A new look at the symbiotic star RW Hydrae

Magdalena Otulakowska-Hypka [1]
Joanna Mikołajewska [1]
Patricia A. Whitelock [2,3]

[1]N. Copernicus Astronomical Center, Warsaw, Poland

[2]South African Astronomical Observatory, P.O. Box 9, 7935 Observatory, South Africa

[3]Astronomy Department, University of Cape Town, 7701 Rondebosch, South Africa

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Symbiotic stars

- interacting binary
- $P_{orb} \sim$ years
- evolved red giant
- hot companion star (MS, WD or NS) accretes material lost by the red giant
- accreted material powers symbiotic activity, including occasional eruptions and jets

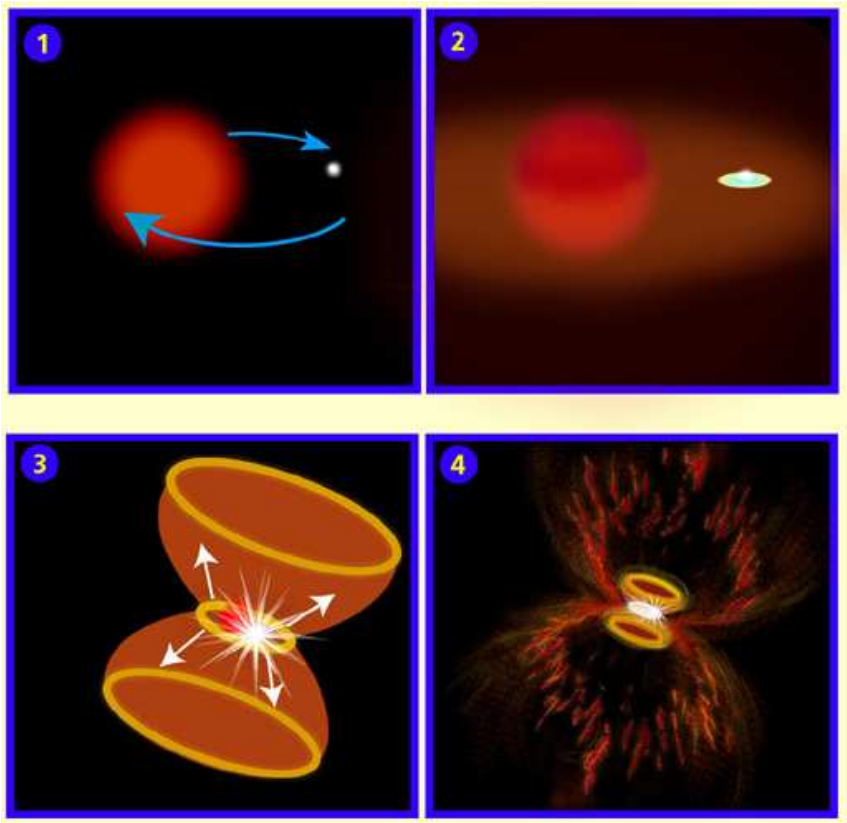


Figure: Corradi et al. (2000) and NASA

RW Hydrae

- eclipsing, non-eruptive symbiotic system with a known spectroscopic orbit
- NIR light curves show a modulation with half-orbital period (Rutkowski et al., 2007) caused by ellipsoidal variability of the red giant, as suggested by Mikołajewska et al. (2002)
- Mikołajewska et al. (2013), in prep.: metal-poor metallicity [M/H]$= -0.5 \pm 0.1$, it has a high proper motion and is located in the outer disk or halo of the Galaxy ($l = 314.9926, b = +36.4856$)

Figure: Digitized Sky Survey, SERC, 14.1' x 14.1', *J* band

Motivation

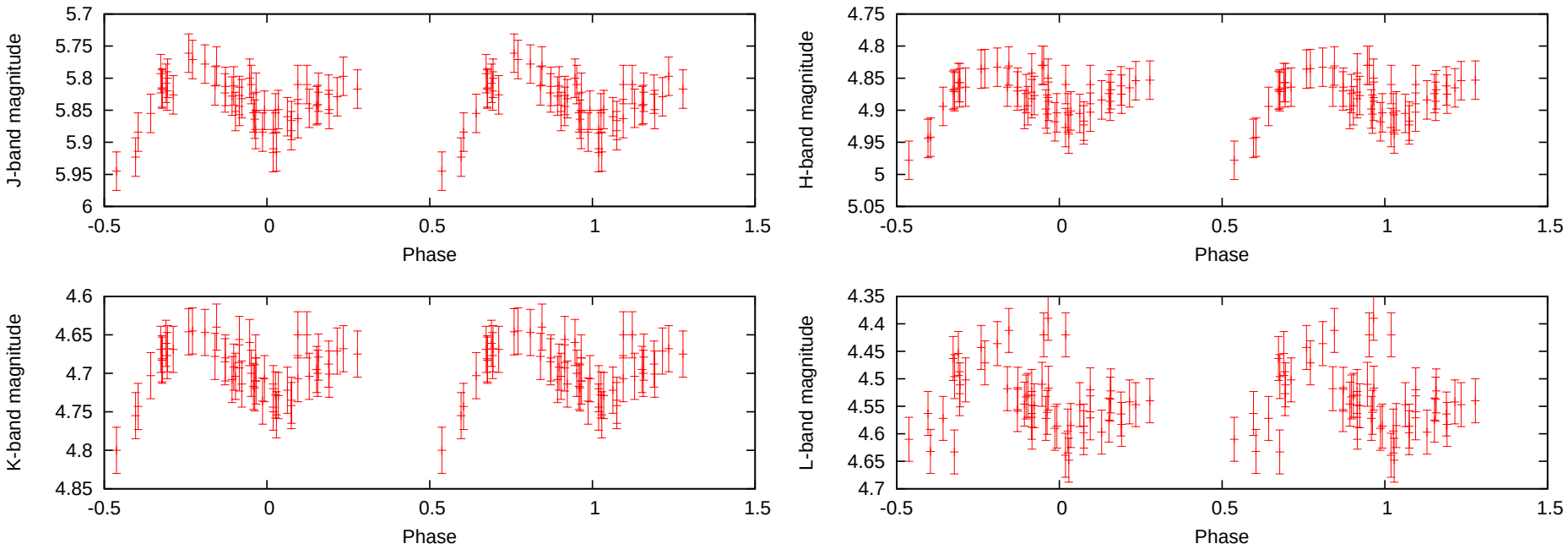
1. Photometry
2. Spectroscopy
   (some data already published)

Aim:
to take a new look at this object
with the latest tools, like *PHOEBE*

Observations: photometry

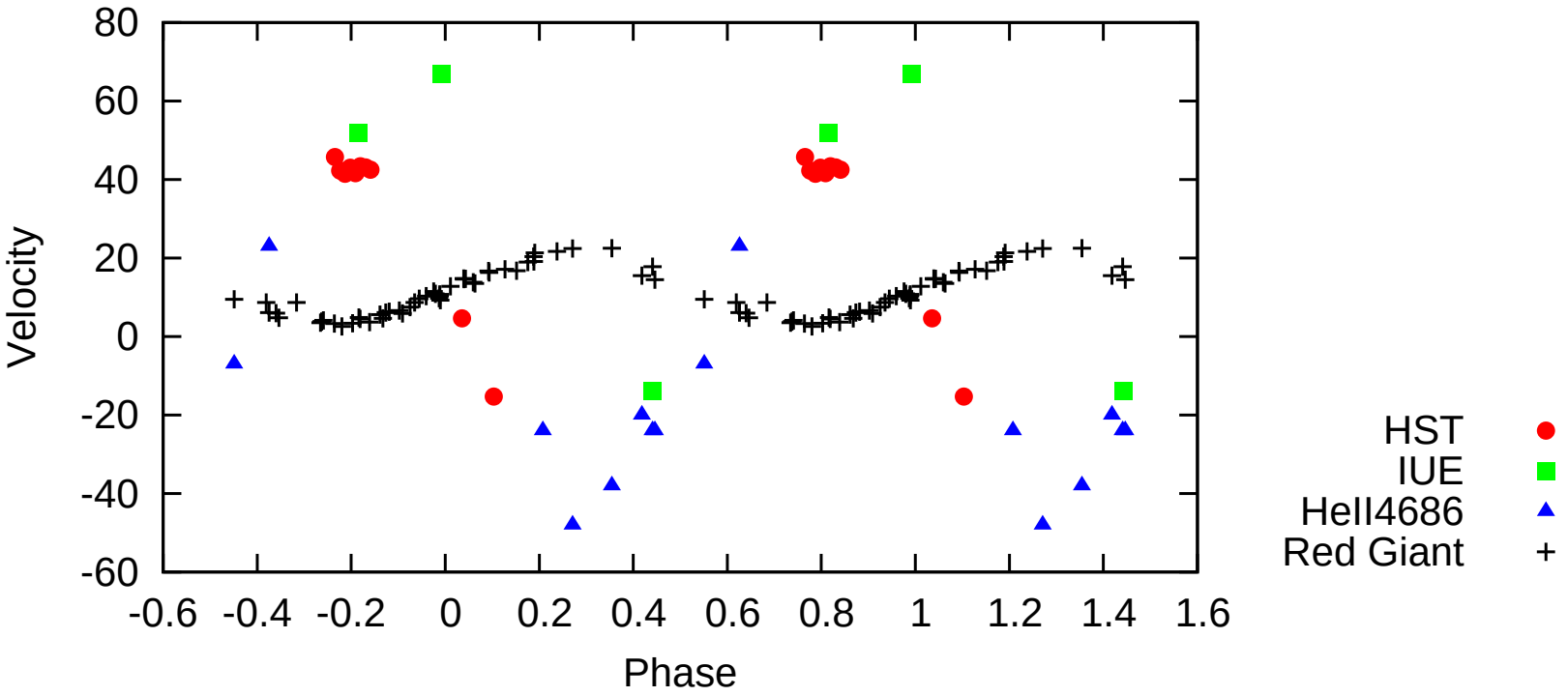
Photometry (Rutkowski et al., 2007)

- *JHKL* (1.25, 1.65, 2.2, 3.45 μ m) broad-band photometry
- Mk II infrared photometer on the 0.75-m telescope at SAAO, Sutherland
- uncertainty on individual measurements is less than 0.03 mag in *JHK*, and less than 0.05 mag in *L*



Observations: spectroscopy

- HeII 4686 line (Merrill (1950) and Mikołajewska)
- HeII 1640 line (IUE and HST - GHRS & STIS)
- Red giant data:
  Merrill (1950), Kenyon and Mikolajewska (1995), Schild et al. (1996)



PHOEBE software

- tool for modeling of eclipsing binary stars (Prša and Zwitter, 2005)
- Wilson-Devinney (WD) model (Wilson and Devinney, 1971)
- solving for all light curves simultaneously with the radial velocity data

Our strategy for *PHOEBE* calculations

- careful assumptions
- iteration steps around the assumed values
  - radial velocity curves only
    - system elements
  - both light curves and velocity curves
    - parameters of components
    - limb darkening corrections

Background and assumptions

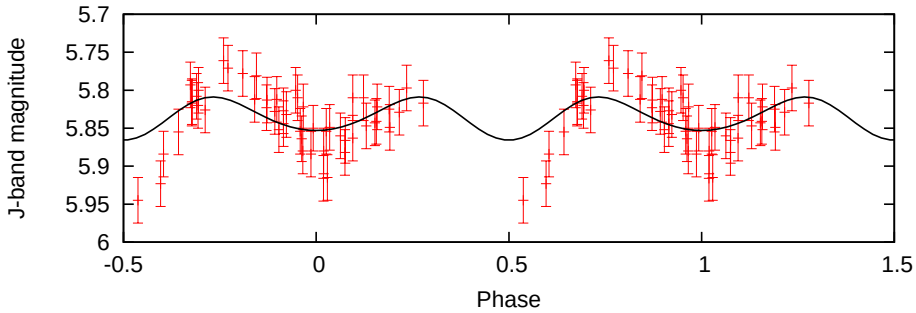
From literature:

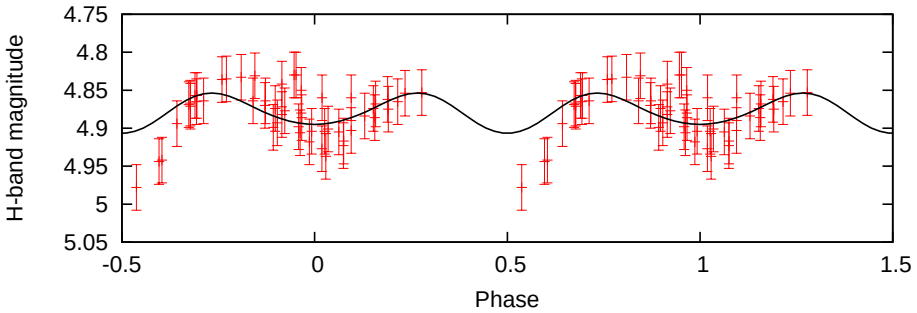
- T_{eff} of red giant from the spectral type M2 (3700 K)
- T_{eff} of hot component 30000 K (Mikołajewska et al. 2013, in prep.)
- spectroscopic orbit solution
  - orbital period
  - velocity of the center of mass
  - superior conjunction
  - ranges of masses, mass ratio
  - e = 0

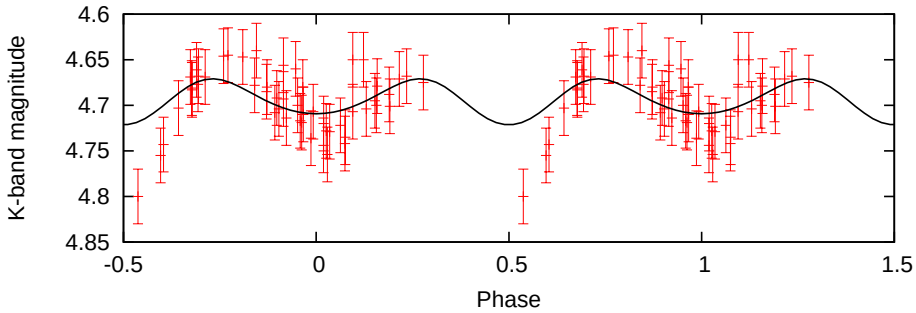
Assumptions:

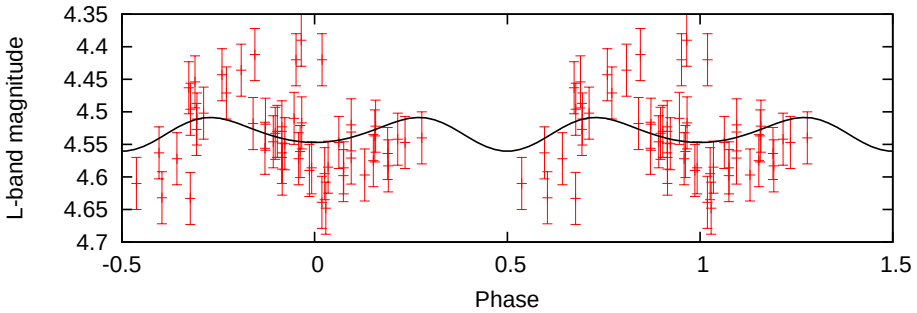
- unconstrained binary system
- red giant is the only source of radiation in the NIR
- hot companion is the primary
- red giant is the secondary
- metallicity [M/H] = -0.5 ± 0.1 (Mikołajewska et al. 2013, in prep.)
- limb darkening coefficients from van Hamme (1993)
- gravity darkening exponent and bolometric albedo – for objects with convective envelope

Results with constrains

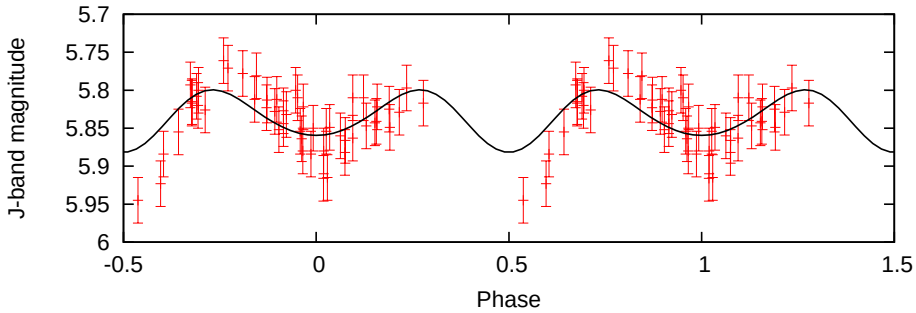


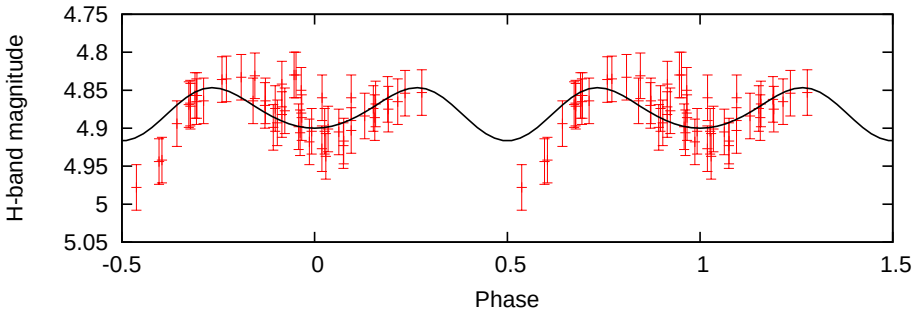


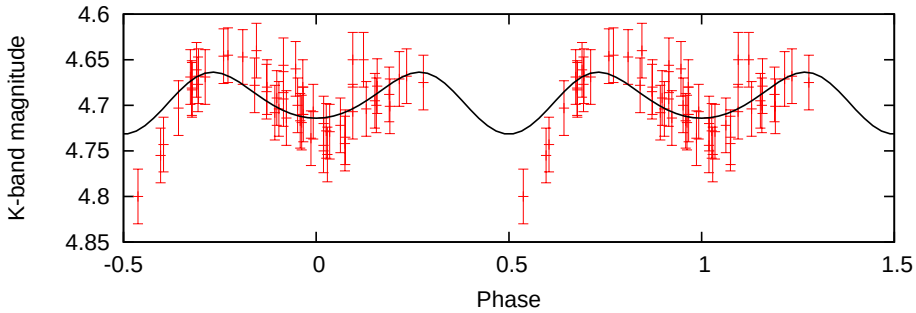


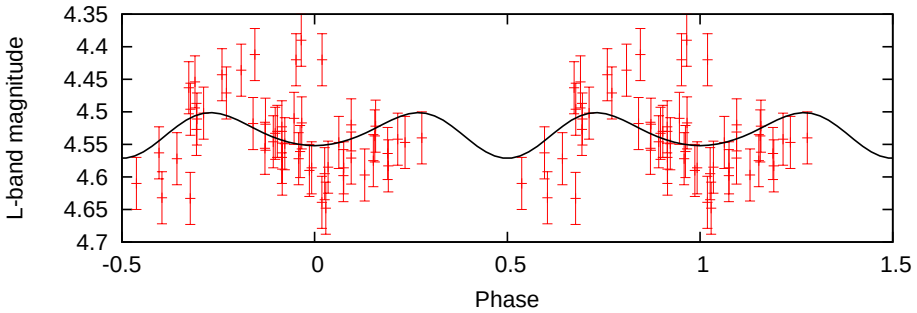


Results w/o constrains

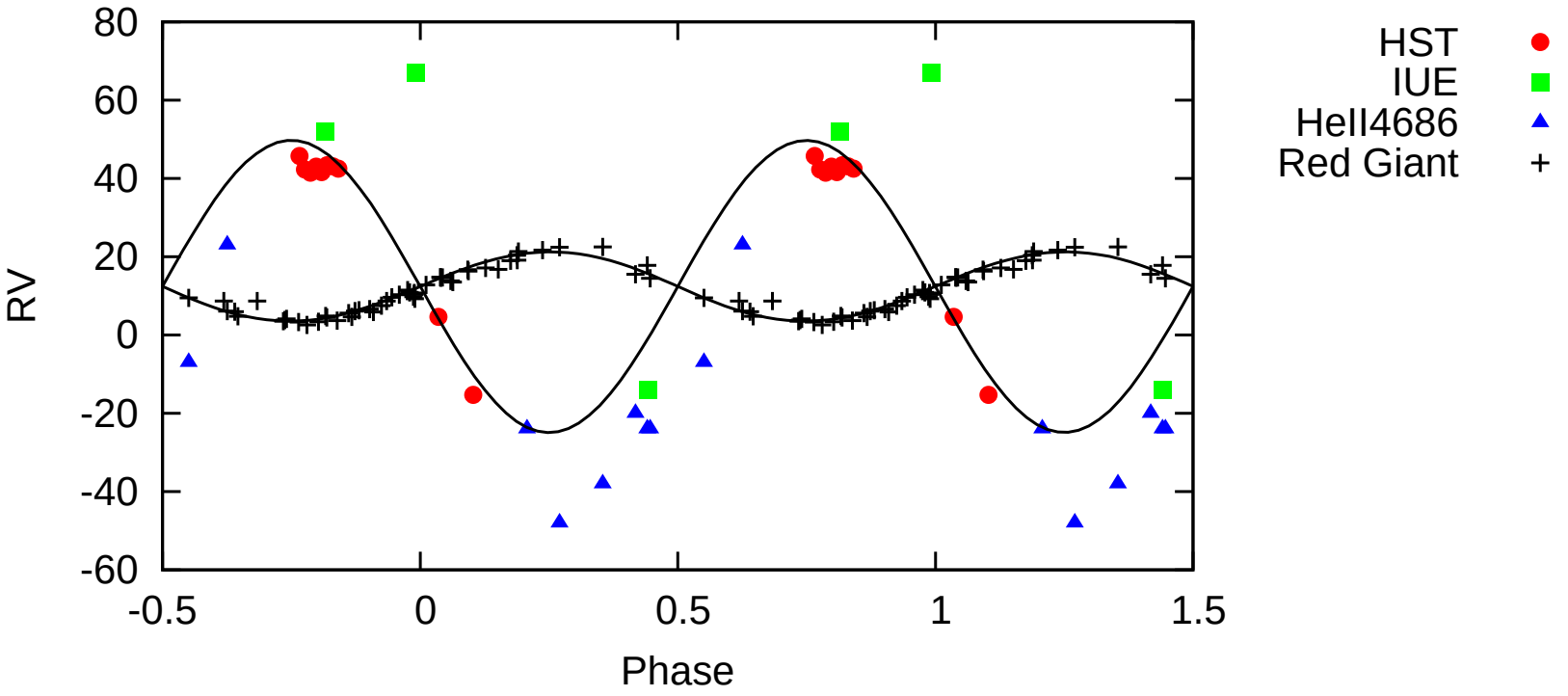








Results with constrains



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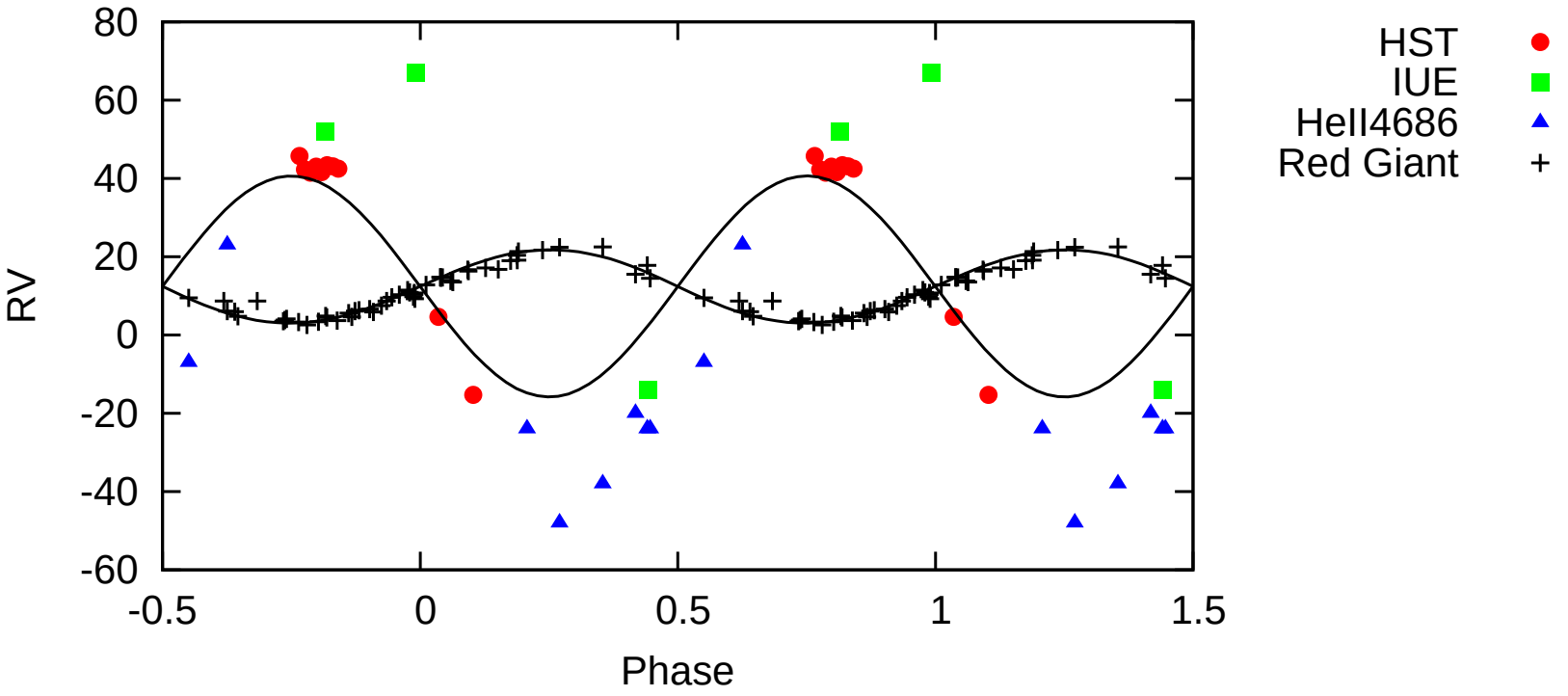

Results

P_{orb} = 370.2
T^1_{eff} = 30000 K
T^2_{eff} = 3700 K

	With constrains	W/O constrains
a	350	280
q	4.2	3
i	75	80
Vo	12.4	12.4
M1	0.8	0.54
M2	3.39	1.6
R1	0.24	0.16
R2	144.5	111.9
RL filling	0.96	0.95

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