Eclipsing Binary Systems with Oscillating Components (oEA stars)

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EBs (detached systems)

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

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.

2D-hydrodyn. simulation: β Per

© Blondin, Richards & Malinowski (1995)
New class of variables: EA with oscillating components


- 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 → attractive targets for asteroseismology
Asteroseismology of \( \delta \) Scuti stars

\( \delta \) SCT stars = low-amplitude A/F-type pulsators of the MS

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

Simul. NR pulsation (\( \ell \)=3, © Zima)
(oEA) CT Her, A3V+[G3IV], B = 11.33 mag

- Modelling with PHOEBE v0.31α
- \( P_{\text{orb}} = 1.7863748 \text{ d} \)
- Filter B: \( N = 7960 \), model & residuals

\( \sigma = 5.9 \text{ mmag} \)

1PHysics Of Eclipsing BinariEs, http://phoebe-project.org/1.0
(oEA) CT Her, B-filter residuals

After binary model subtraction ⇒

multiperiodic low-amplitude oscillations ($P_{\text{puls}} \sim 27 \text{ min}$)
(oEA) AS Eri, binary modelling

Light curve: data & model (PHOEBE)

Rad. velocities (HERMES) & model (PHOEBE)

(Lehmann et al., work in progress)
Non-radial modes & visibility

© Aerts et al., IvS (KULeuven)
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.

Spatial filtering of NR Pulsations

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

Modelling of eclipse effects

Mode visibility: best for $\ell + |m| = \text{even}$

The ‘screening’ effect for the prograde NR mode $\ell = 3$, $m = -3$. The different phases during primary eclipse are illustrated. © Gamarova et al. 2003
Possible targets (Min I light)

OO Dra

EW Boo

“BINA, an Expanding International Collaboration”, ROB, Brussels, Belgium

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Instrumental challenge - Summary

- Eclipse monitoring (i.e. short, critical phases)
- High S/N & T(ime) resolution → Fast photometry @medium/large telescope (e.g. DOT?)
- Simultaneous 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