

# The additional-mode garden of RRab stars



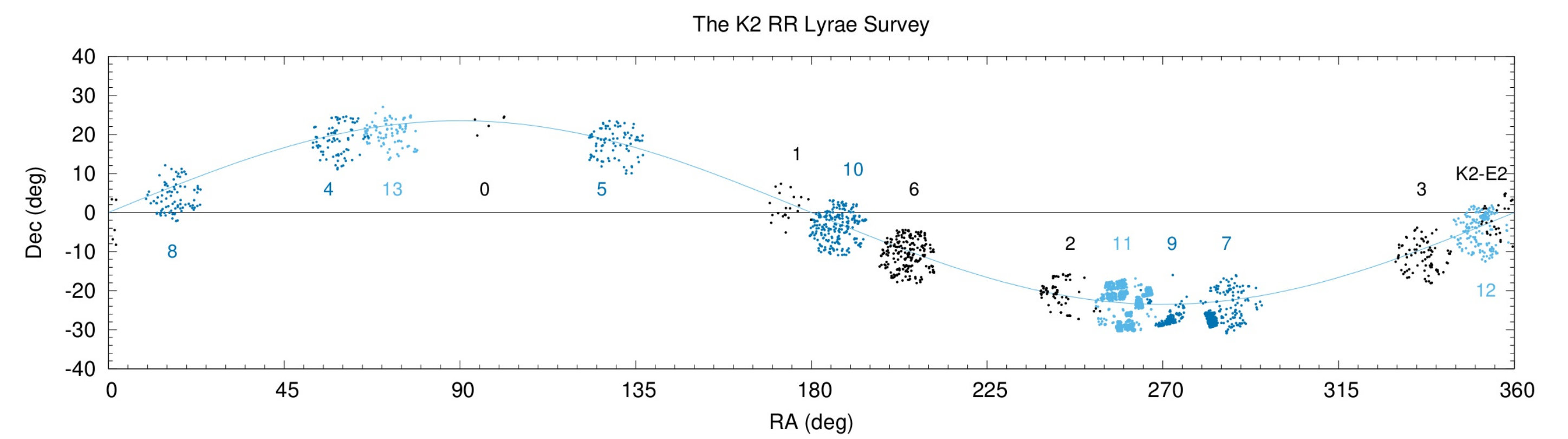
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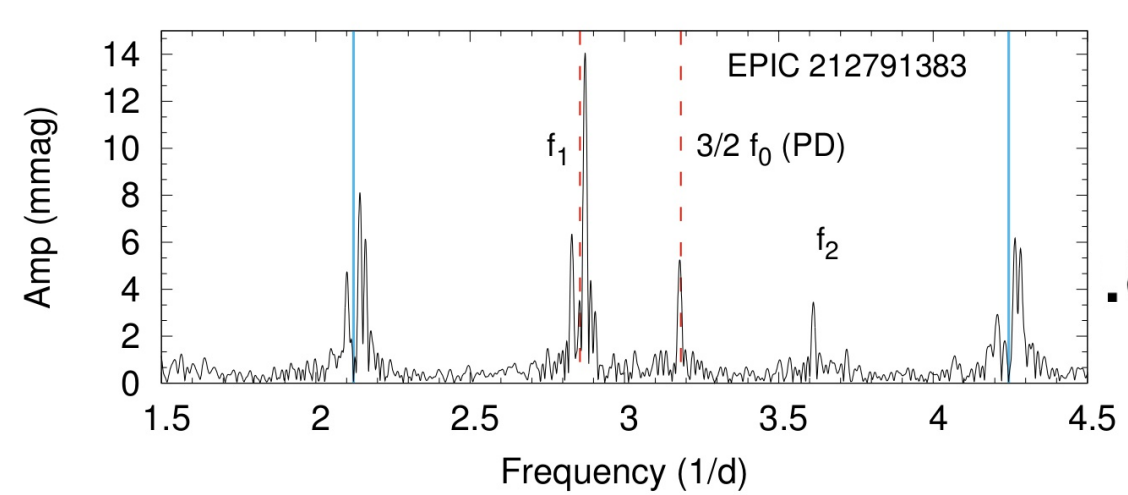
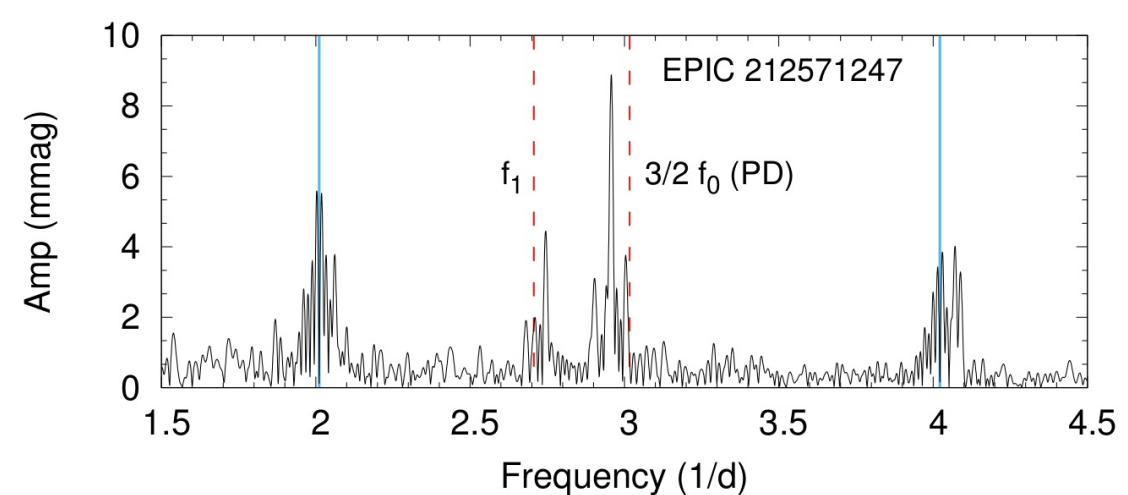
## Results from the K2 RR Lyrae survey

The RR Lyrae survey of the K2 mission is going to be a quantum leap in the photometry of pulsating variables, only matched by the OGLE survey. We proposed more than 4000 stars for observation between C0 and C13. (Black: analysed, dark blue: observed, light blue: proposed.) See poster PB.510.45 by Róbert Szabó.



This is a Petersen (period vs. period ratio) diagram for fundamental-mode RR Lyrae stars.

Main additional-mode peaks mostly appear between  $f_0$  and  $2f_0$ , with smaller harmonics elsewhere: these are presented in the poster:



Strongest peaks may be offset from ratios we would expect.

Classical RRd stars are confined to this thin band. Crosses are weird ones (e.g. Blazhko, mode switchers). Note overlap with some RRab additional modes: likely those are the radial first overtone in at least some of them too.

The  $P:P_0 = 2:3$  ratio - this is where the half-integer peaks of period doubling (PD) are expected. These are the signs of dynamical instability caused by a 9:2 resonance with the 9th overtone.

Is the  $f_2$  group here the second radial overtone? Period ratios agree, but not seen in non-linear 1D hydro models yet.

K2 RRab stars with low-amplitude additional modes seems to be mostly limited to between  $P = 0.44-0.66$  days. Why?

The altitude correction frequency of K2. No blue points along these lines.

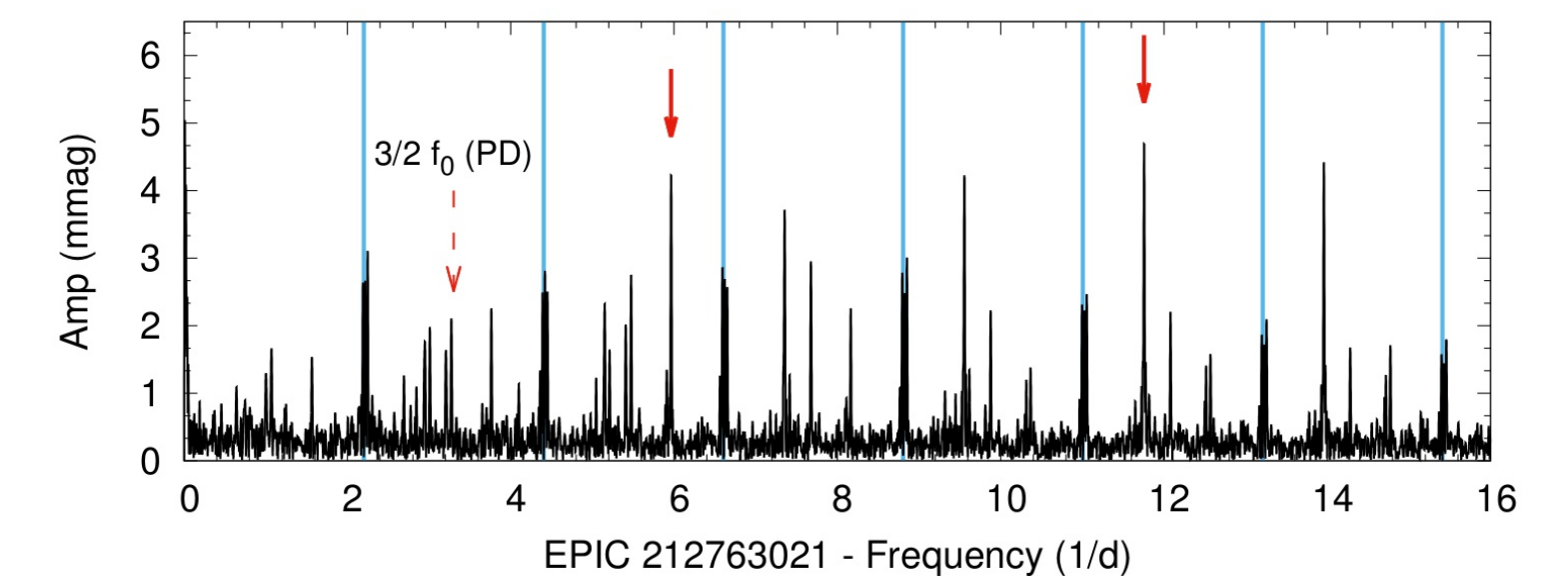
Half of the altitude correction freq. Possible caveat for blue points.

Orange diamonds are all from the star RR Lyr!

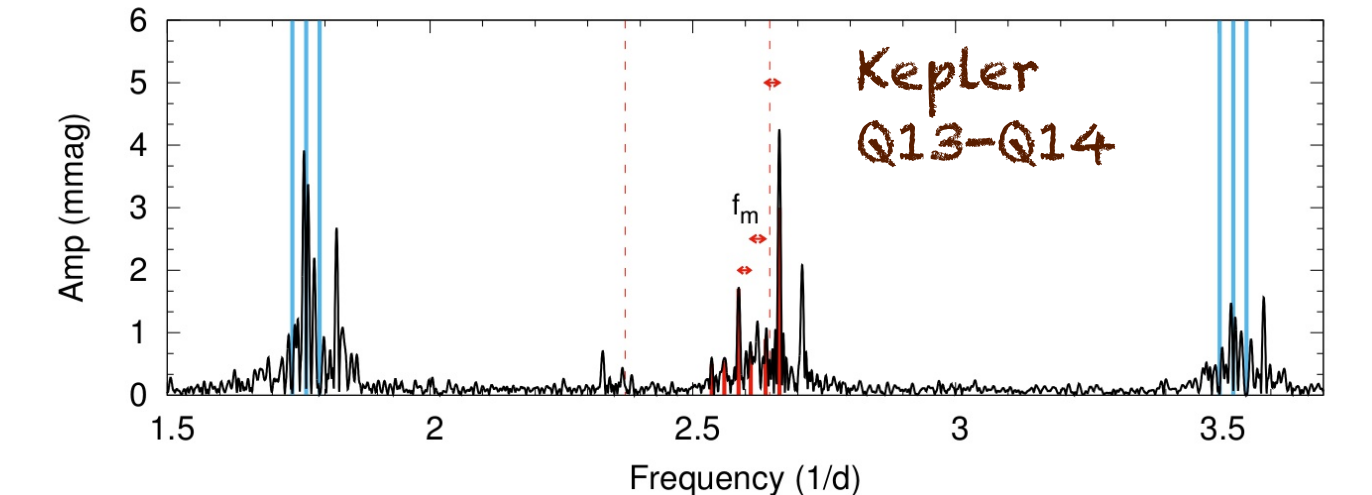
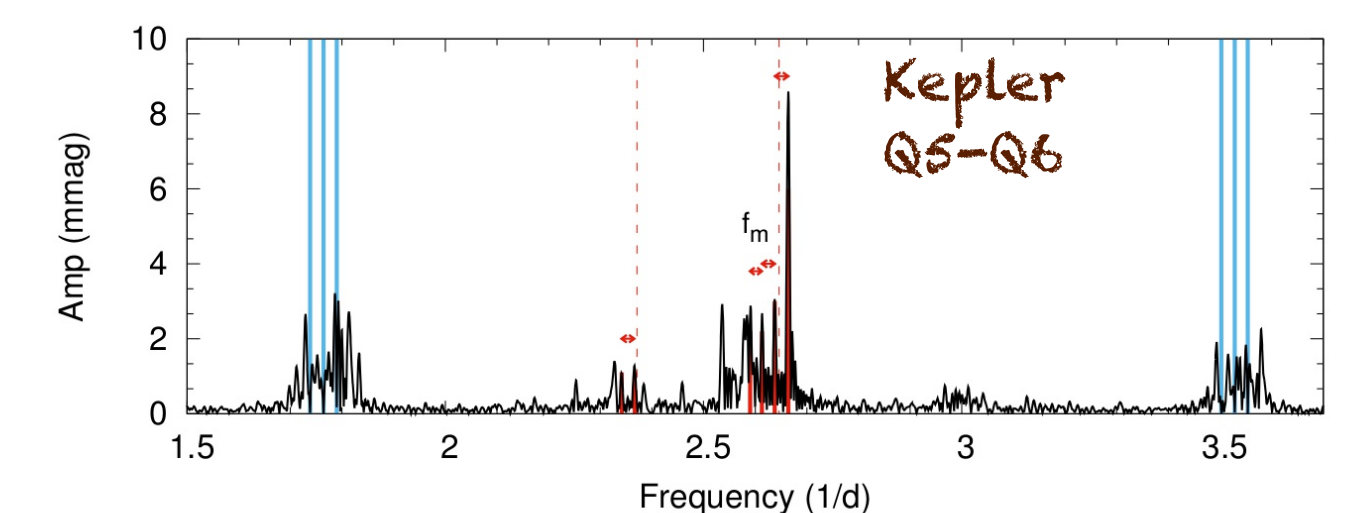
Anomalous RRds really spread out, and overlap with some RRabs.

What The Frequency???

V1127 Aql, the only short-period one.



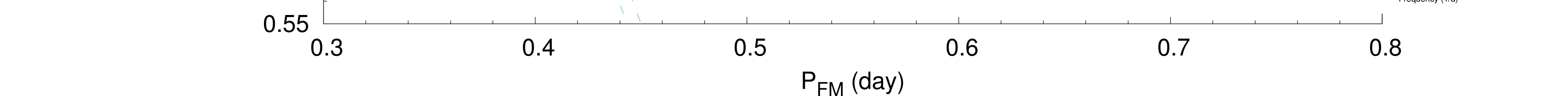
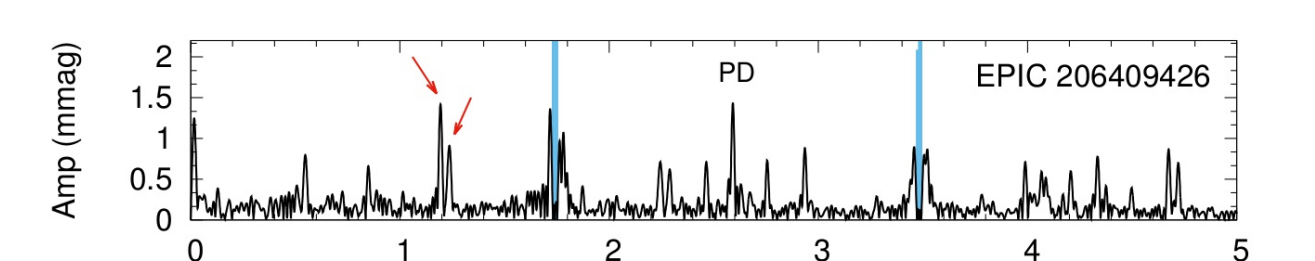
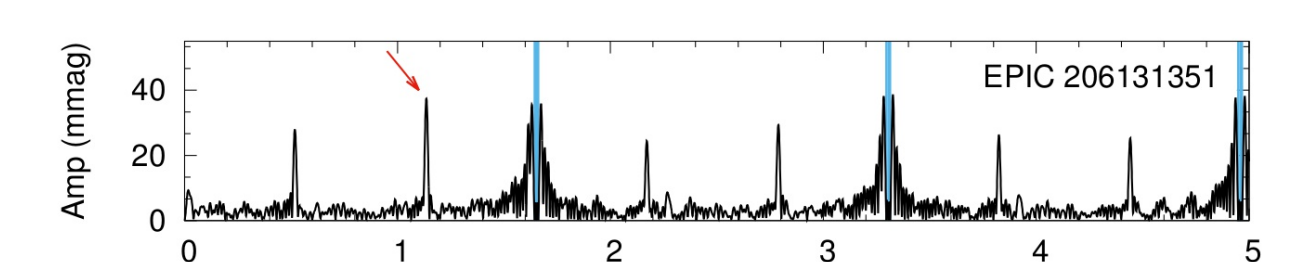
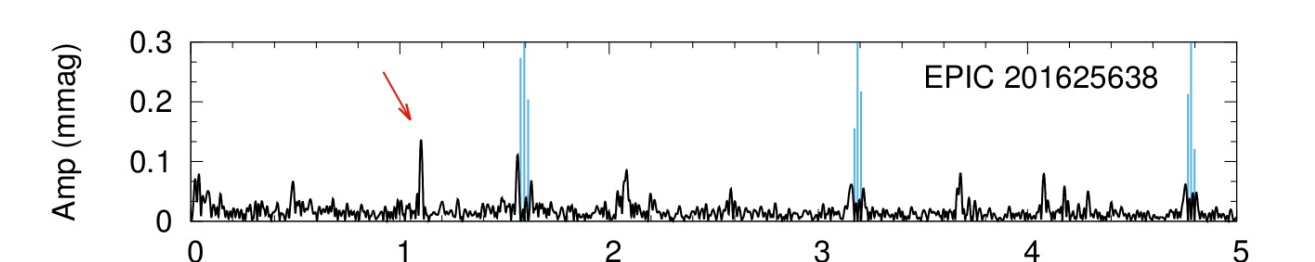
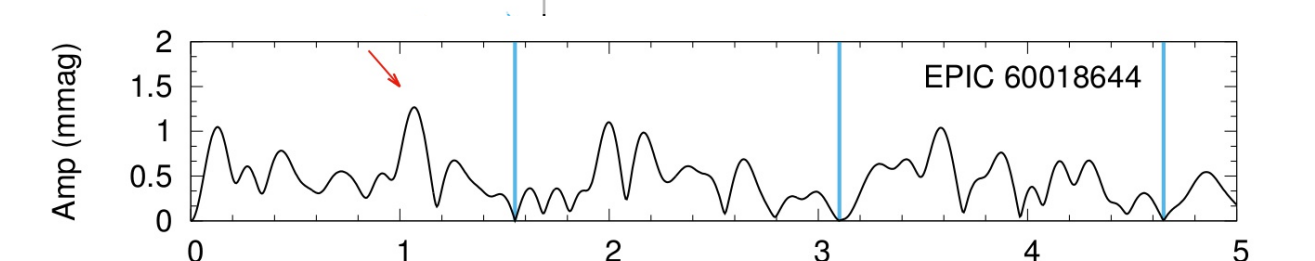
But there might be high-frequency additional modes in some stars too?



RR Lyr is super-weird: solid reds are forests of peaks separated by the Blazhko frequency. Dashed reds are expected values.

Could these be g-modes up here? Strongest signals have longer periods than the fundamental mode, but...

...the  $f+f_0$  peak is in the second-overtone region. Non-radial  $f_2$  modes with weird geometry perhaps?



RRabs: blue - K2; red dots - Kepler; red circles - CoRoT; triangles - ground-based RRds: grey - OGLE-IV; black: field; crosses: anomalous

## References & Acknowledgements

Benkő et al., 2014, ApJS, 213, 31  
Molnár et al., 2012, ApJL, 757, L13  
Molnár et al., 2015, MNRAS, 452, 4283  
Smolec et al., 2016, MNRAS, accepted, arXiv:1606.06928\*  
Sódor et al., 2012, MNRAS, 427, 1517  
Soszynski et al., 2014, AcA, 64, 177  
Soszynski et al., 2016, AcA, subm, arXiv:1606.02727  
Szabó et al., 2015, A&A, 570, 100  
Zalain et al., 2006, MNRAS, 456, 192

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