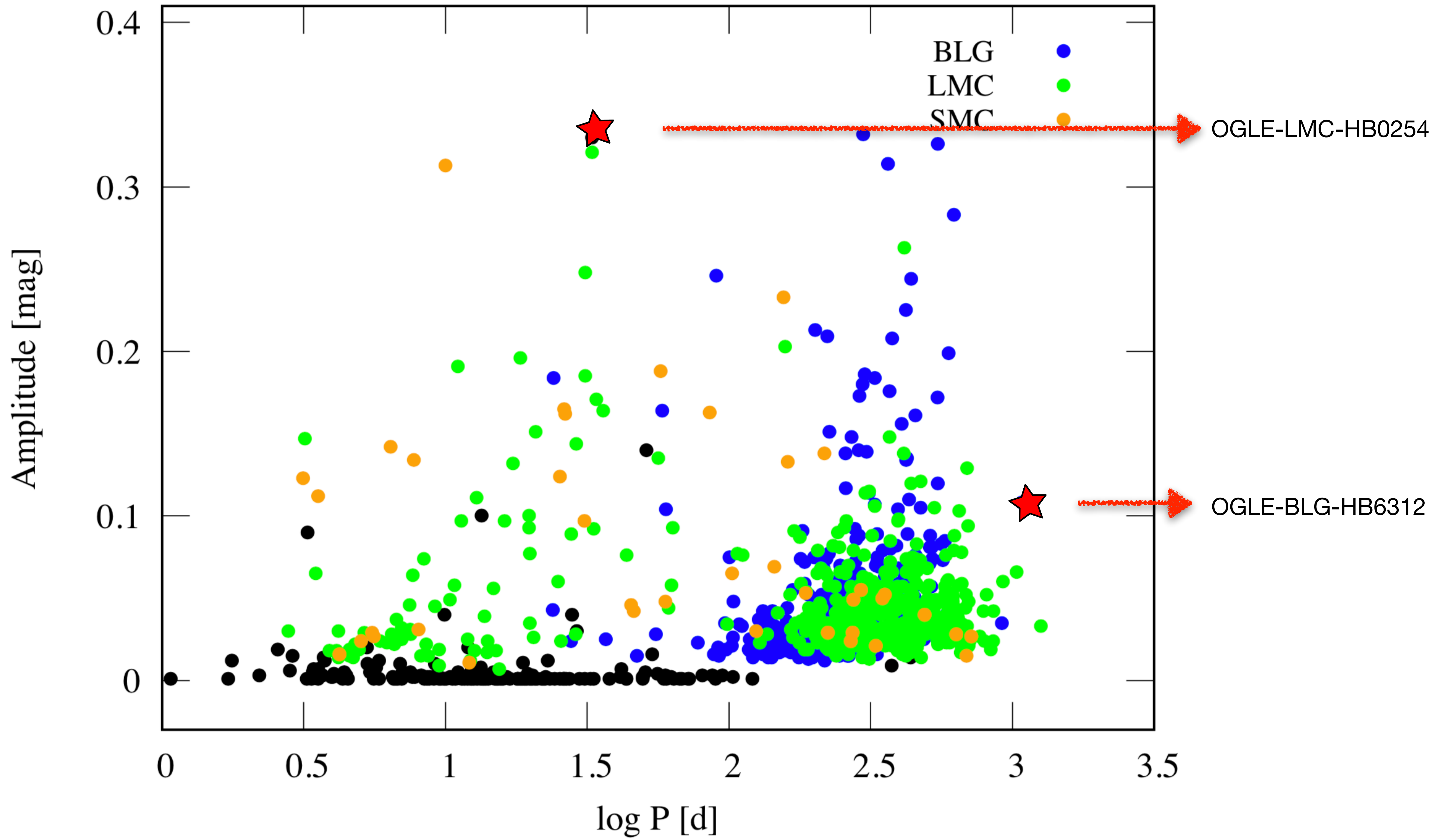
data from Kirk et al. 2016 & Jayasinghe et al. 2019

EEVs with OGLE



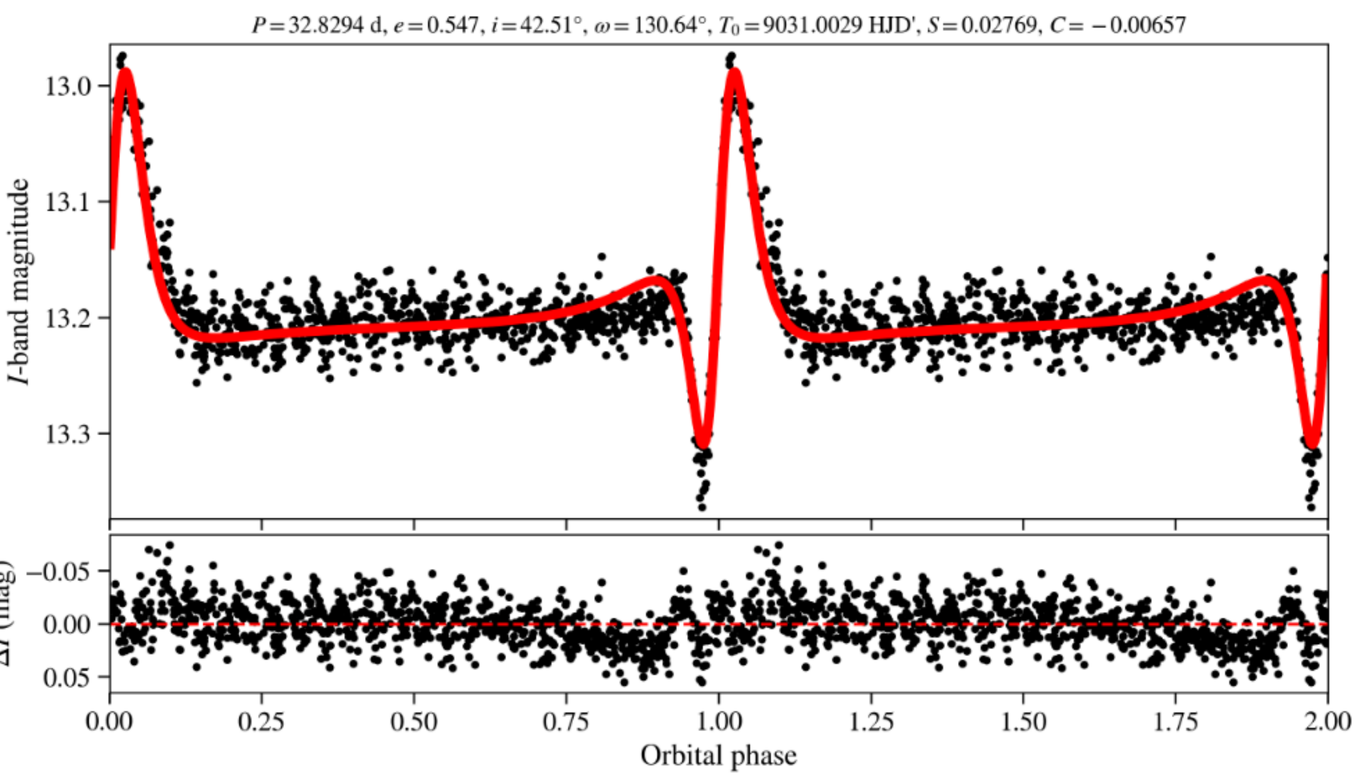
data from Wrona et al. 2022A

EEVs with OGLE



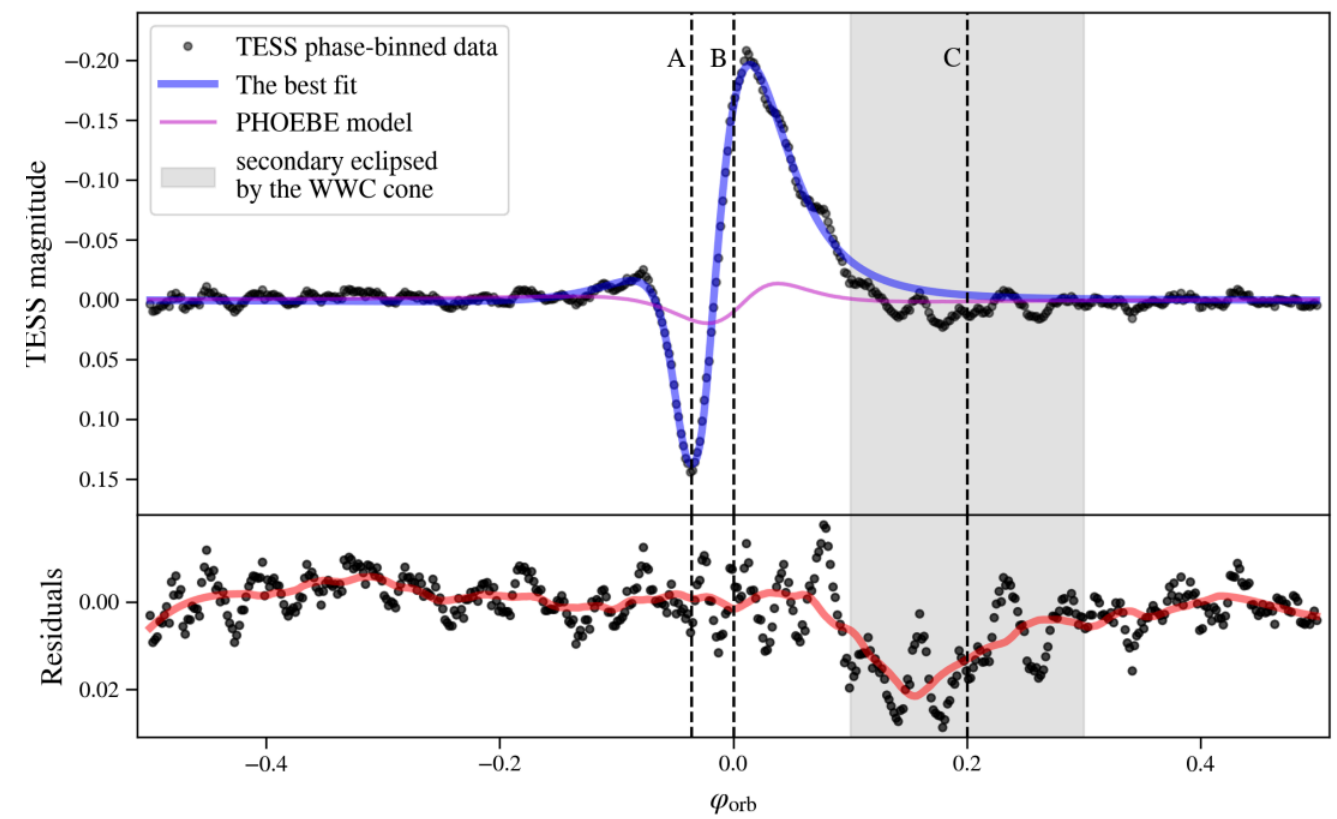
data from Wrona et al. 2022A

OGLE-LMC-HB0254



TEO studies

variable amplitudes and frequencies of TEO

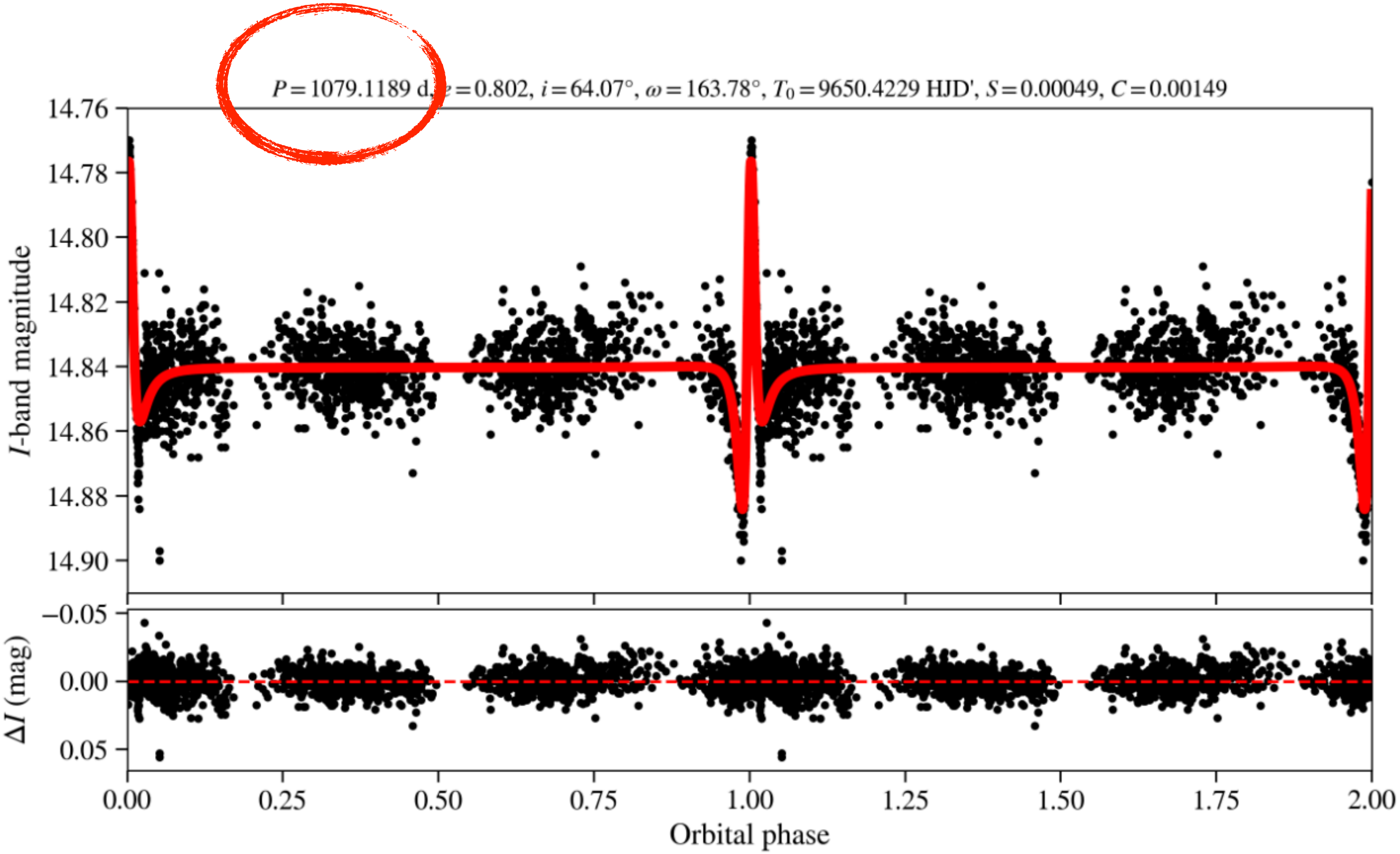


TESS data

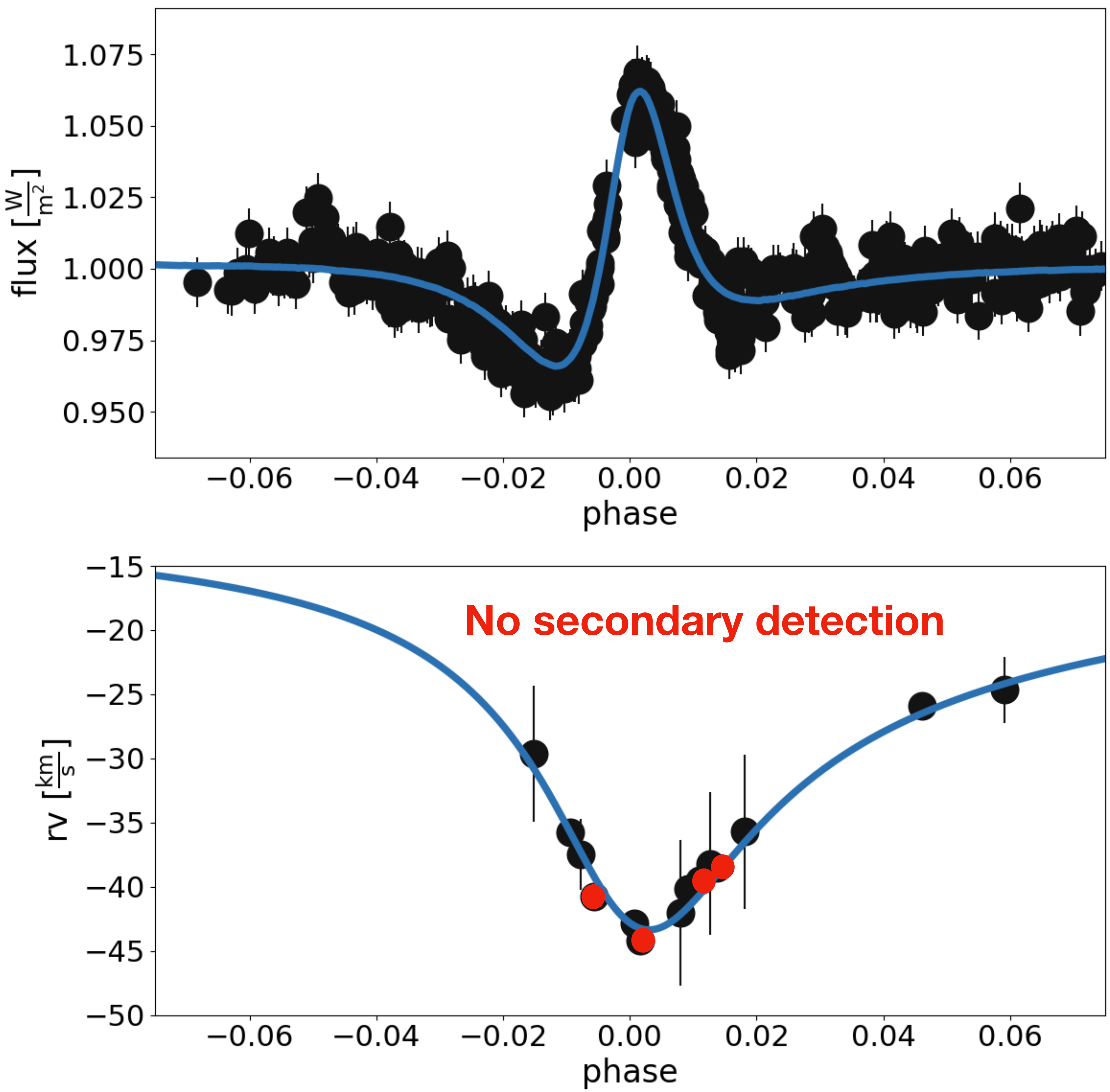
wind-wind collision

Kołaczek-Szymański et al. 2024

OGLE-BLG-HB6312

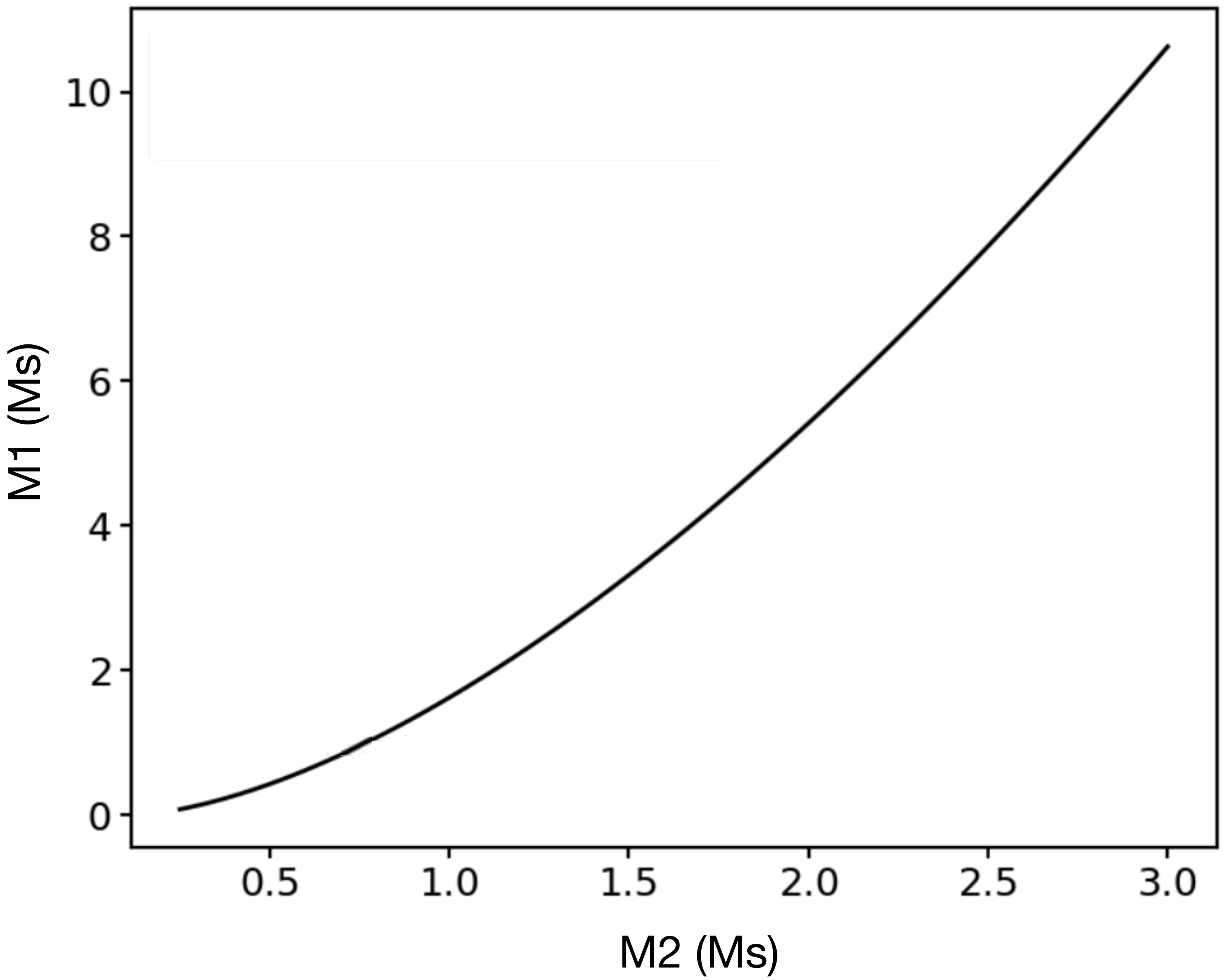


Simultaneous LC & RV fitting



Mass function

$$f(M) = \frac{M_2^3 \sin^3 i}{(M_1+M_2)^2} = \frac{K^3 P}{2\pi G}(1-e^2)^{3/2},$$

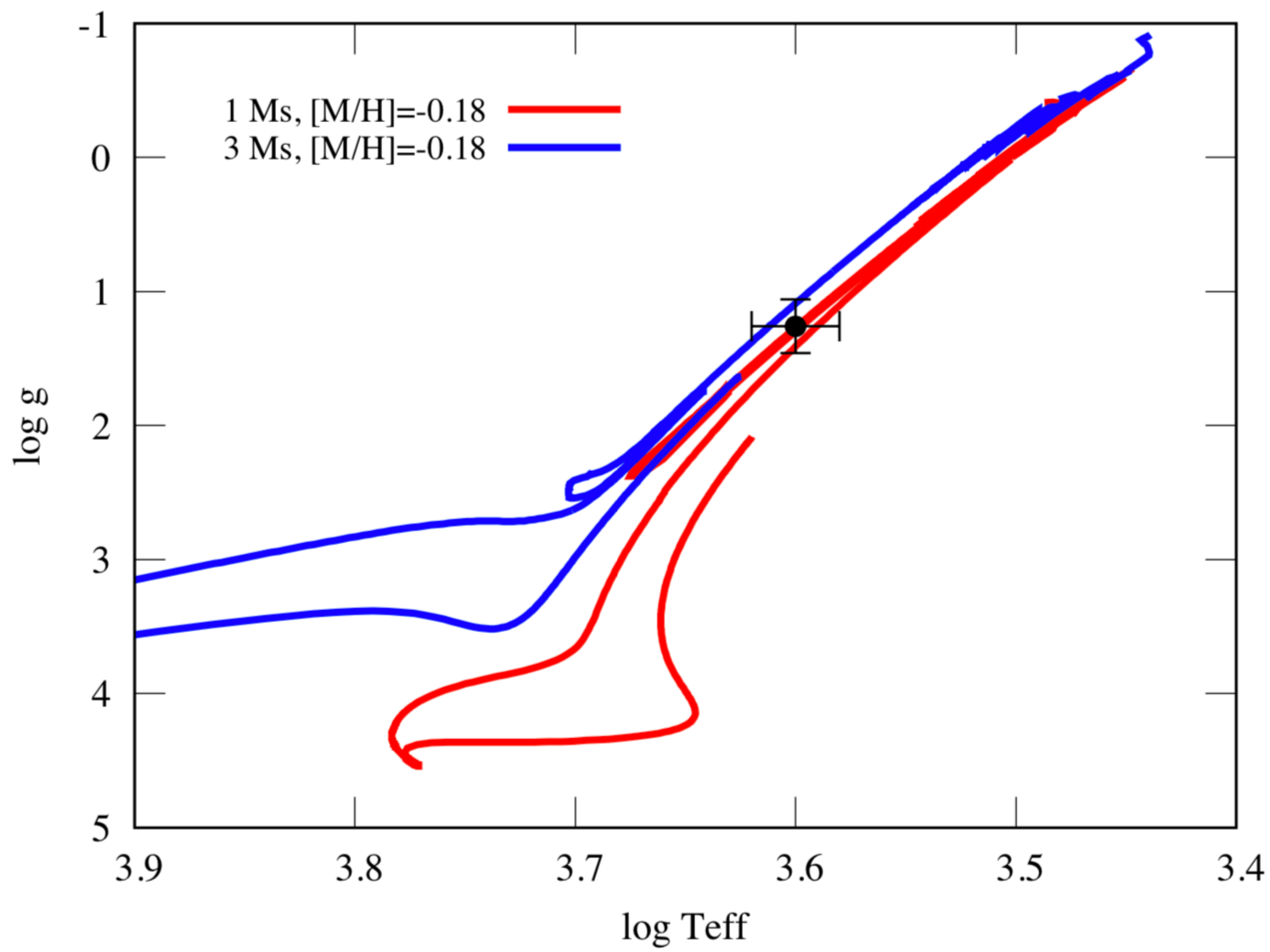


Spectroscopic analysis

SALT HRS data
ESO XSHOOTER data

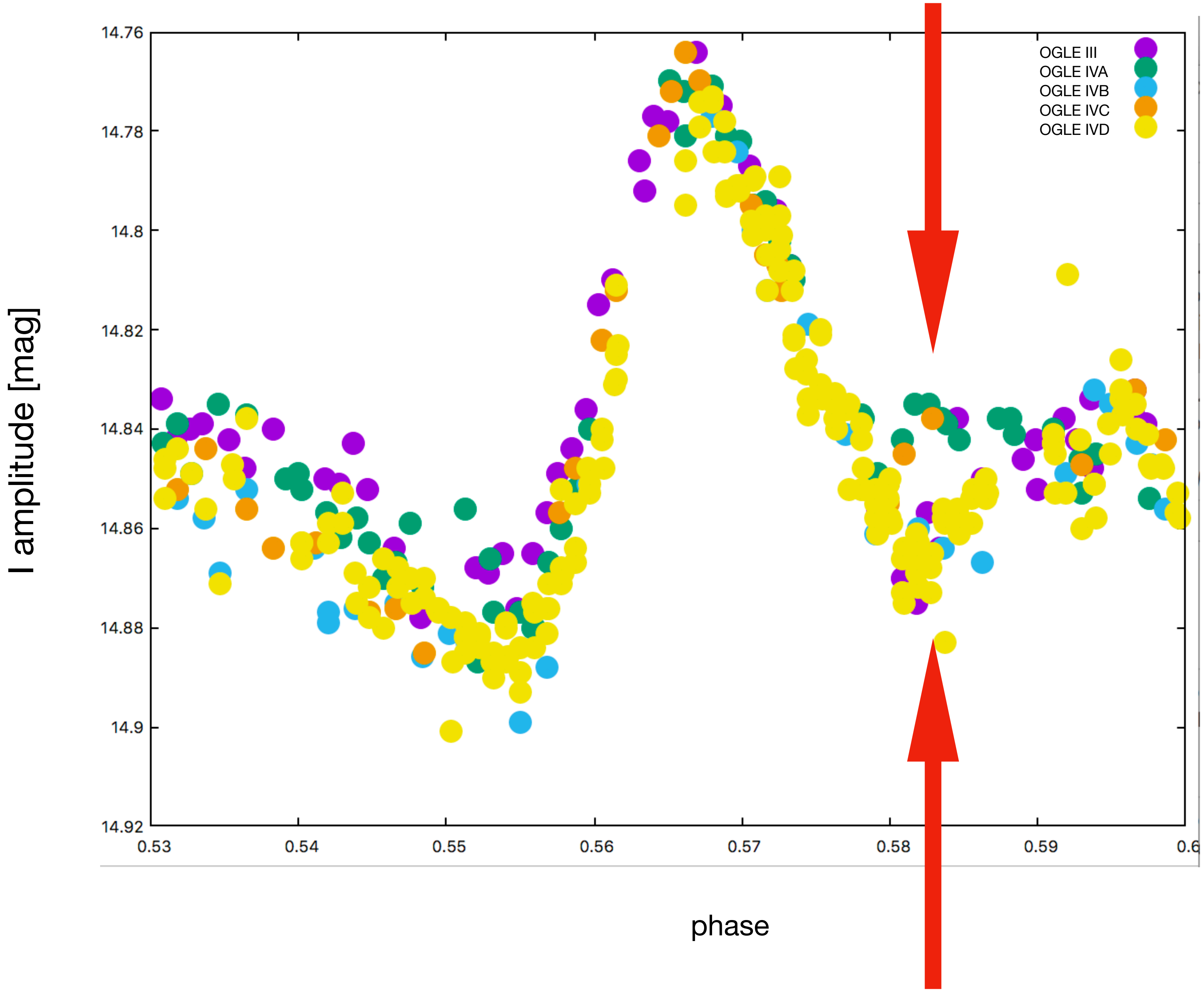
Teff = 4004 +- 188 K
log g = 1.26 +- 0.22
M/H = -0.18 +- 0.13

Transfer code: SPECTRUM
Model atmosphere: MARCS



data from MIST models
Dotter (2016), Choi et al. (2016),
Paxton et al. (2011, 2013, 2015)

LC changes



Eclipse? Lensing? Disk?

RLOF

No matter what value of M1, M2, R1 we choose, the system has the peryastron distance close to RLOF

Possible scenario: in previous evolutionary stages the primary lost the material - disk/wind tracers?

Are dips in LC related to the eclipse by disk changing its density?

emission lines (disk / wind)

IR excess in spectra (cold matter)

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Possible scenario: in previous evolutionary stages the primary lost the material - disk/wind tracers?

Are dips in LC related to the eclipse by disk changing its density?

emission lines (disk / wind) ✗

IR excess in spectra (cold matter) ✗

MESA binary model

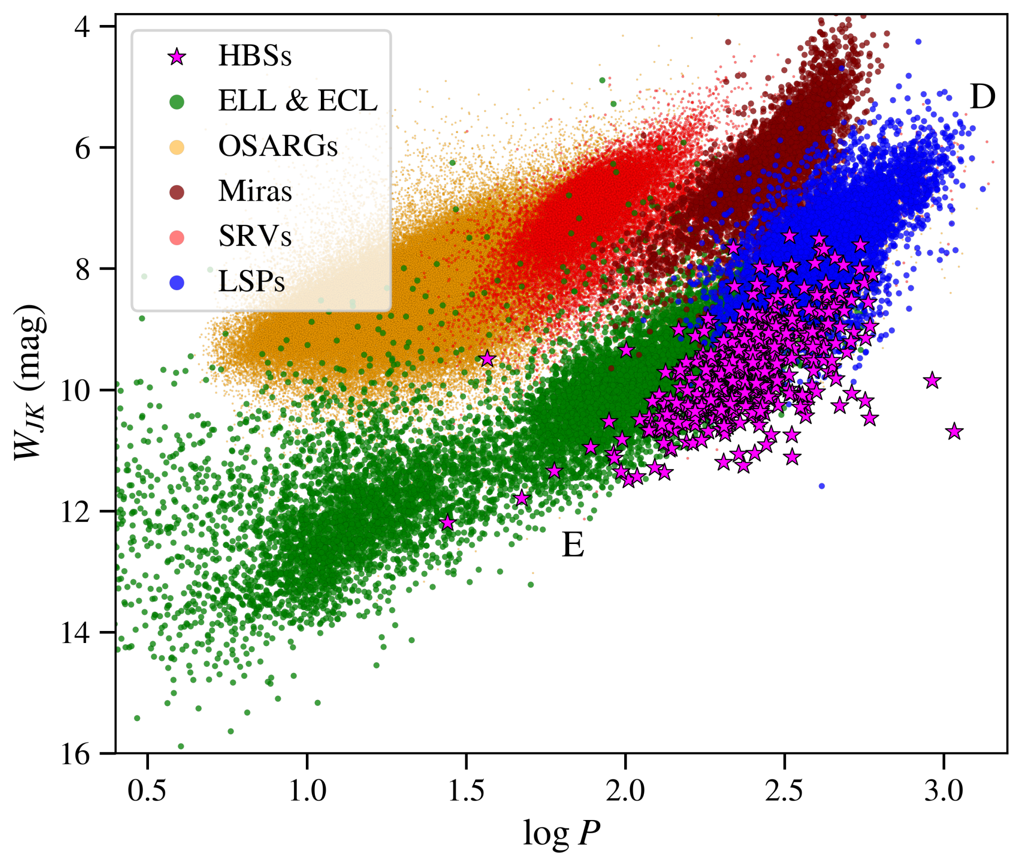
If RGB + MS (1.5 M_s and 1M_s), it was born as e~0.9 and P >~ 5000 d

No mass transfer

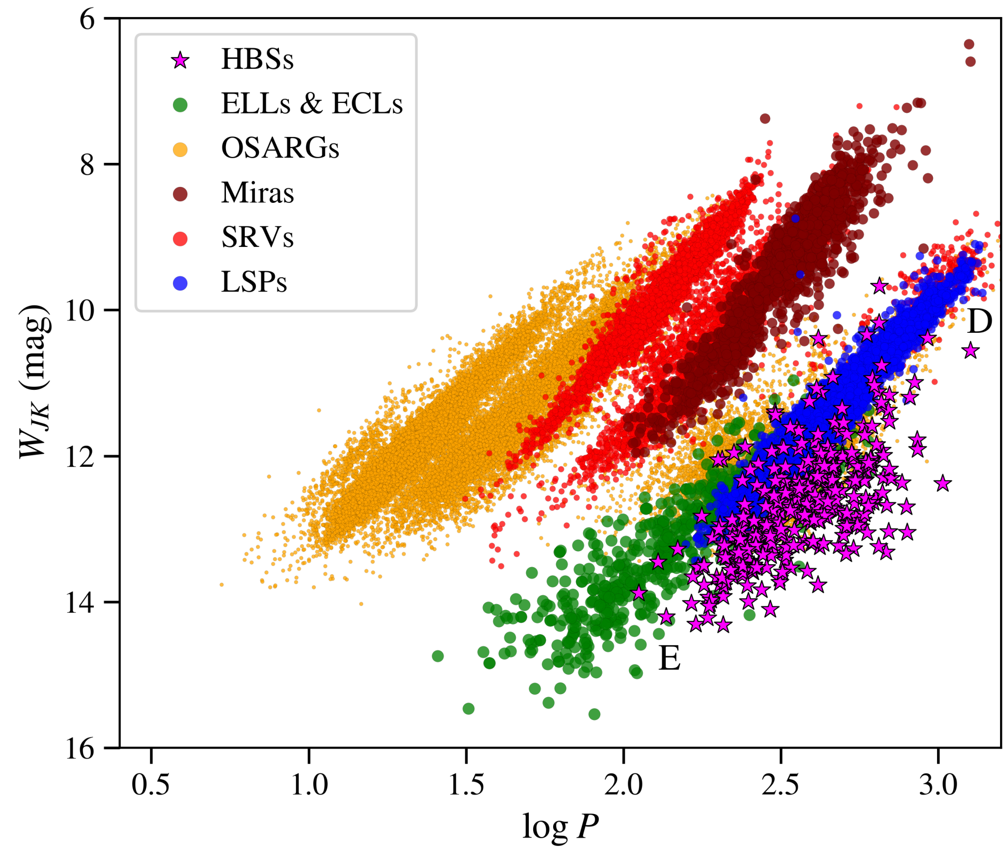
P, e dumping are strongly related to R1; it is difficult to keep e~0.8 during RGB, not mentioning AGB -> RGB scenario preferred

(de/dt) on RGB ~-10^{-3} / 1000 years
(dP/dt) on RGB ~-0.5 d / 1000 years
(we won't see it in LC)

Period-luminosity relation



Galactic bulge



LMC

Extinction free Wesenheit index W_{JK}