

Eclipse mapping study of the eclipsing binary KIC 3858884 with hybrid δ Sct/ γ Dor component

Bókon, A., Bíró, I. B. and Derekas, A.

PhD student

Institute of Physics, Faculty of Sciences and Informatics, University of Szeged, Hungary

Research fellow assistant

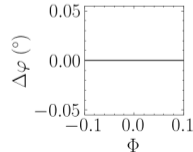
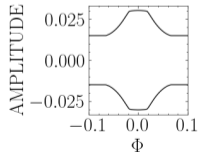
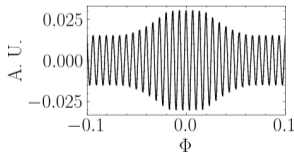
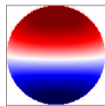
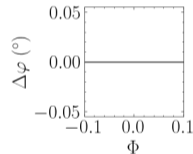
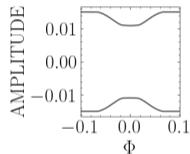
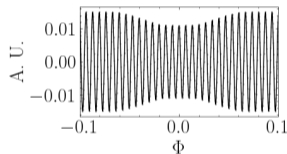
Gothard Astrophysical Observatory, Eötvös Loránd University, Hungary

`andras.bokon@gmail.com`

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Pulsation in binaries, in eclipsing binaries

- ▶ Asteroseismology: need of ℓ , m
- ▶ Effect of binarity on pulsation
- ▶ In eclipsing binaries: modulations due to eclipse



Inverse methods

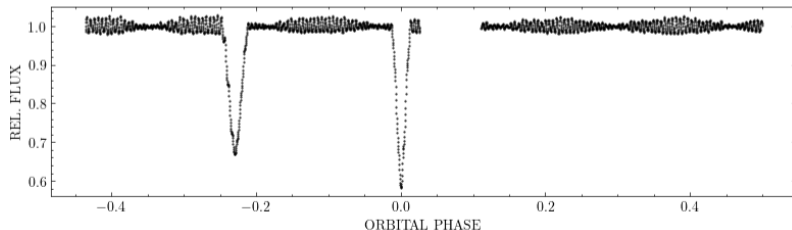
Challenge due to degeneracy; used in this Study:

- ▶ Dynamic Eclipse Mapping (DEM, Bíró & Knuspl, 2011)
 - actively developed recently
 - e.g. “*hidden*”, smaller images; fuzzy pixel; spline interpolation
- ▶ Direct Fitting of Y_ℓ^m (DF, Bíró, 2013)
 - may be used to determine symmetry axis of pulsation
 - two variants: DF & DFCLEAN
 - new, novel method using as core: YLMCMC (Bókon & Bíró, 2019)

There are other inverse methods in the literature as well (e.g. *spatial filtration*, Mkrtychian et al., 2002; Gamarova et al., 2003)

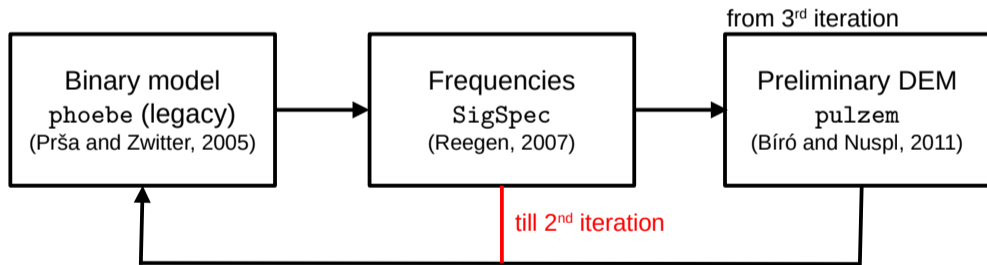
KIC 3858884 system

- ▶ Maceroni et al. (2014) – first full system analysis
 - ▶ Eccentric ($e = 0.465$), but wide system ($P = 25.952^d$)
 - ▶ Components – **similar** radii ($3.45R_{\odot}$; $3.05R_{\odot}$),
 - ▶ and **similar** masses ($q \sim 0.98$, $M_1 = 1.88M_{\odot}$),
 - ▶ and **similar** temperatures ($6,800K$; $6606K$).
 - ▶ **Both** components are pulsating.
- ▶ Manzoori (2020) – investigated tidally excited pulsations



Improving binary model

- ▶ Iterative process, successful after 4 iterations.
- ▶ Slightly changed parameters
- ▶ Residuals are more symmetric



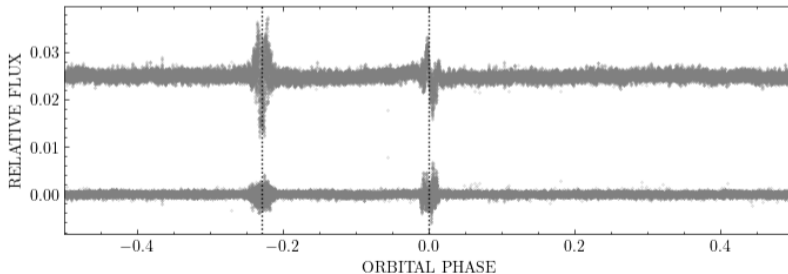
Improving binary model

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Parameter	Maceroni et al (2014)	This work
i	88.176	88.1942
e	0.465	0.46502
ω [$^{\circ}$]	21.61	21.4000
R_1 [R_{\odot}]	3.45	3.465
R_2 [R_{\odot}]	3.05	3.000

Improving binary model

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- ▶ Slightly changed parameters
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Source identification

According to Manzoori (2020), F2 originating on primary

Four methods used:

- ▶ Investigation of residuals
- ▶ Wavelet-transformation
- ▶ **PM (Murphy et al, 2014), modified** – fitting according to *orbital phases*
- ▶ **Double Eclipse Mapping**
 - ▶ Frequencies to both of components
 - ▶ Using general mode of *image reconstruction*

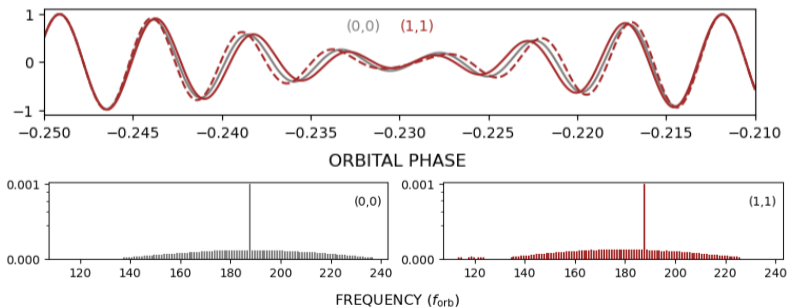
Result

From eight dominant frequencies: seven on secondary, one (F10) on primary.

Selecting for mode identification I

First Eclipse Mappings

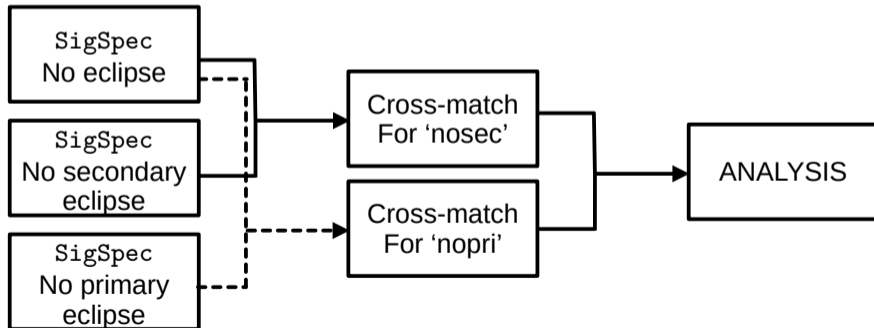
Not enough improvement of residuals, as expected; strict χ^2 results in ambiguous images, reconstructions



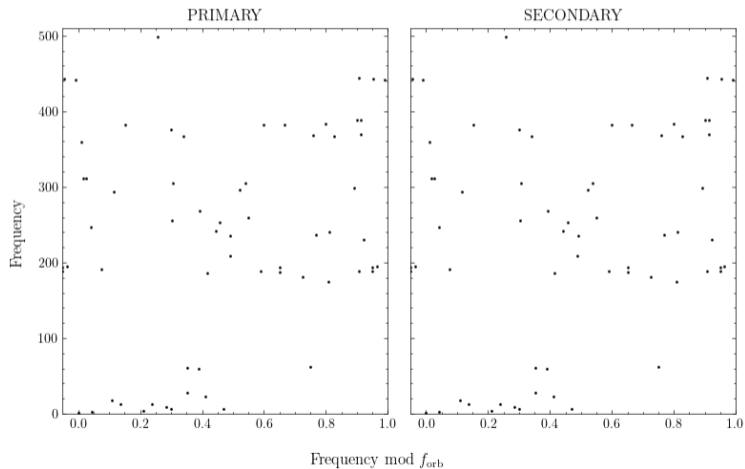
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First Eclipse Mappings

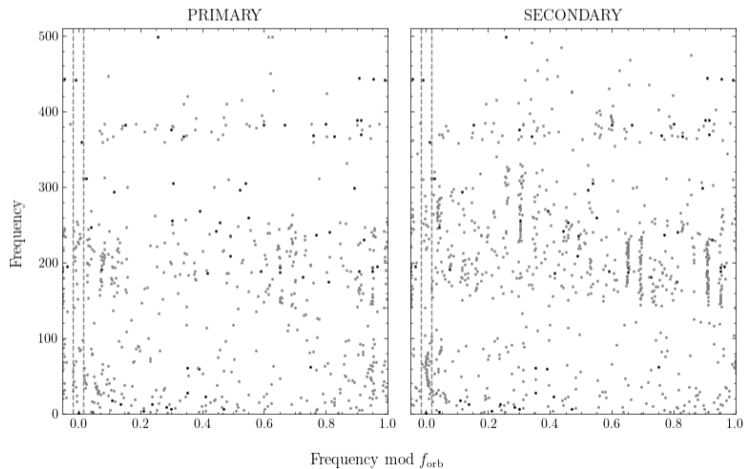
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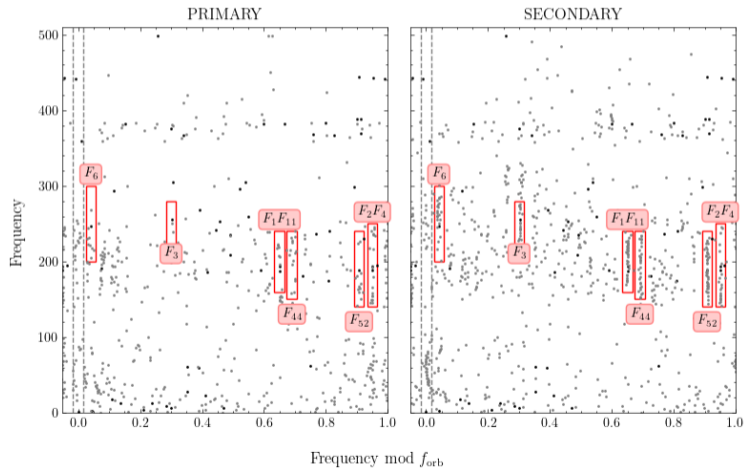
Selecting for mode identification II



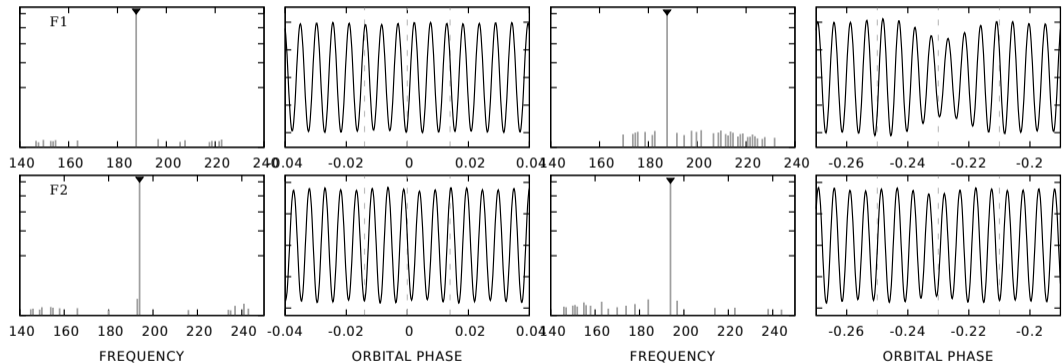
Selecting for mode identification II



Selecting for mode identification II

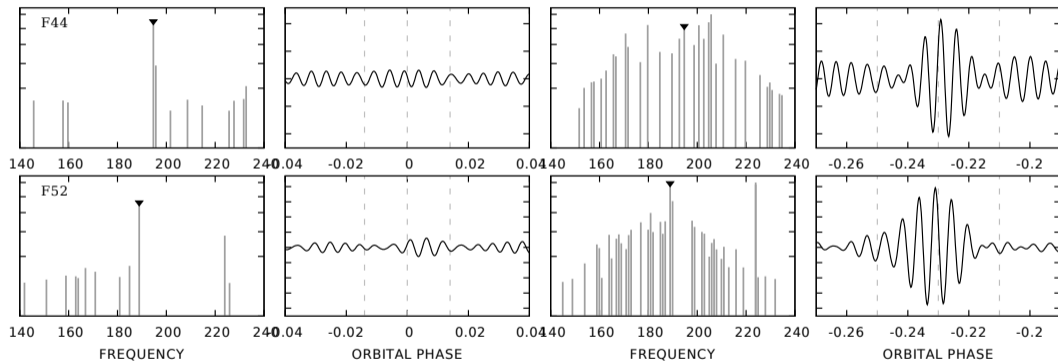


Selecting for mode identification III



New evidence for F2 being on the secondary component! (SQRT scale!)

Selecting for mode identification III



Quasi hidden modes? (**SQRT scale!**)

Actual mode identification I

- ▶ Special ℓ -multiplets fit and with Wigner coefficient:

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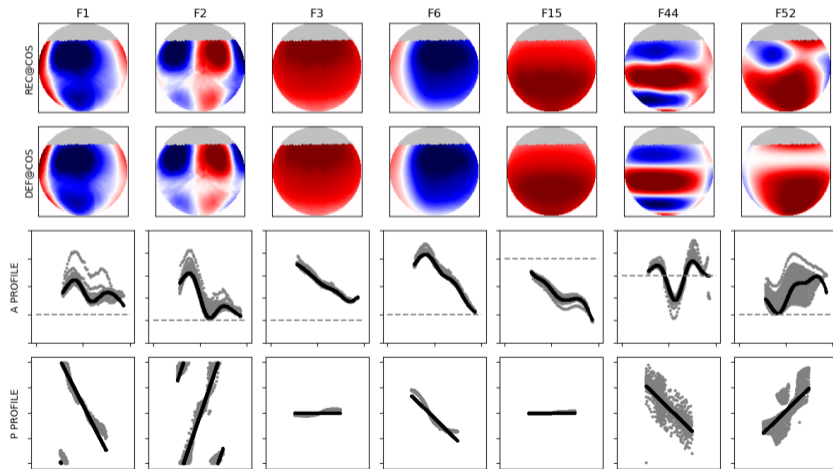
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	F1	F2	F3	F6	F15	F44	F52
DF	(0,0)	(0,0)	(0,0)	(0,0)	(1,-1)	(3,1)	(2,-1)
DFCLEAN	(0,0)	(0,0)	(0,0)	(1,1)	(1,-1)	(3,1)	(2,-1)
YLMCMC	(0,0)	(0,0)	(0,0)	(2,0)	(2,-2)	(3,-1)	(2,1)
percent	92.5	99.4	27.8	17.7	13.2	18.1	25.0
odds	12.4	168.5	1.2	1.7	1.1	1.01	1.05
odds of median	12.4	168.5	2.2	2.8	1.6	2.4	10.6

Actual mode identification II



Actual mode identification II

	F1	F2	F3	F6	F15	F44	F52
EM	(2,-2)	(3,3)	(0,0)	(1,-1)	(0,0)	(3,-1)	(2,1)
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- ▶ Most dominant two frequencies:

Actual mode identification II

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YLMCMC	(0,0)	(0,0)	(0,0)	(2,0)	(2,-2)	(3,-1)	(2,1)

- ▶ Most dominant two frequencies:
 - ▶ radial by DF **or** non-radial by EM?
 - ▶ distorted pattern due to large amplitude?

Actual mode identification II

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- ▶ Most dominant two frequencies:
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- ▶ F3 and F15 – radial

Actual mode identification II

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- ▶ Most dominant two frequencies:
 - ▶ radial by DF **or** non-radial by EM?
 - ▶ distorted pattern due to large amplitude?
- ▶ F3 and F15 – radial
- ▶ predicted hidden modes for F44 and F52 **confirmed**

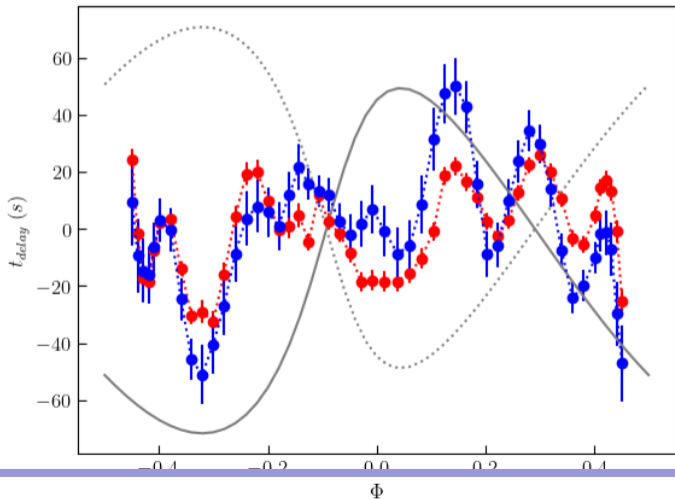
Conclusion and ending remarks

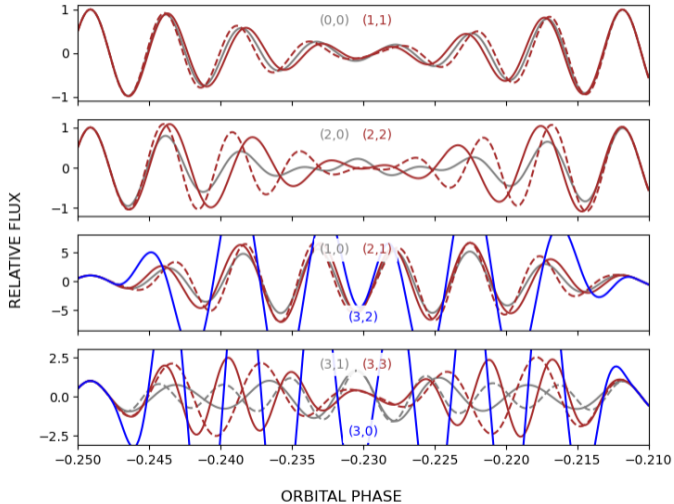
- ▶ Refined model for KIC 3858884 system
- ▶ Specified origin star for dominant frequencies
- ▶ Designed and utilized a special method for finding the modulations
- ▶ Successful mode identification – two hidden modes found.

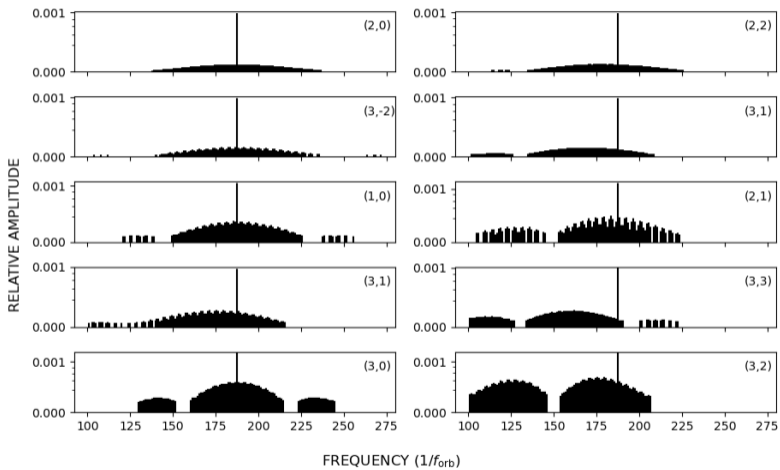
Submitted to A&A – arXiv: 2408.14464

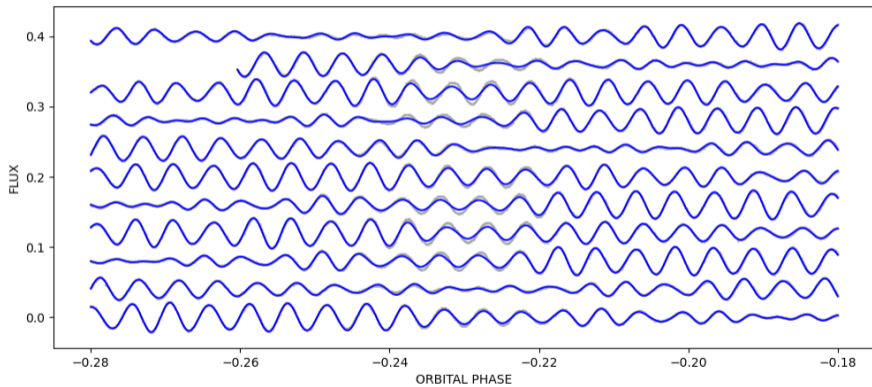
Thank you for your attention!

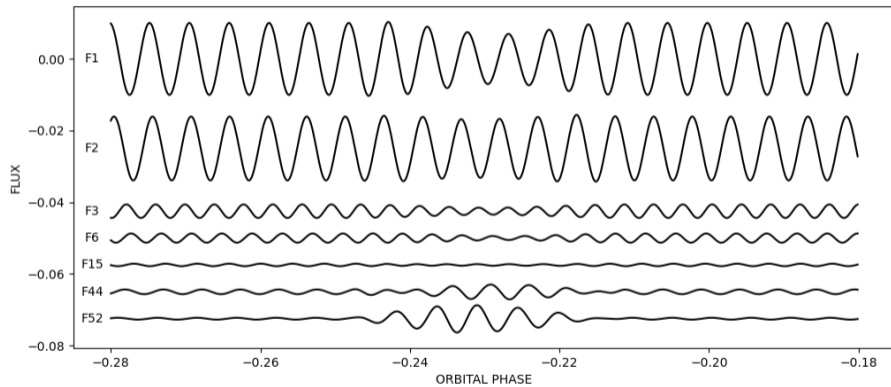
Additional - slides



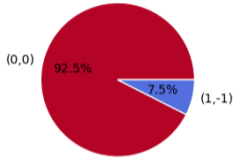




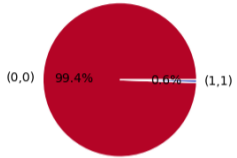




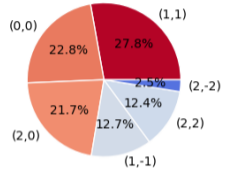
F1



F2



F3



F6

