ROCHE:
Analysis of Eclipsing Binary Multi-Dataset Observables

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(why) Multi-dataset modeling ?

- Combination of different datasets results in more reliable orbit and parameters of components
- Typically LCs + RVs, better LCs + BFs (LSD profiles), even better LCs + BFs + visual orbit, possibly also LCs + BFs + LBI visibilities…, can include timing in multiple systems
- RVs + LBI ➔ model-independent distance
- Problem: relative weighting of datasets and realistic data error estimates…

Inputs/outputs/code

INPUTS
- HJD/phases as input
- up to 7 passband-specific LCs
- two photo-centric RV curves
- two barycentric RV curves
- up to 200 BFs (=LSQ deconvolved profiles) - takes into account instrumental profile and exposure times
- relative visual orbit
- interferometric visibilities for one baseline

OUTPUTS
- *UBVRIJHK* apparent magnitudes
- Absolute parameters of components + orbital parameters

COMPUTING TRICKS
- Using space symmetries of the 3D model
- Using phase symmetries (both circular and eccentric orbits)
- Interpolation in between 360 phase points
- Adaptive phase step in detached systems (i) eclipse or (ii) LC phase-derivative defined….
- surface grid density equal/unequal for components
- optional computation without reflection effect

δ Vel

- V_{max}=1.96, π = 40.9 mas
- the brightest Southern EB
- member of visual binary ➔ triple
- Interferometrically resolved EB (Kellerer et al., 2007)
- Complications: never detected as a SB, orbital 45.15 days with eclipses lasting hours, eccentric orbit
- Simultaneous modelling of LCs, BFs + visual orbit (from interferometry)
- Result: precise masses, first reliable orbit, detection of fast spin of components (2/3 of break-up),
- Age about 400 My

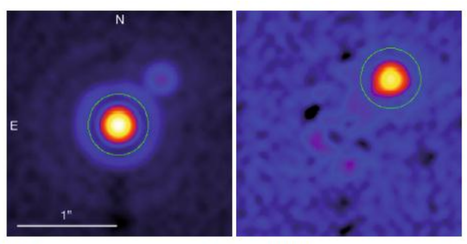
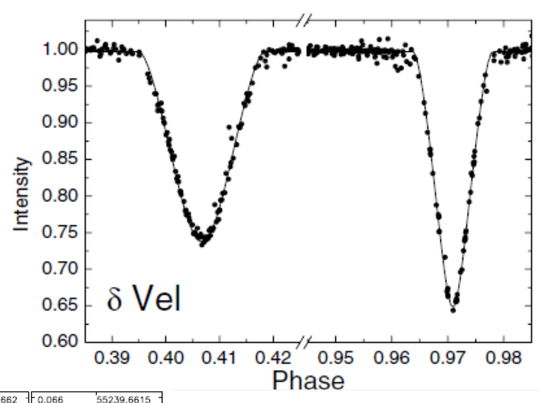
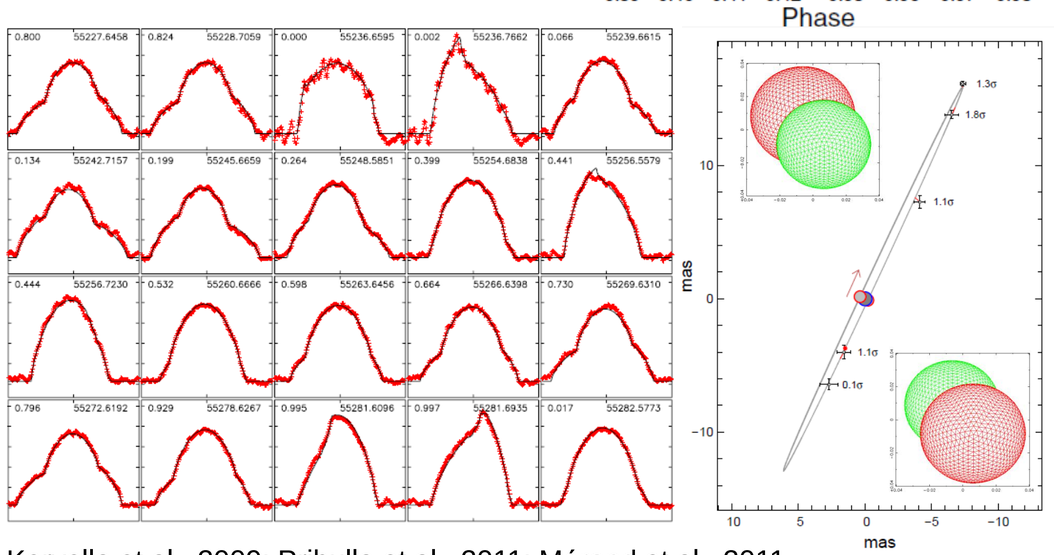


Fig. 3. Apertures (circles) used for the VISIR photometry of δ Vel A (*left*) and B (*right*) shown respectively on the PAH1 image #B and the subtracted image #B–#D (see text for details).

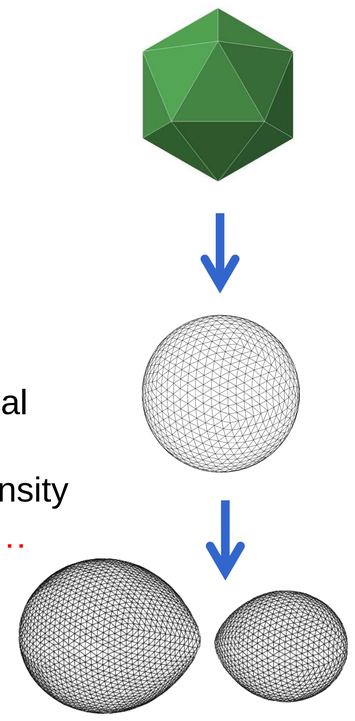




Kervella et al., 2009; Pribulla et al., 2011; Mérand et al., 2011

Model assumptions

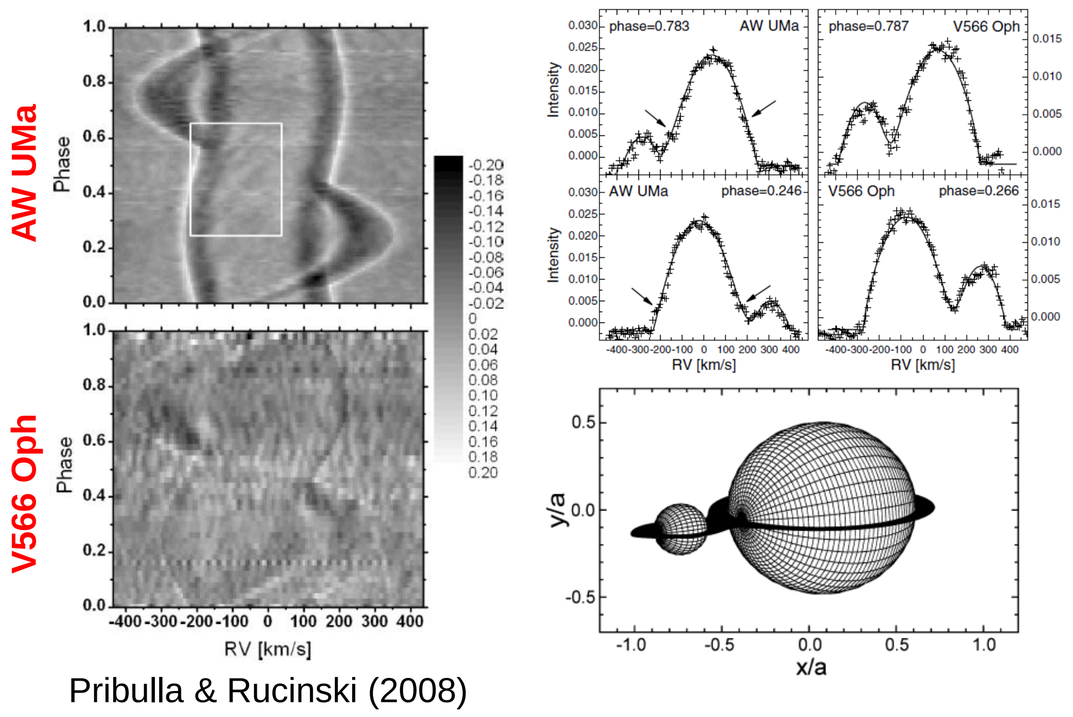
- Roche surface geometry
- Circular/eccentric orbits
- asynchronous/synchronous rotation
- Differential rotation
- Circular surface spots
- Third light stellar/free
- Linear/logarithmic LD, gravity darkening, mutual irradiation
- Model atmospheres ➔ passband-specific intensity
- No accretion disks, no mass streams, no dust…
- Surface grids based on regular icosahedron
- …



$20n^2$ elements (detached)
Area of the elements equal to about 15% for spherical stars

AW UMa

- Modeling with ROCHE showed departures from the Roche model
- The system is probably engulfed in a stream of matter
- The secondary is possibly just a helium core (see Stępień, 2009)



Pribulla & Rucinski (2008)

Prospects for future

- More realistic surface inhomogeneities modeling (MEM ?)
- better optimization methods and error budget analysis
- Radiation pressure for OB-type systems (Drechsel et al., 1995)
- Doppler boosting
- Free orientation of the rotational axes of either of the components in non-synchronously rotating systems (e.g., for retrograde orbits)
- Distance as one of the optimized parameters (now *UBVRIJHK* magnitudes synthetized), including IS extinction
- Modeling of interferometric visibilities including all proximity effects (now spheres)
- Extending accurate modeling down to planet/star mass ratios (q < 0.01) and radii ratios (Rp/Rs < 0.10) [hot Jupiters very probably follow the Roche model !!!]
- Resolving close and finally contact binaries with LBI ?
- Interferometry of planetary transits ?

References:
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Ten Years of VLTI Conference, October 24-27, 2011, Garching, Germany