Peculiarities in the (θ^1) Orion Trapezium Components A and B (V1016 and BM Ori)

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θ^1 Ori B = HD 37021 = BM Ori

V = 8.0 B1-3 V

Eclipsing and spectroscopic binary P = 6.47053 d

- Primary eclipse: Color dependent; depth ~ 0.7 mag in V. Total duration WAS ~16 hours (8h of flat bottom), but it shortenned to less than 12 hours (Windemuth, 2013)
- Shallow secondary eclipse; better detected at NIR λs
- Spectroscopic observations have shown the eclipse is NOT an occultattion. A pre-main-sequence, early-F secondary star + circumsecundary disk are required to explain the observations.

θ^1 Ori B = HD 37021 = BM Ori

Spectroscopic orbital parameters lack precision because:

- **The primary component has very wide spectral lines (mostly H and He) that are contaminated by strong nebular lines.**

- **Vitrichenko & Klochkova (2004) propose a variable sistemic velocity due to a thrird component with mass ~2 Mo in a very excentric orbit (e = 0.92) , P ~ 1302 d and K(1+2) ~ 20 km/s (only the primary was used).**

- **There is probably circumstellar mater flowing around and between both components. (The MgII λ4481 strong line shows no correlation with the orbital phase)**

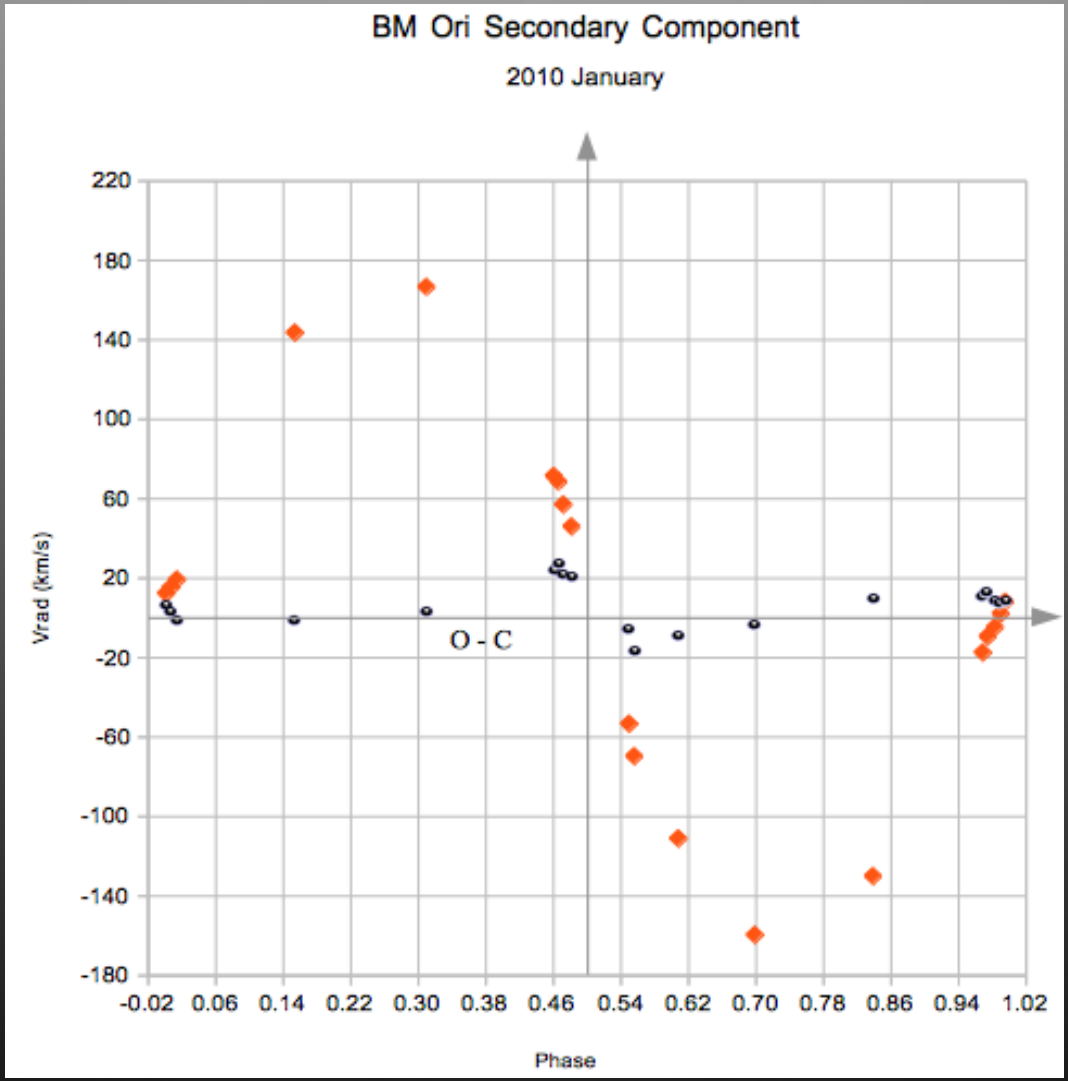
θ^1 Ori B = HD 37021 = BM Ori

The secondary spectrum is clearly show when cross-correlating BM Ori spectrum with an early-F type template (except during secondary eclipses).

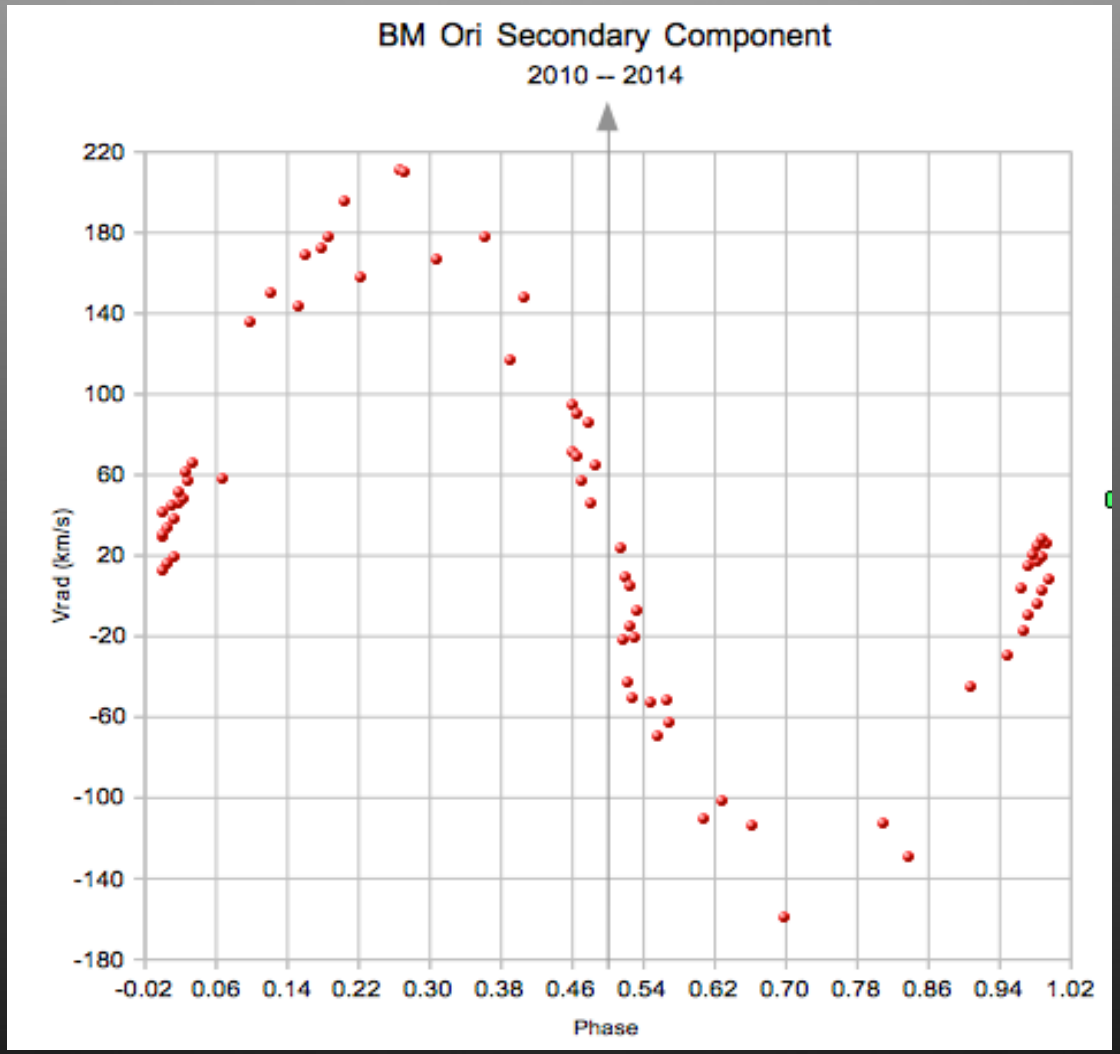
We propose to obtain the orbital parameters of the eclipsing binary using the secondary component, in order to check for the existence of a third, putative CLOSE component.

A progress report is here presented.

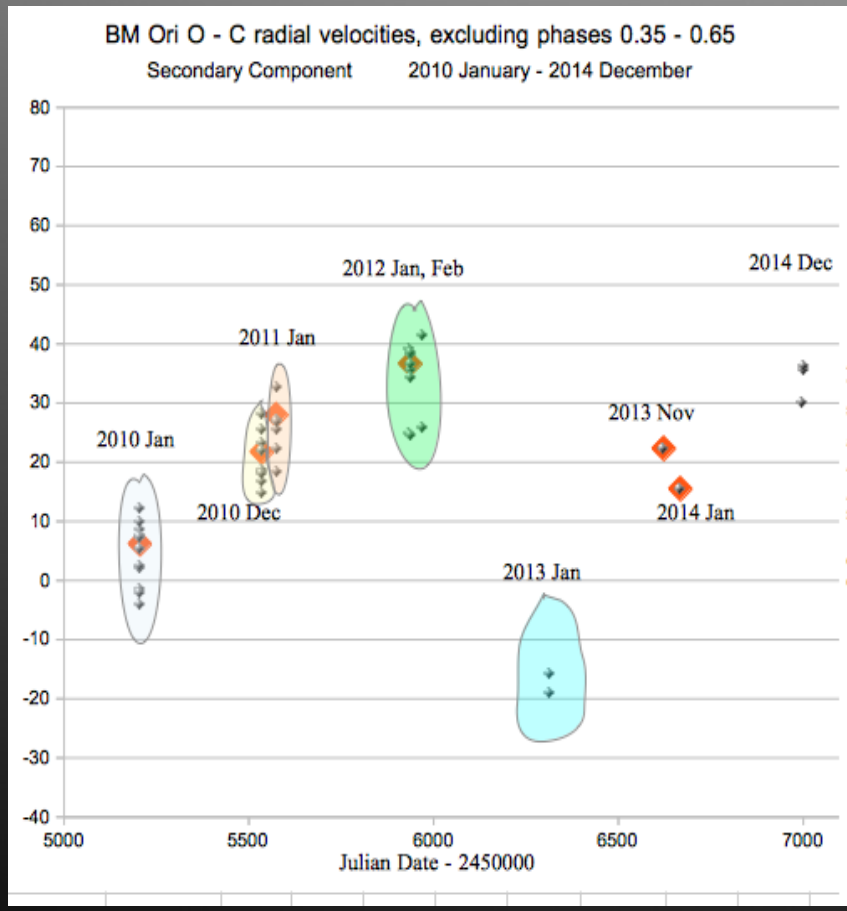
The only observed complete cicle: 2010 Jan . Orbital parameters (P=6.47053 d fixed) e=0.05 ω=82° K=170 km/s γ=4.9 km/s

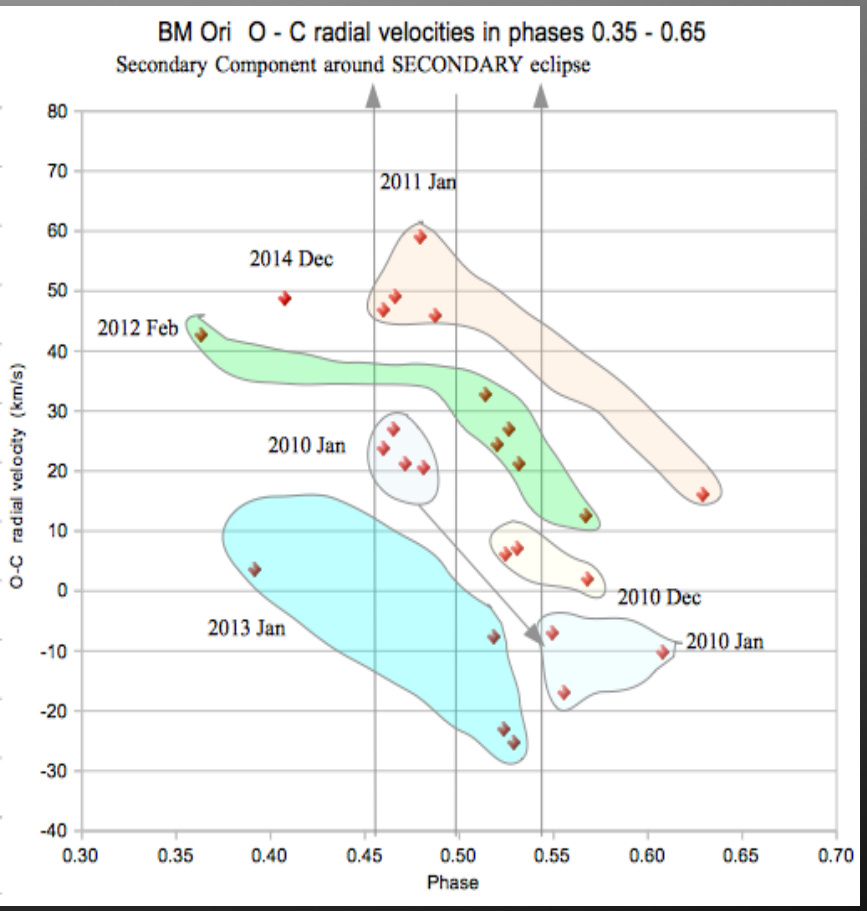


All the data (2010 Jan through 2014 Dec) P = 6.47053 d

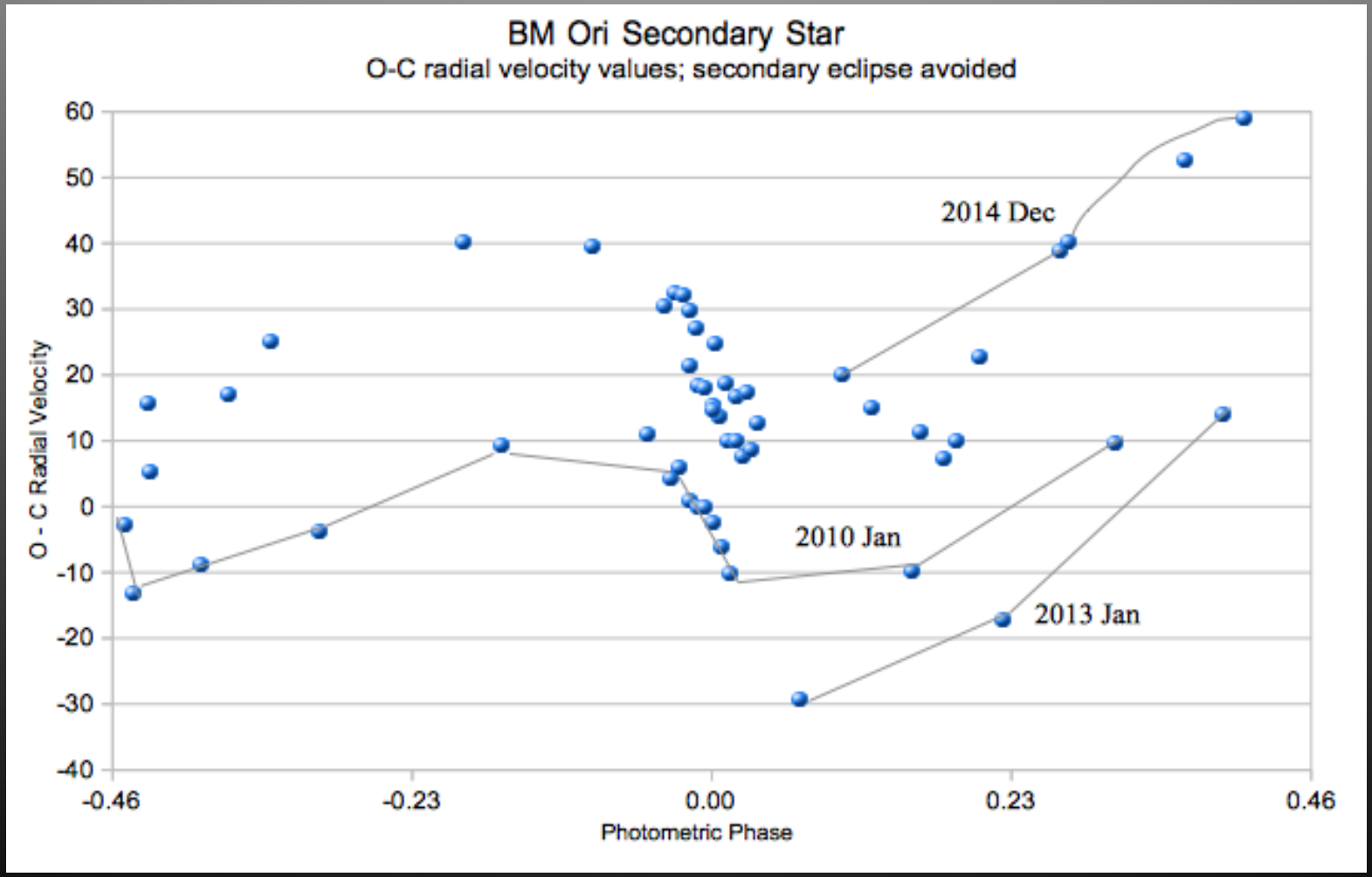


O-C grouped by epochs; orbital patameters are those obtained for the 2010 Jan run (one whole cicle)

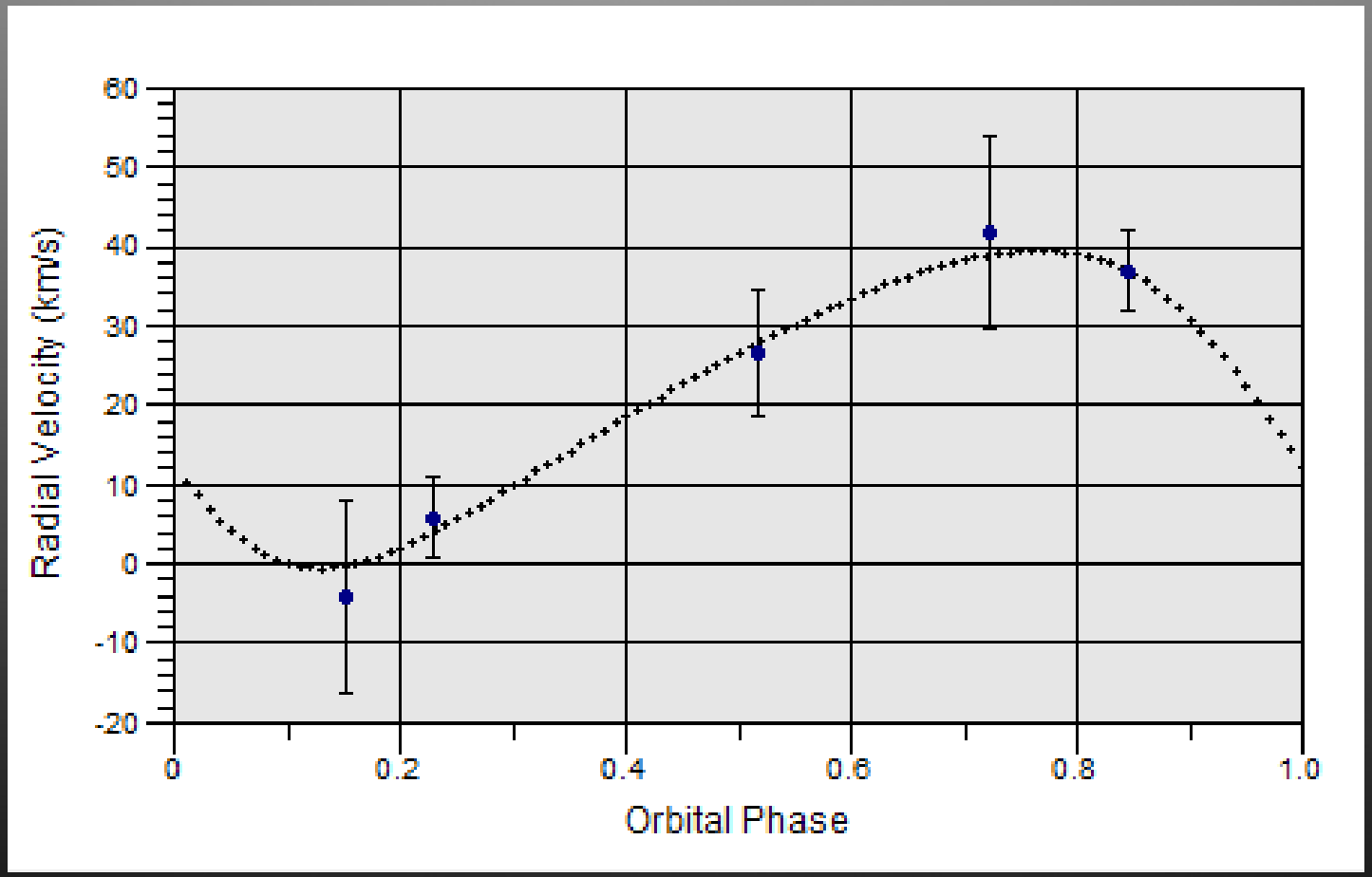




O-C folded by the photometric phase; orbital patameters are those obtained for the 2010 Jan run (one whole cicle)



Setting orbital patameters equal to those of the 2010 Jan run, except for the sistemic velocity, we obtain values for this parameter in five epochs, and a velocity curve for the eclipsing binary due to its motion about the center of mass of the system.



θ^1 Ori B = HD 37021 = BM Ori

CONCLUDING REMARkS

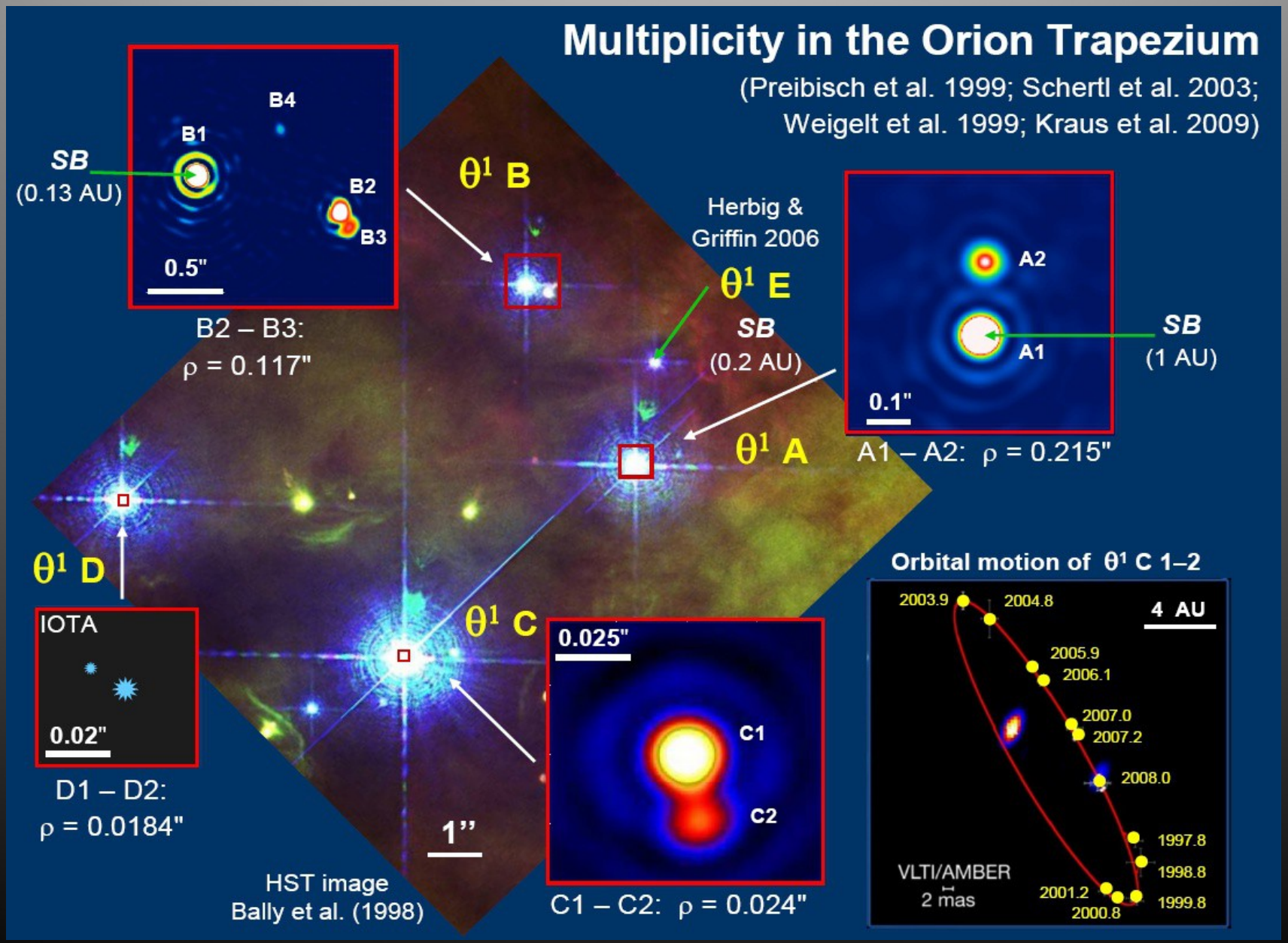
With only 5 data points it is, of course, imposible to find a solution to the orbit of the binary+third component. But such triple system appears to be real.

Lower values of the excentricity are compatible with our data (0.27 +- 0.07 for the previously shown "must likely" solution). Shorter period values (512 d) are also possible!!!

"Complete cicle" observations are needed in order to minimize the efect of (circumstellar-induced?) variations in the radial velocities througha out each cicle. Past observations of "complete cicles" must be incorporated (there is at least one; search is in progress).

Multiplicity in the Orion Trapezium

(Preibisch et al. 1999; Schertl et al. 2003;
Weigelt et al. 1999; Kraus et al. 2009)



θ^1 Ori A = HD 37020 = V1016 Ori

V = 6.73 B0.5 V

v sen i = 55 km/s (Simón-Díaz et al 2007)

Eclipsing and spectroscopic binary P = 65.433 d

Eclipse discovered by Lohsen (1975)

Aprox. depth: 1.0 mag. Aprox. Duration: 21 hours

Its delayed discovery as an eclipsing variable sugest:

— recent perturbation

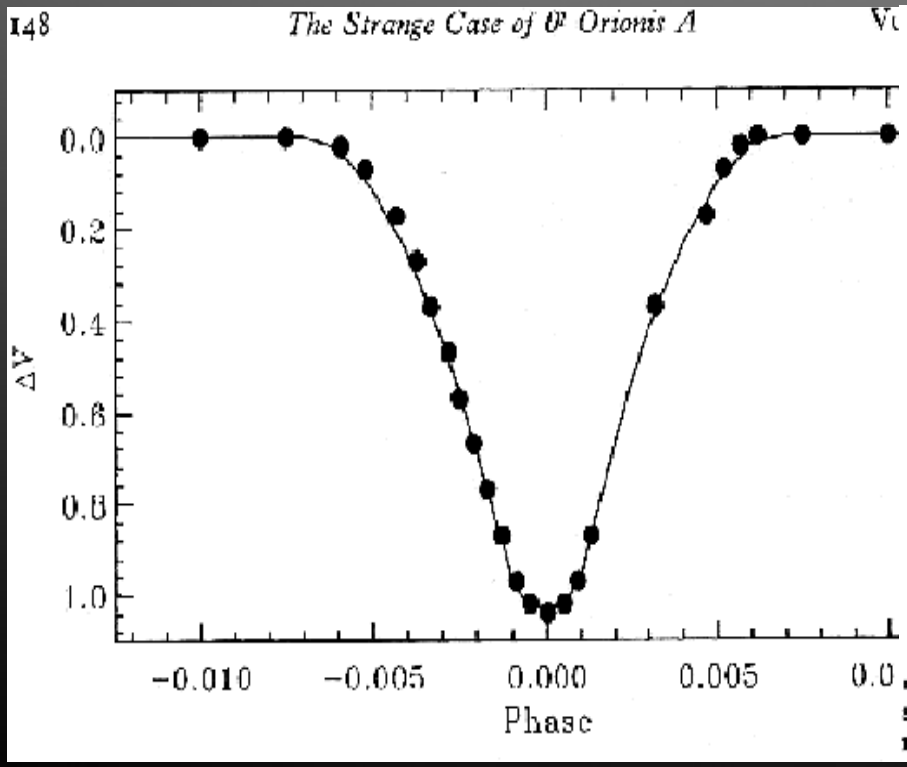
— capture of the secondary component

(Dolgachev et al, 1989 ; Poveda 1999)

NO SECONDARY ECLIPSE HAS BEEN OBSERVED

Strickland & Lloyd (2000)

Compilation of photometric and radial velocity data (+ 5 IUE spectra) yield photometric period and orbital parameters. They (wrongly) conclude that the secondary is a late B or an early A pre-main-sequence star.



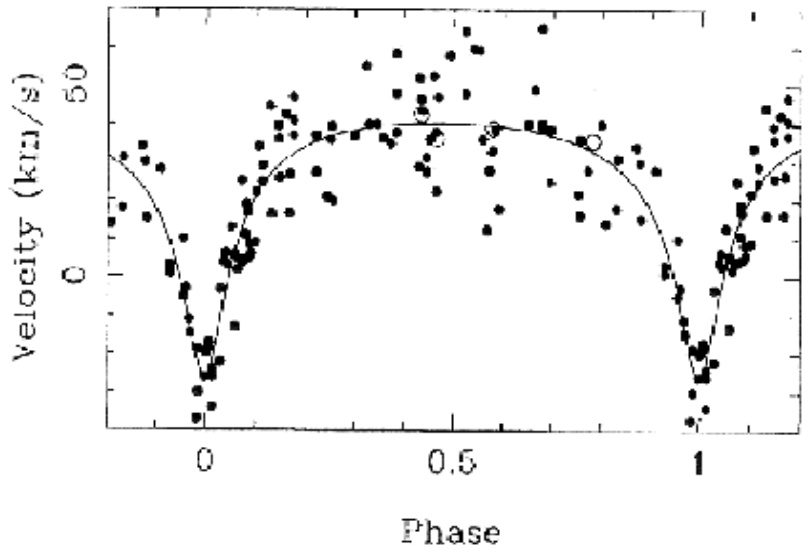


Fig. 1

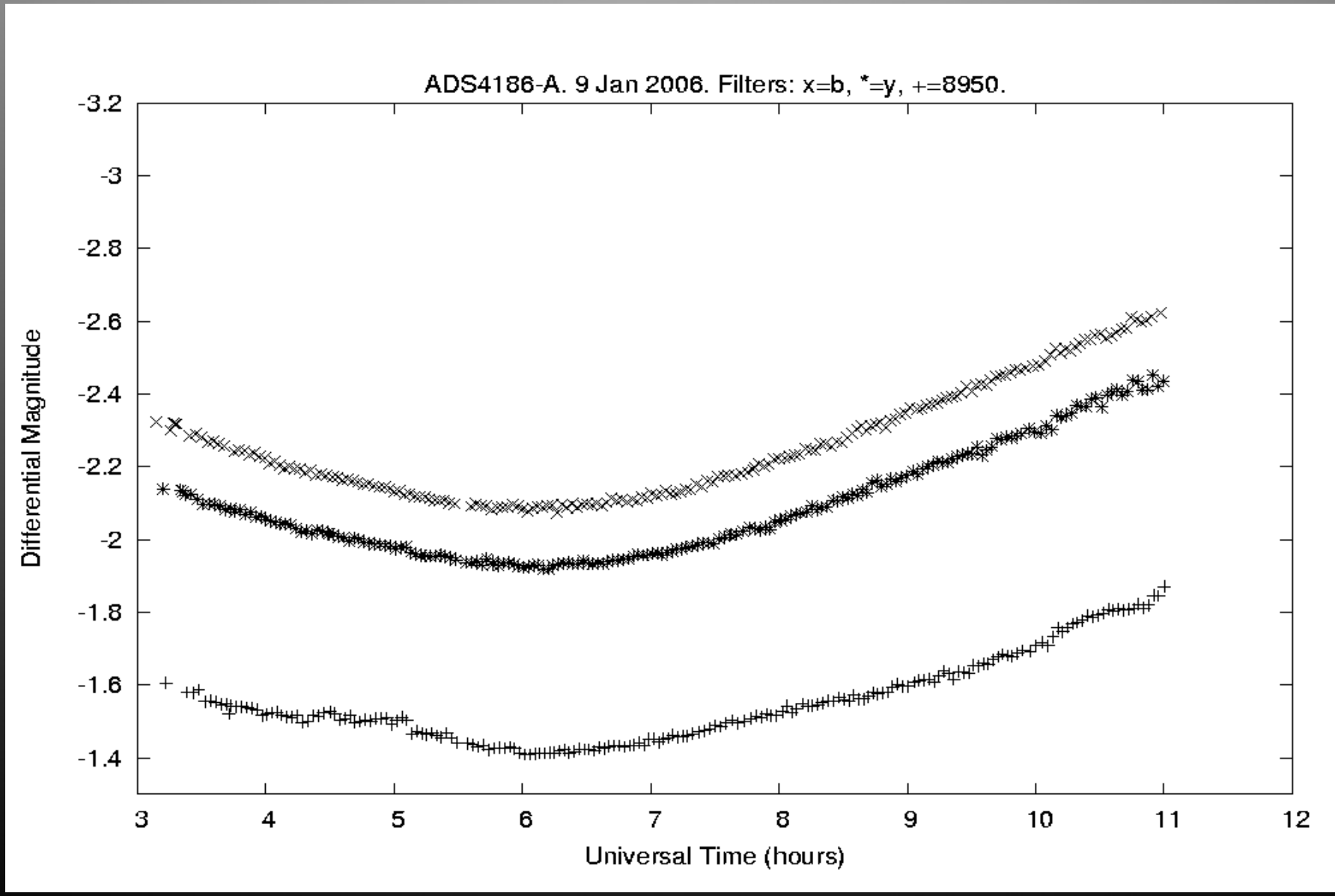
The orbital solution for θ¹ Ori A with the optical measurements represented by filled circles and the *IUE* observations by open circles. The primary minimum occurs at spectroscopic phase 0·938; no spectra have been secured precisely in the very slurp one-magnitude minimum, which only lasts about 1% of the 65-day cycle.

Orbital parameters not very well determined

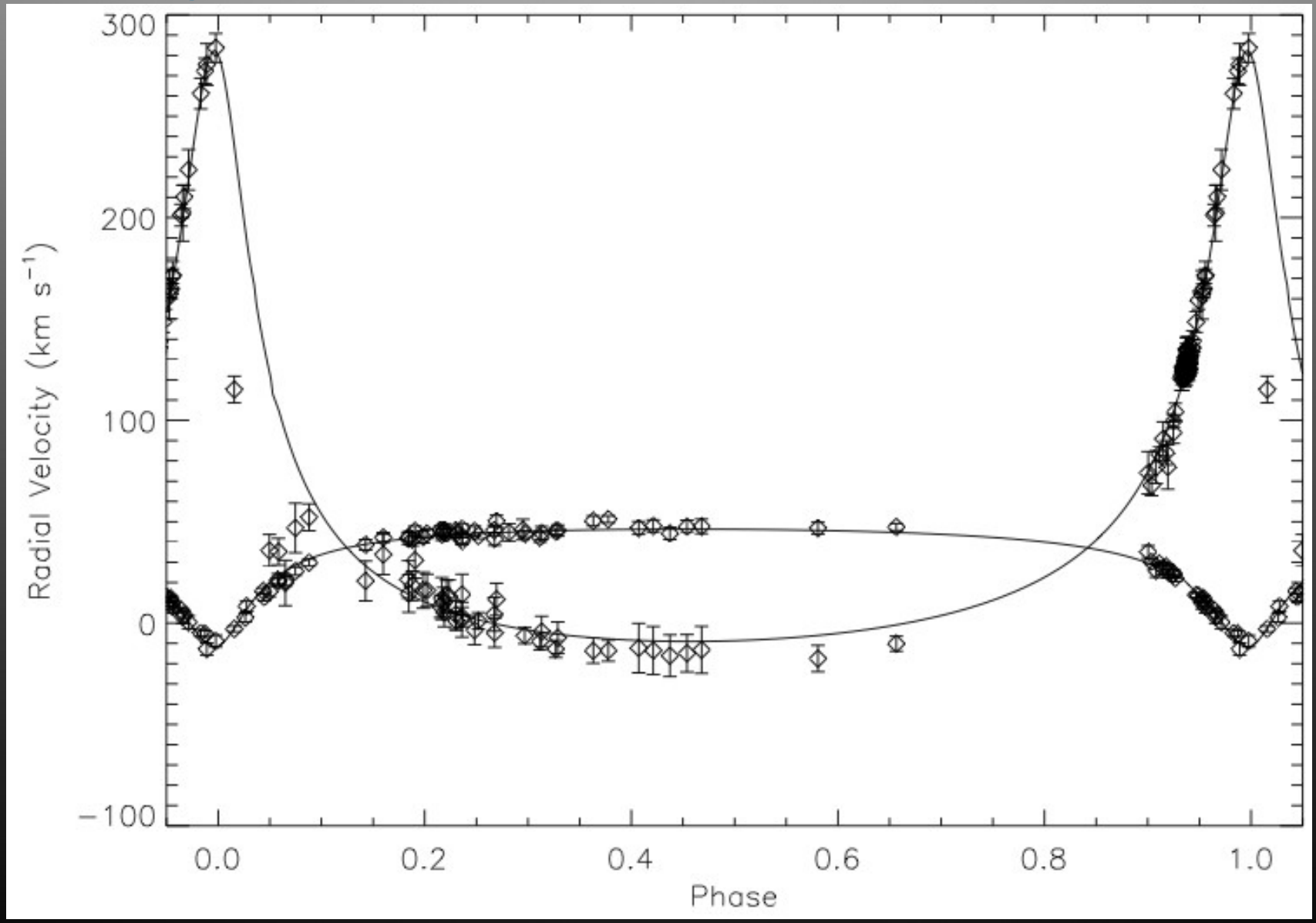
Orbit excentricity :

- **0.73 ± 0.03 (Bossi et al. 1989)**
- **0.50 ± 0.11 (Abt et al. 1991)**
- **0.66 ± 0.03 (Vitrichenko et al. 1998)**
- **0.626 ± 0.031 (Stickland & Lloyd, 2000)**
- **0.66 ± 0.02 (This work)**

Light curve obtained simultaneosly with the first spectroscopically observed eclipse



Velocity curve of V1016 Ori with both components

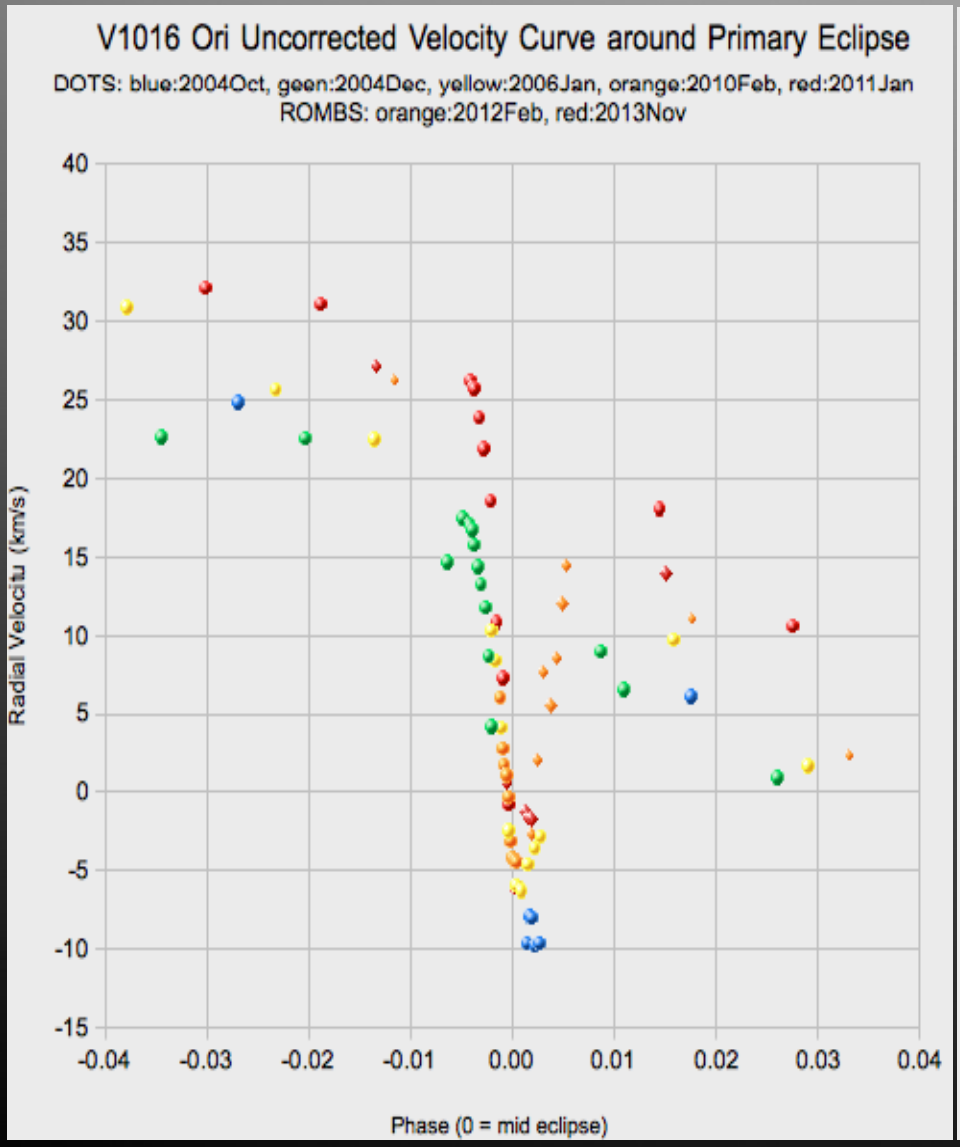


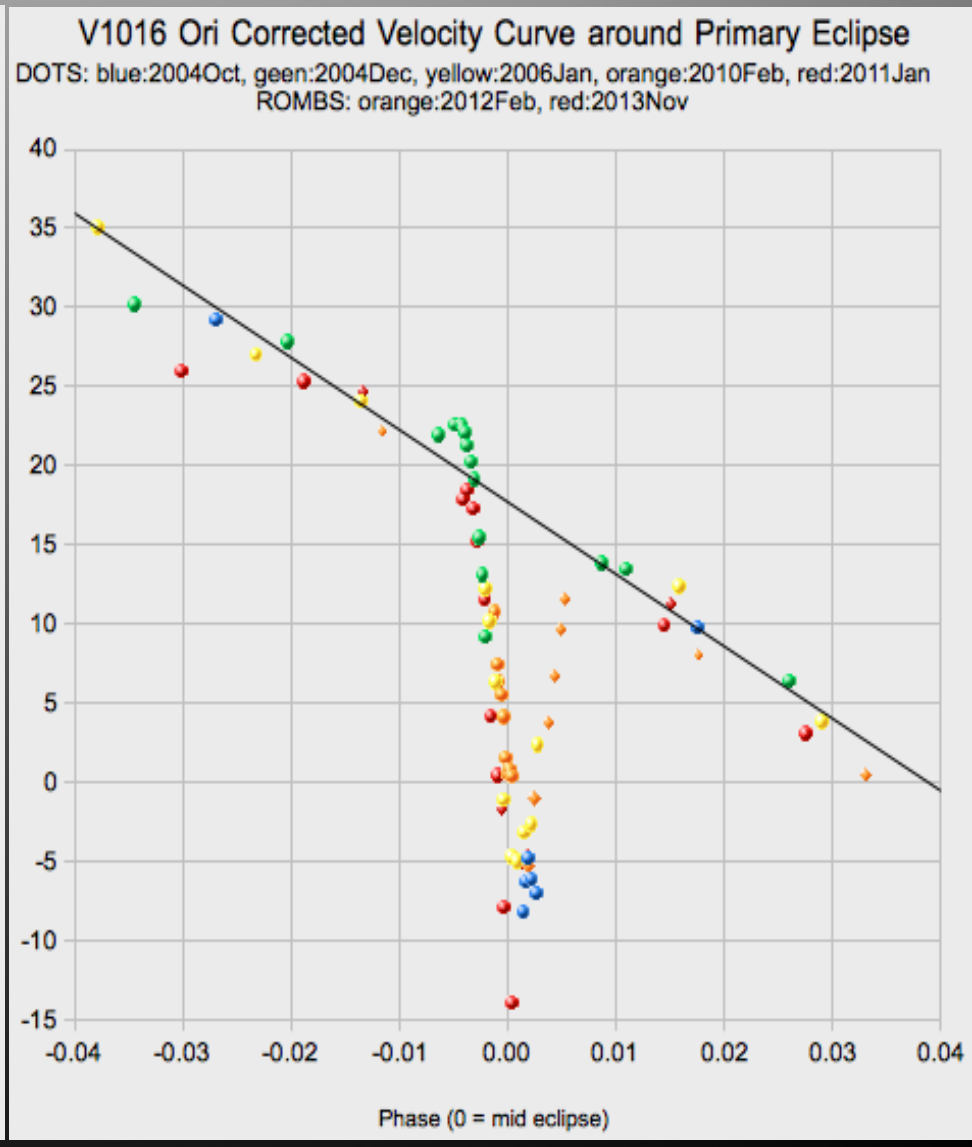
Orbital parameters obtained

	Both components	Primary	Secondary	
• e	0.685	0.649	0.670	
• ω	183º8	179º7	180º2	
• γ	37.1	38.15	34.0	km/s
• $a_1$sen i	27.9 Ro			
• $a_2$sen i	139.5 Ro			

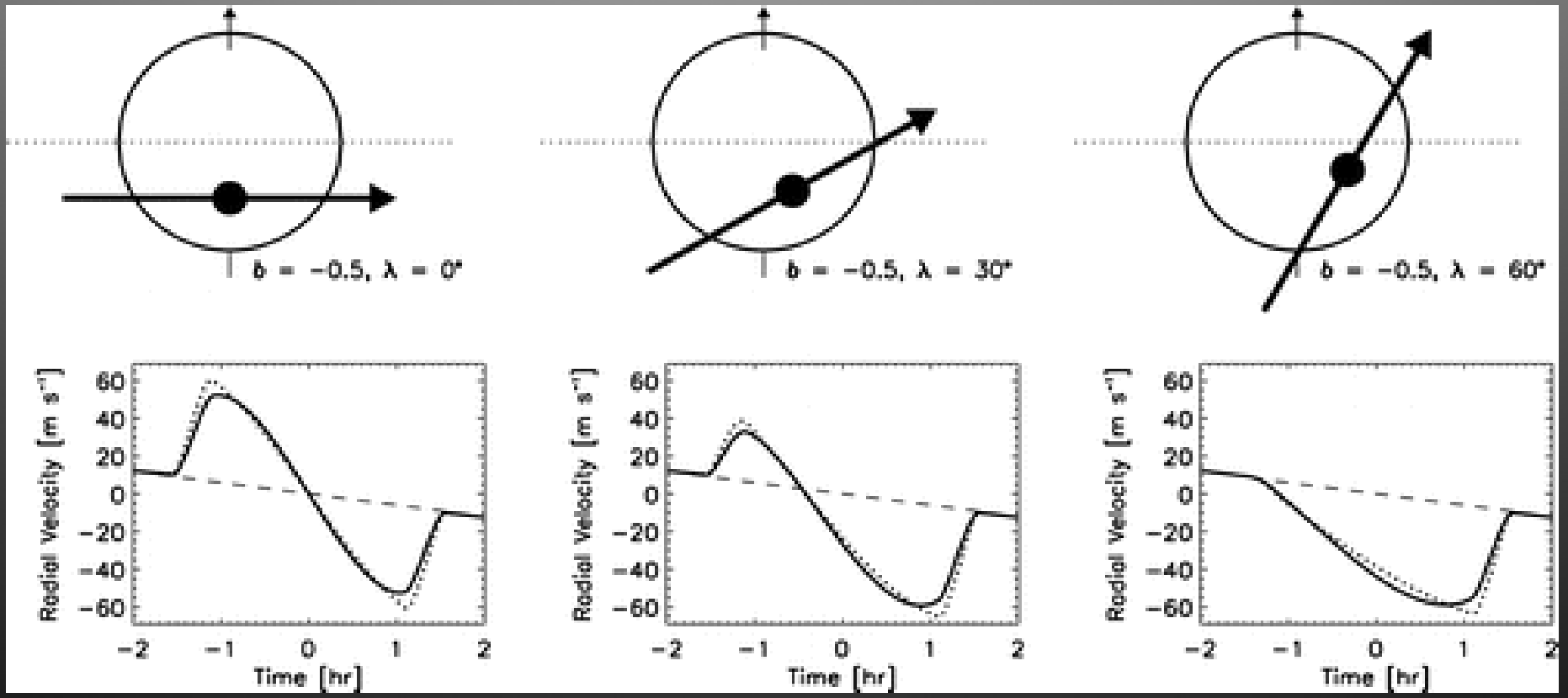
$q = M_2/M_1 = 0.200$

The Rossitter-MacLaughlin (R-M) effect in V1016 Ori = θ^1Ori A

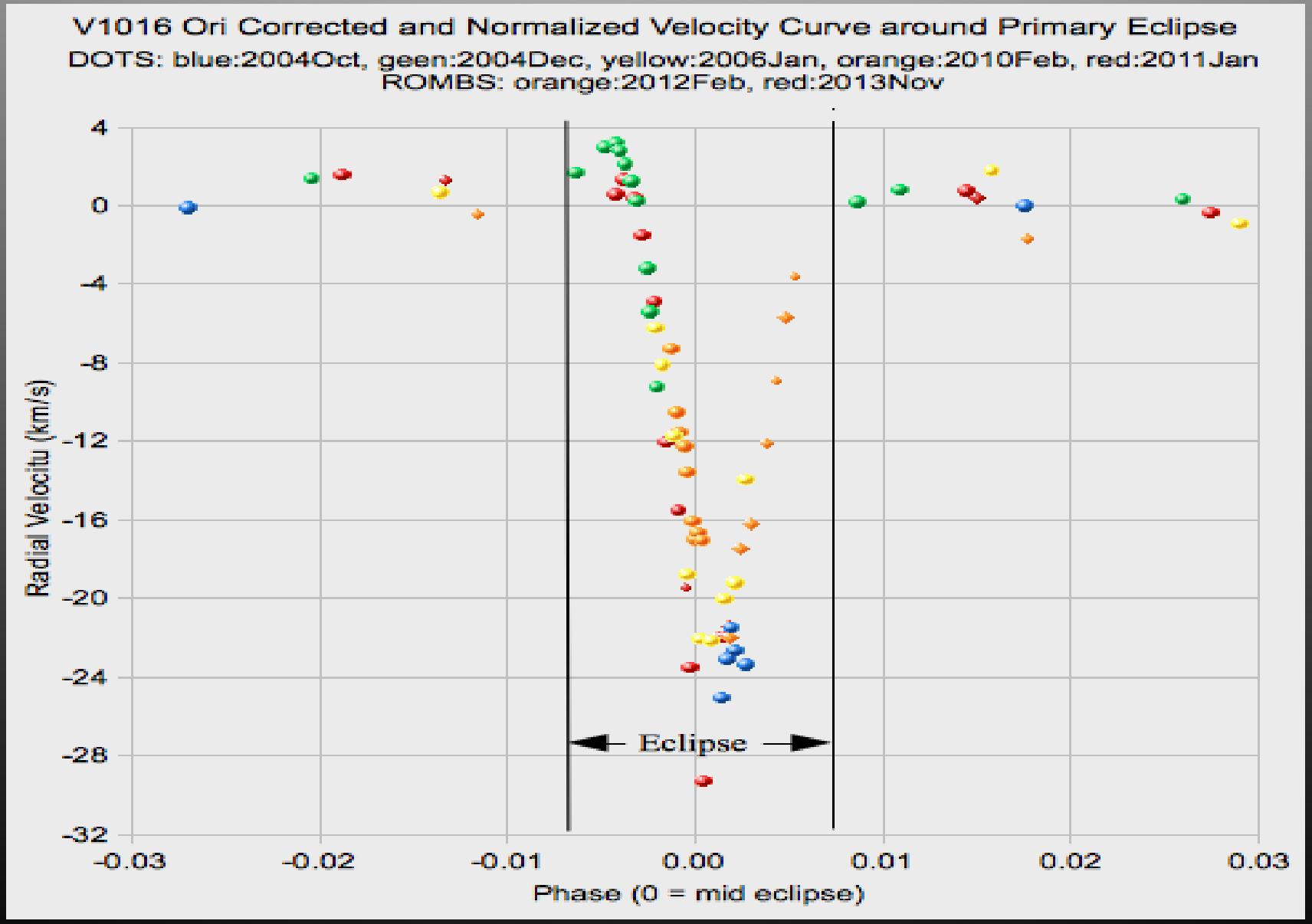




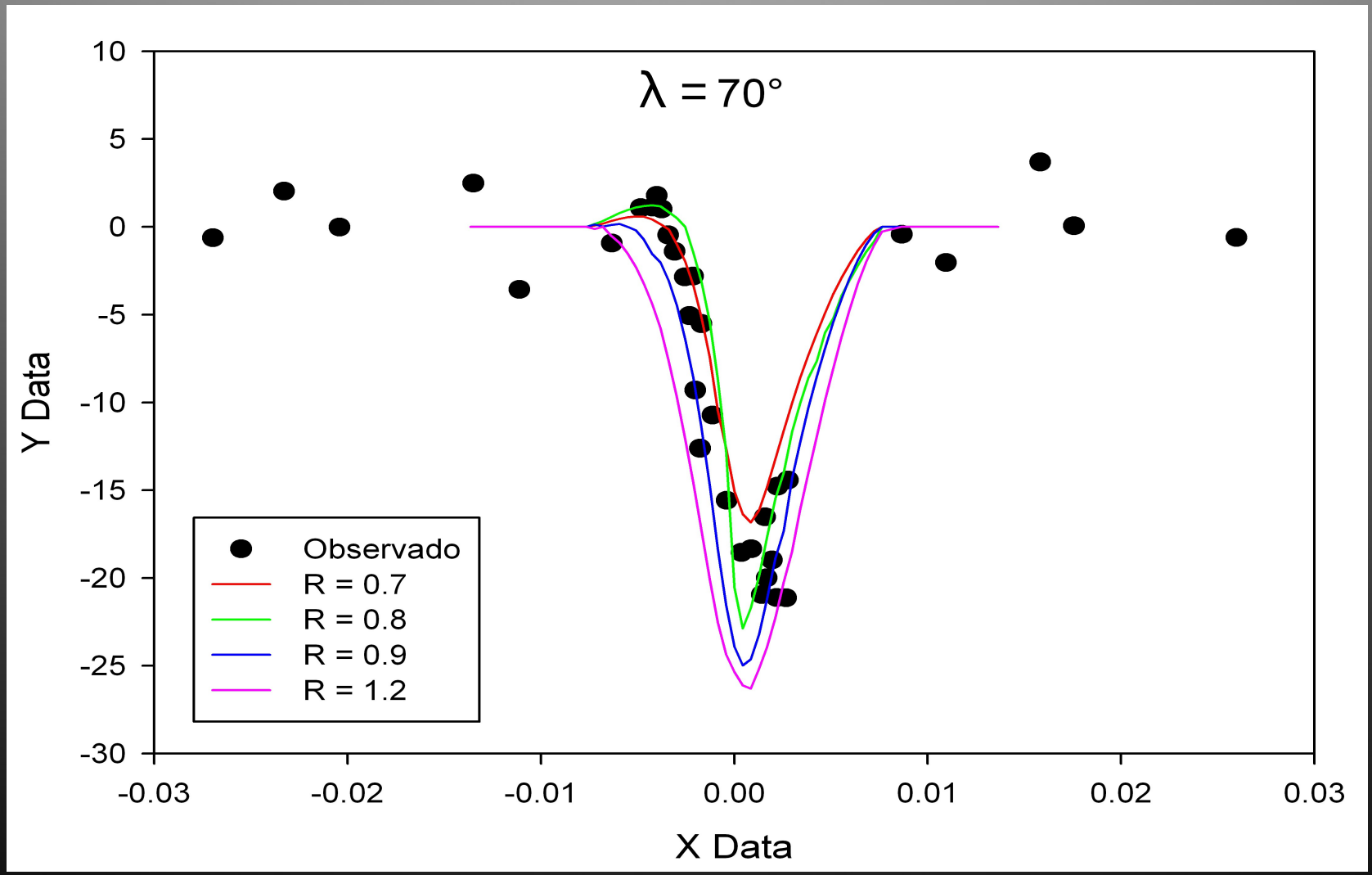
Simulation of the R-M effect as produced by HD209458b in transit, with λ (the orbital obliquity) as free parameter



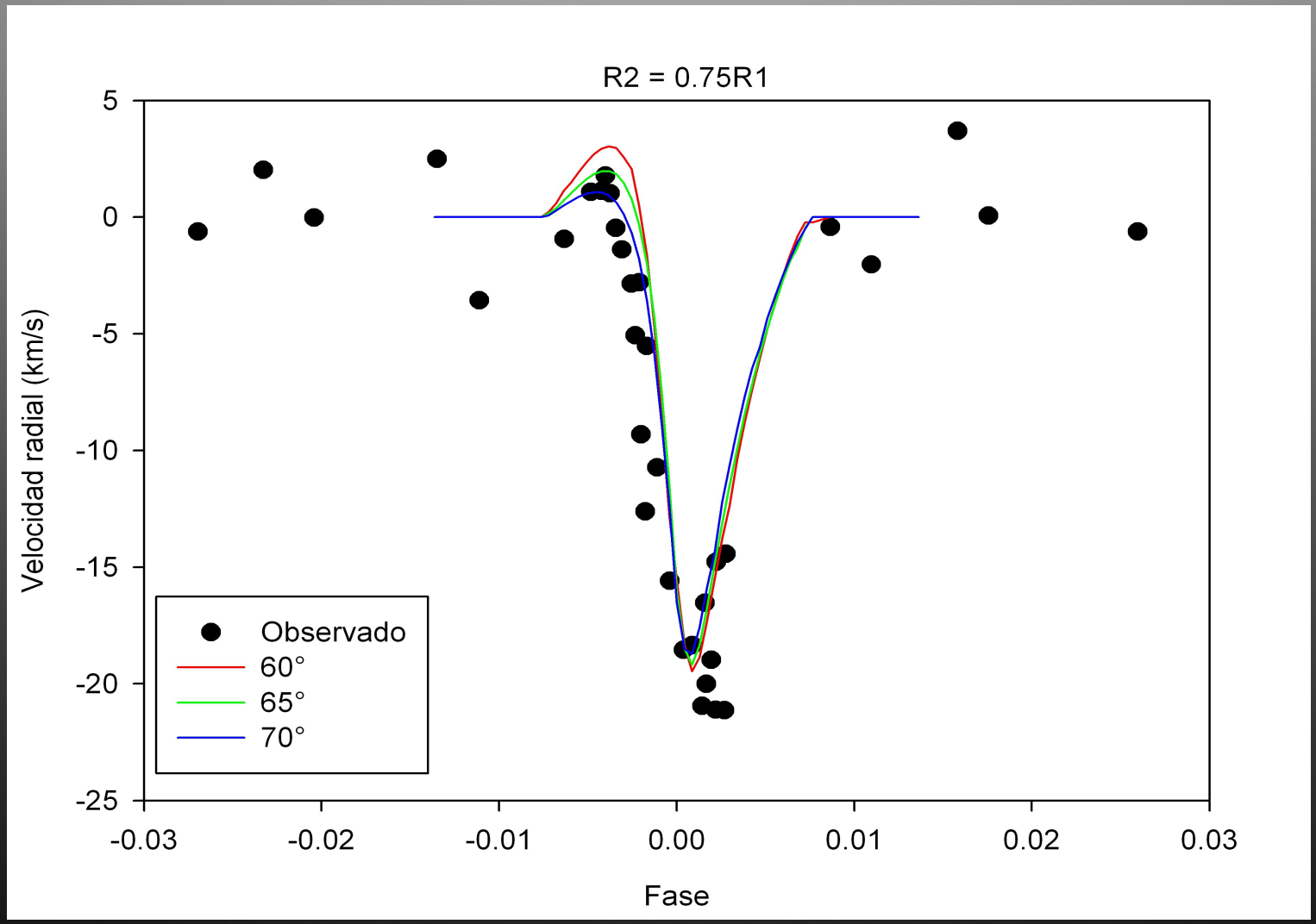
Normalized (O-C) curve: RM effect in 7 eclipses



Simmulated R-M effect as a function of R=R1/R2, the ratio of the componets' radii



R=R1/R2=0.75 and λ as the free parameter



CONCLUSIONS for V1016 Ori

- The secondary is almost as large as the primary but much cooler (about 5800 K).
- Orbital parameters are consistent with those previously calculated (except for the sistemic velocity?).
- The orbital obliquity (spin-orbit angle) is very large ($\approx 70^{o}$) sugesting strong perturbations during multiple star formation processes.

THANKS FOR YOUR KIND ATENTION