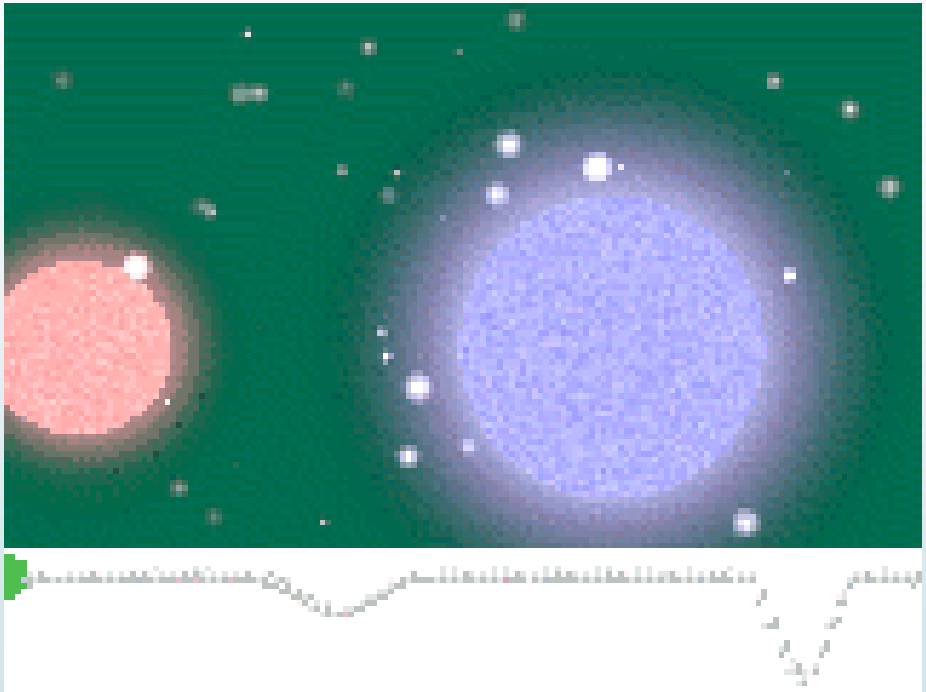
Eclipsing Binary Systems with Oscillating Components (oEA stars)

Patricia Lampens, Lore Vermeylen,
Peter De Cat and Paul Van Cauteren

EBs (detached systems)

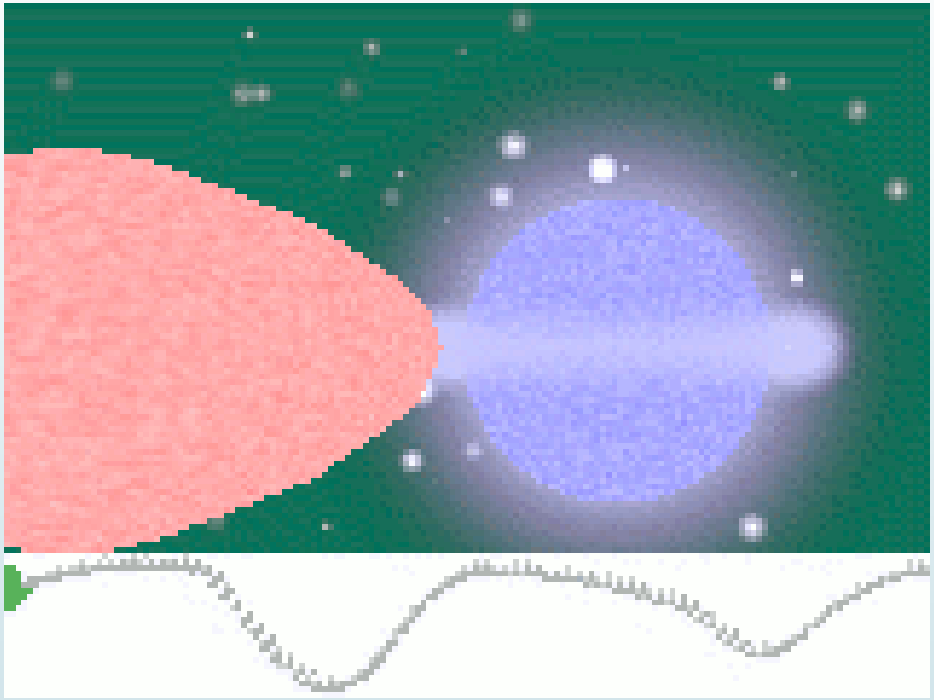
- Sources of fundamental stellar parameters, e.g. EB+SB2: accur. masses, radii (±1-2%), L_2/L_1, [T_{eff1}, T_{eff2}, distance]
- Common origin (same age/environment/cc)
- Interaction binarity – rotation – [pulsation] etc.



Source: Wikipedia

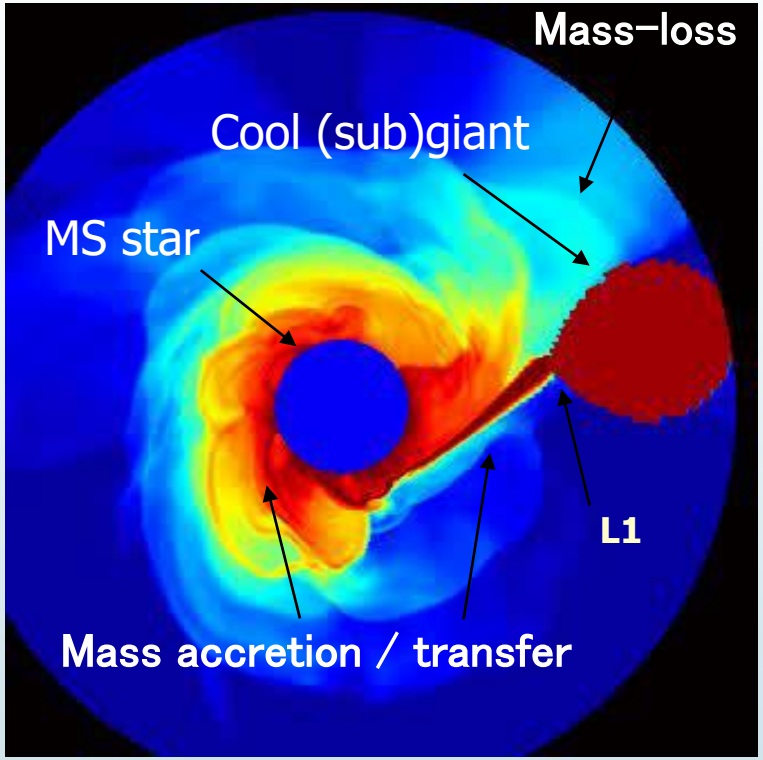
EBs with interaction (semi-detached systems)

- Tides & (a)sync. rotation
- Binary evolution
- (Episodical) mass transfer/loss
- Origin of "blue stragglers"
- Interaction binarity – rotation - **accretion** – [pulsation] etc.



Source: Wikipedia

2D-hydrodyn. simulation: β Per



(X,Y) orbital plane

© Blondin, Richards & Malinowski (1995)

New class of variables: EA with oscillating components

(Mkrtichian et al. 2002, 2004)

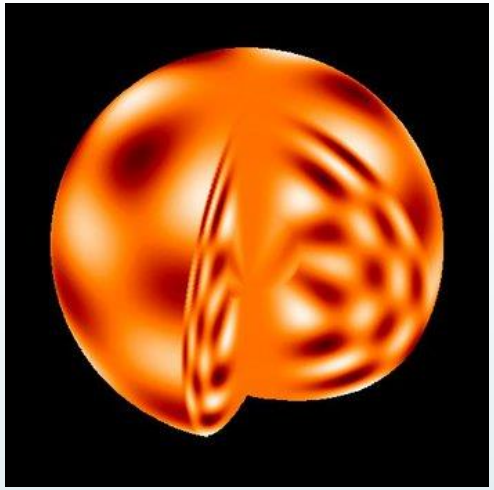
- **oEA stars** = mass-accreting A/F-type comp.t of semi-detached systems **with short-period oscillations** (δ SCT)
- *Remnants* of rapid mass transfer in evolved close binaries
- On-going *accretion process*
- Evolving *upward* along the MS

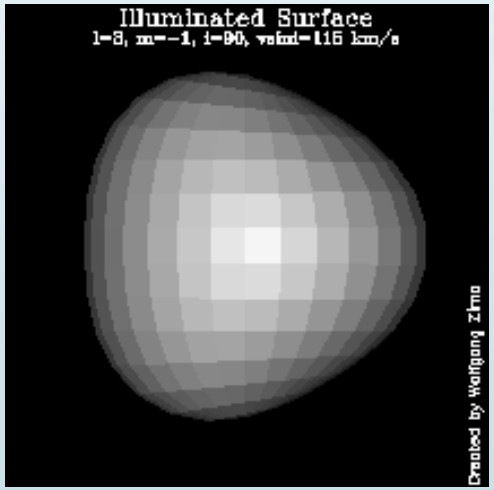
oEA's = abnormal δ SCT's $\rightarrow$ attractive targets for asteroseismology

Asteroseismology of δ Scuti stars

δ **SCT stars** = low-amplitude A/F-type pulsators of the MS

- Acoustic modes (& gravity modes → many hybrid stars)
- Radial/non-radial pulsations
- Need for accur. atmospheric & fundamental st. parameters
- Need for reliable **mode identification**

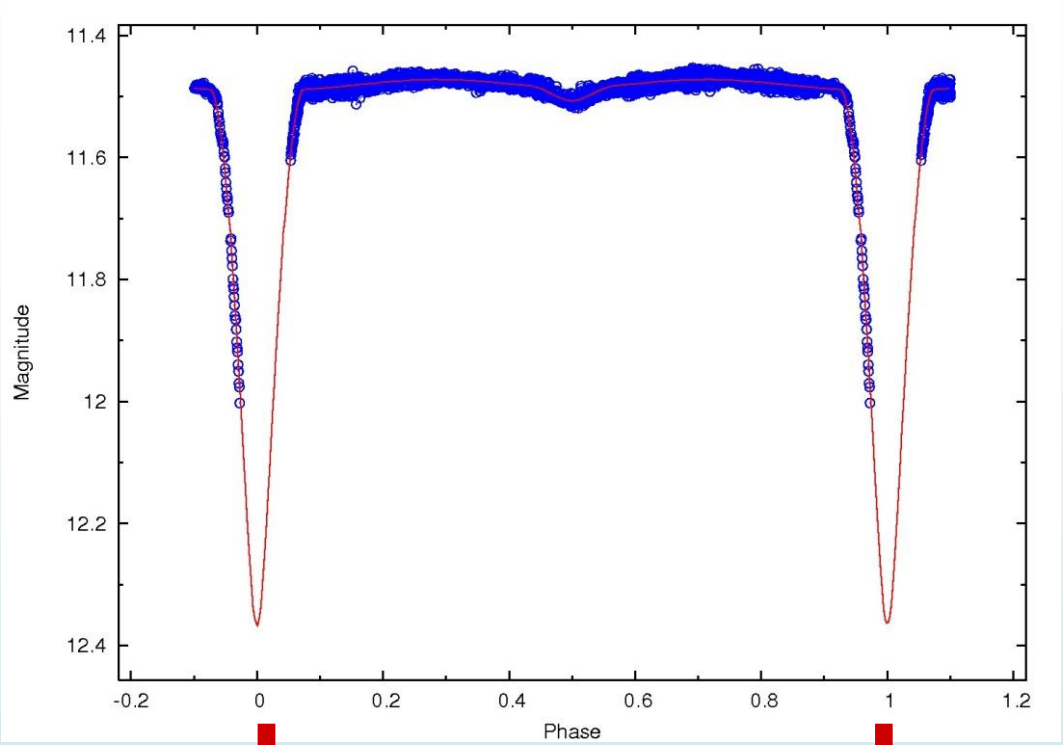


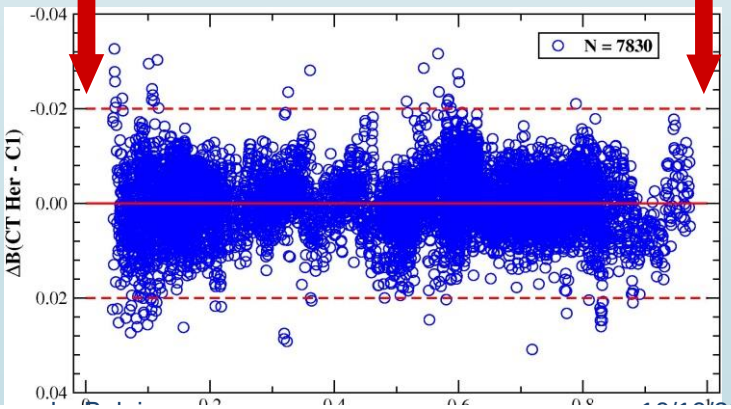


Simul. NR pulsation (ℓ=3, © Zima)

(oEA) CT Her, A3V+[G3IV], B = 11.33 mag

- Modelling with PHOEBE v0.31a[1]
- P_{orb} = 1.7863748 d
- Filter B: N = 7960, model & residuals





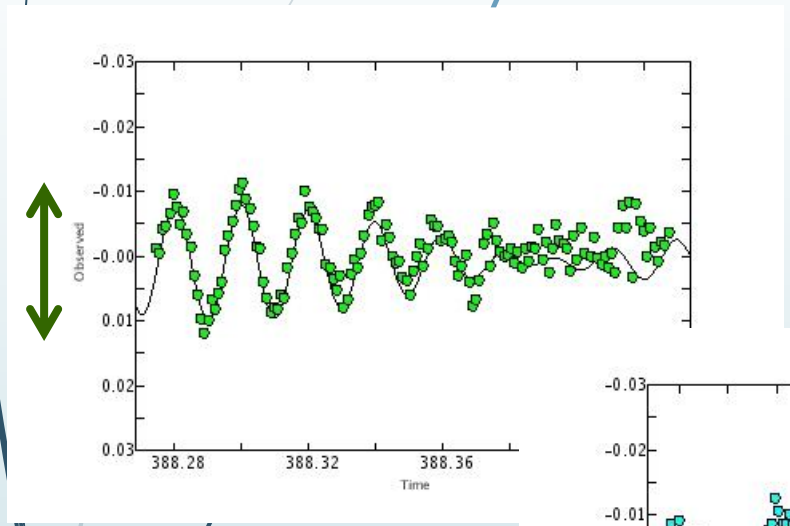
σ = 5.9 mmag

[1]PHysics Of Eclipsing BinariEs, http://phoebe-project.org/1.0

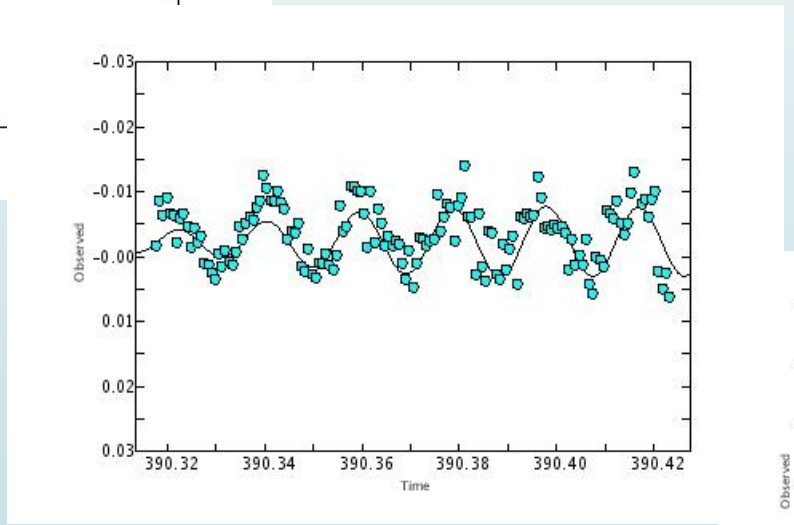
(oEA) CT Her, B-filter residuals

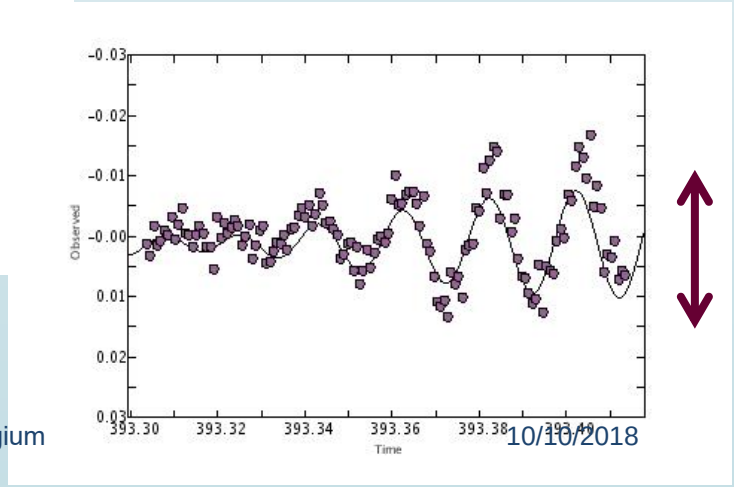
(Lampens et al., 2011)

After binary model subtraction ⇨



multiperiodic low-amplitude *oscillations (P_{puls}~ 27 min)*

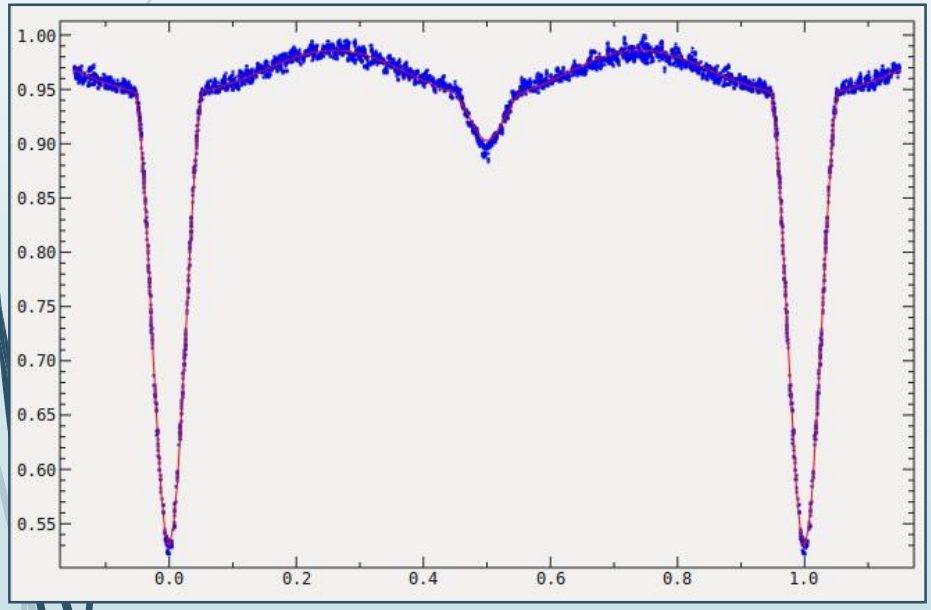




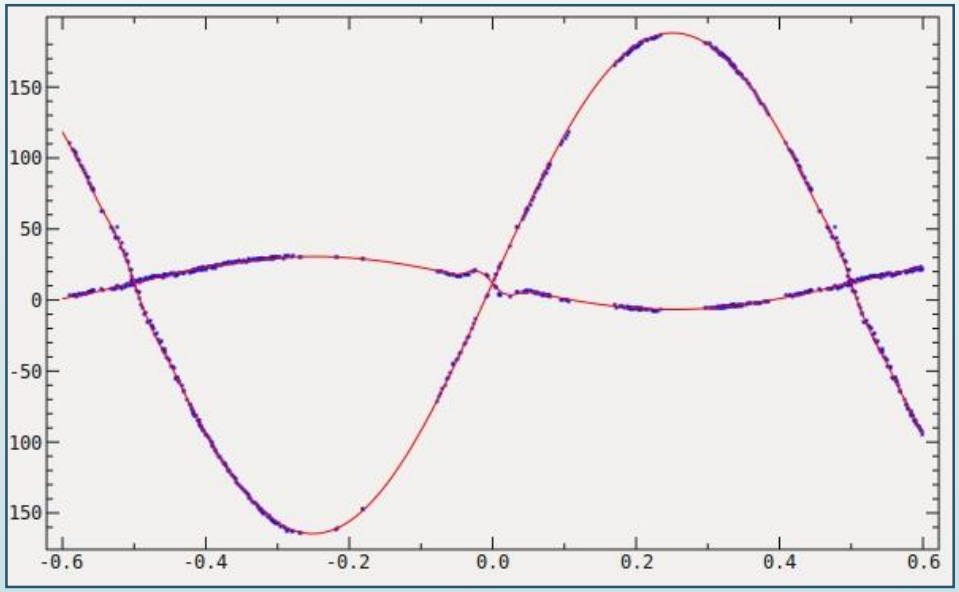
(oEA) AS Eri, binary modelling

(Lehmann et al., work in progress)

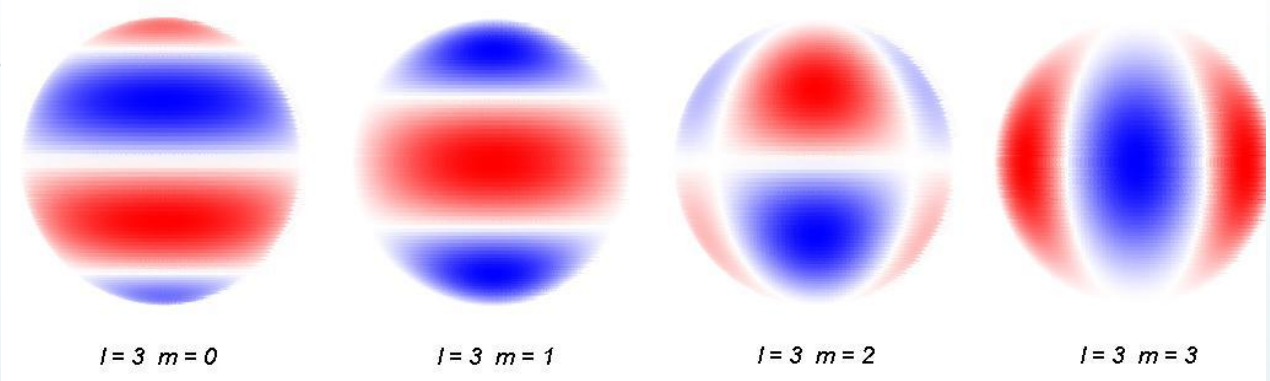
Light curve: data & model (PHOEBE)

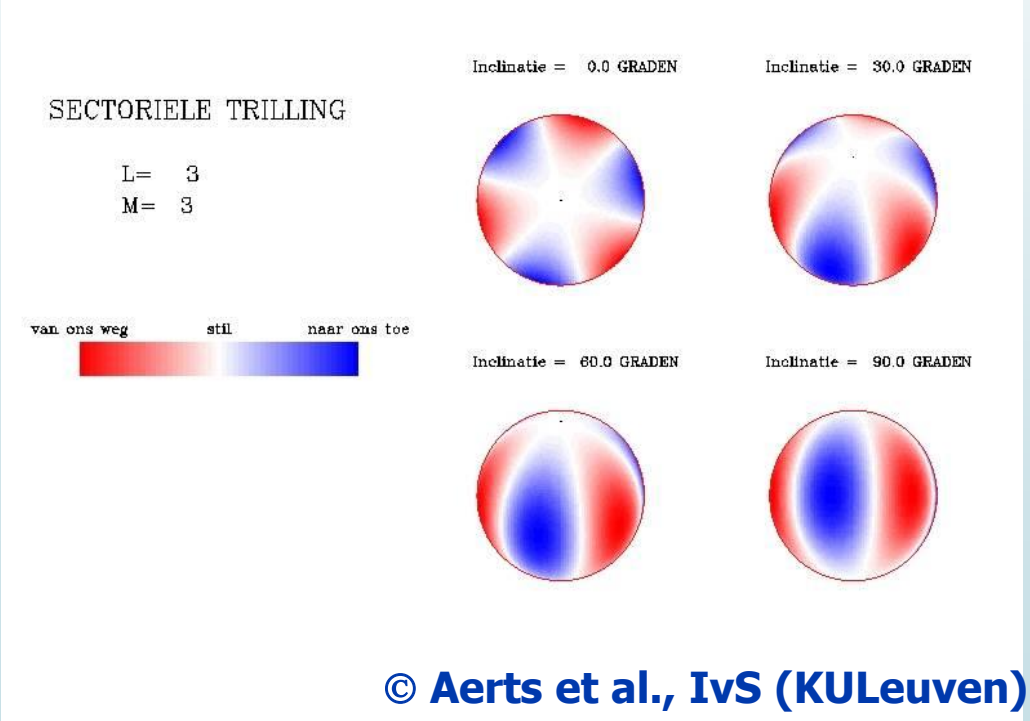


Rad. velocities (HERMES) & model (PHOEBE)



Non-radial modes & visibility

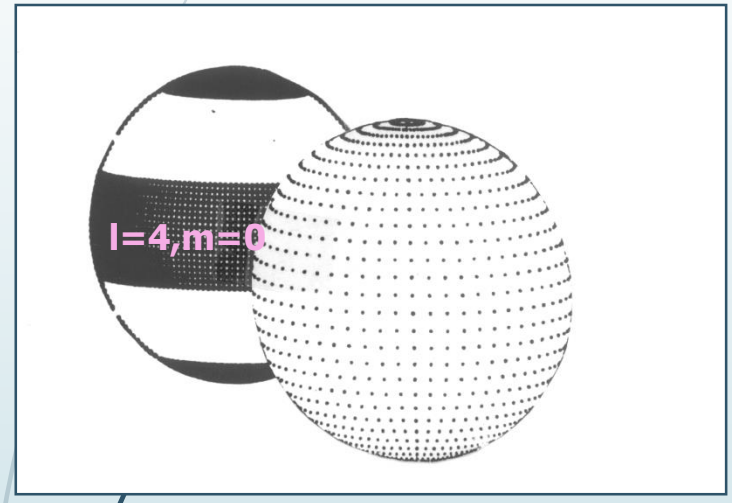




© Aerts et al., IvS (KULeuven)

Spatial filtering of NR Pulsations

Original idea from Nather & Robinson (1974). **Courtesy of D. Mkrtichian**



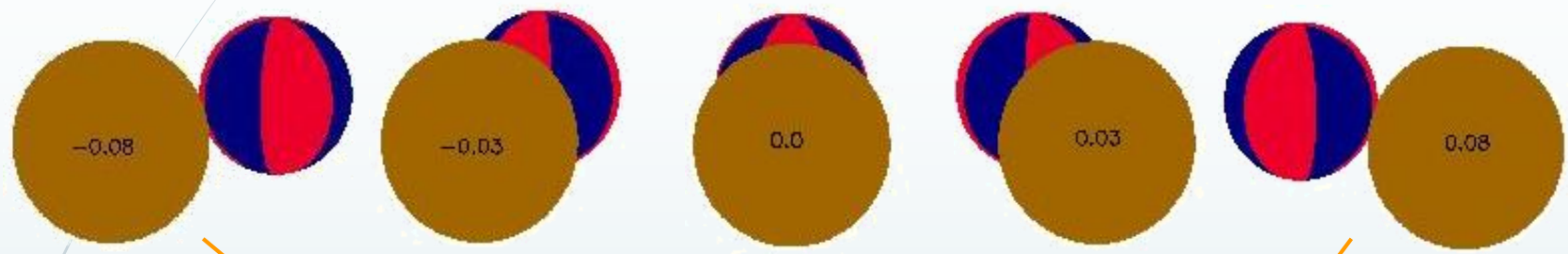
The (non-pulsating) companion acts periodically as a geometric spatial filter during eclipses. This 'screening' produces amplitude & phase changes of NRPs which depend on the spherical wave numbers and on the geometry of the eclipse. By comparing modelled and observed amplitude & phase changes, *spatial information on the non-radial modes i.e. (ℓ, m)* (and on the inclination of the symmetry axis of the pulsations) can be obtained.

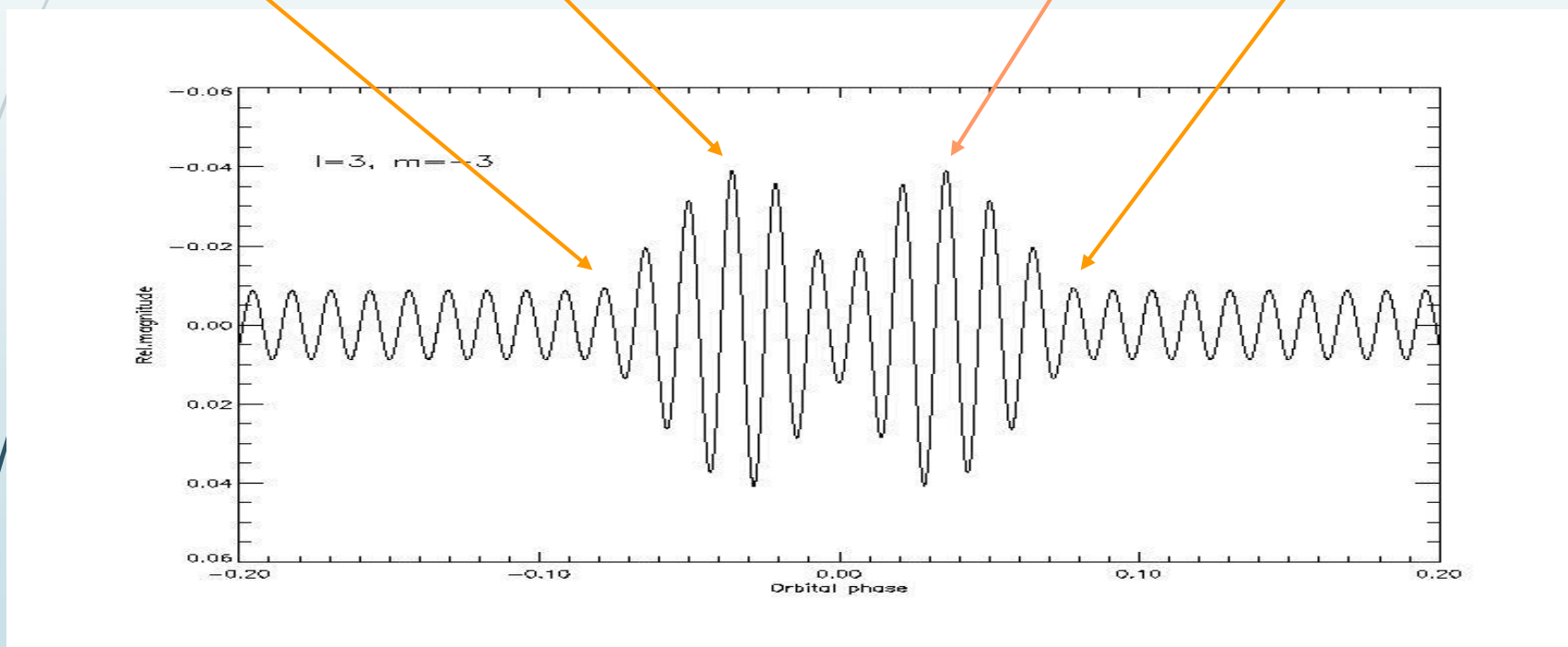
Also: Image reconstruction of NRP modulation patterns in EB's by Bíró & Nuspl 2005, Bíró et al. 2011.

Modelling of eclipse effects

Mode visibility: best for ℓ+|m| = even

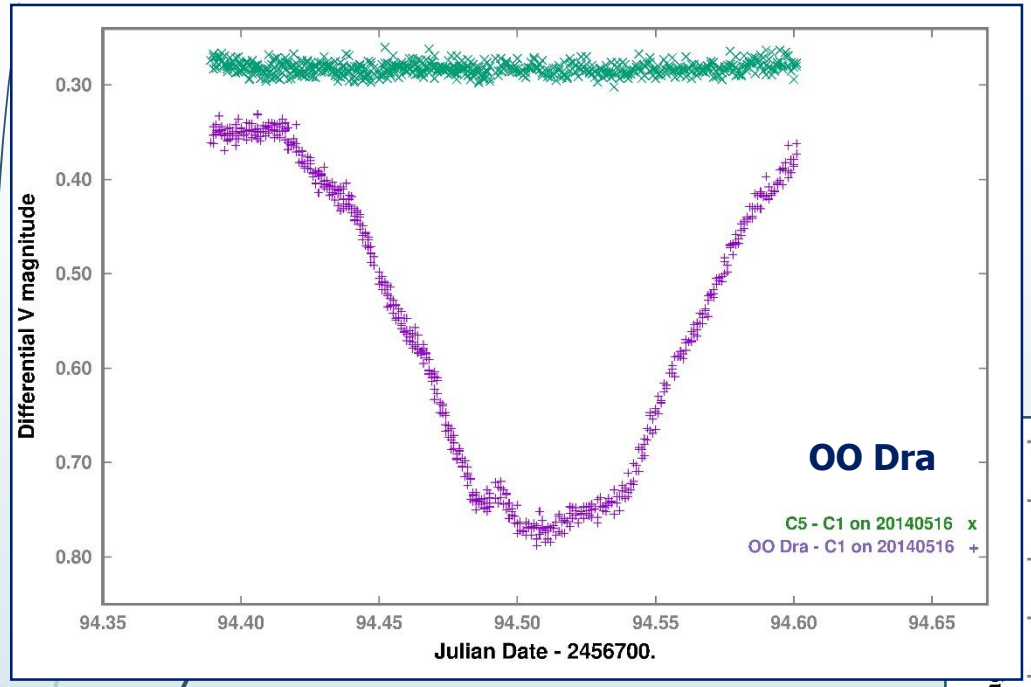
(Mkrtichian et al. 2005)

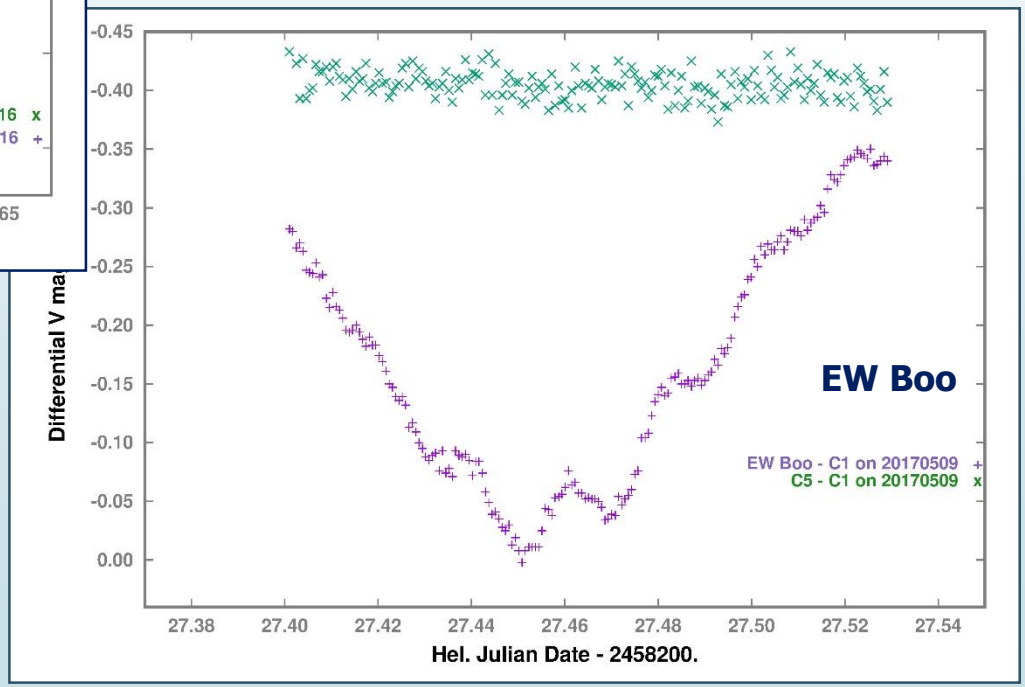




The 'screening' effect for the prograde NR mode ℓ =3, m=-3. The different phases during primary eclipse are illustrated. **© Gamarova et al. 2003**

Possible targets (Min I light)





Instrumental challenge - Summary

- Eclipse monitoring (i.e. short, critical phases)
- High S/N & T(ime) resolution → Fast photometry @medium/large telescope (e.g. DOT?)
- Simultan. multi-colour channels → Mode ID via amplitude ratios and phase differences **(Garrido 2000, Sterken 2000)**
- oEA stars provide **another tool for mode ID of δ Sct stars**
- Understanding of **Pulsation + Accretion + Tides!**
- Need for **high-resolution spectroscopy (mode ID)**

Thank you