First TESS results on Cepheid and RR Lyrae stars: towards asteroseismic inferences

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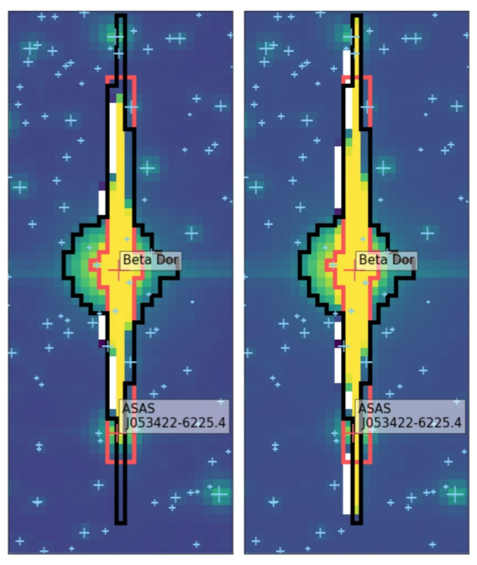
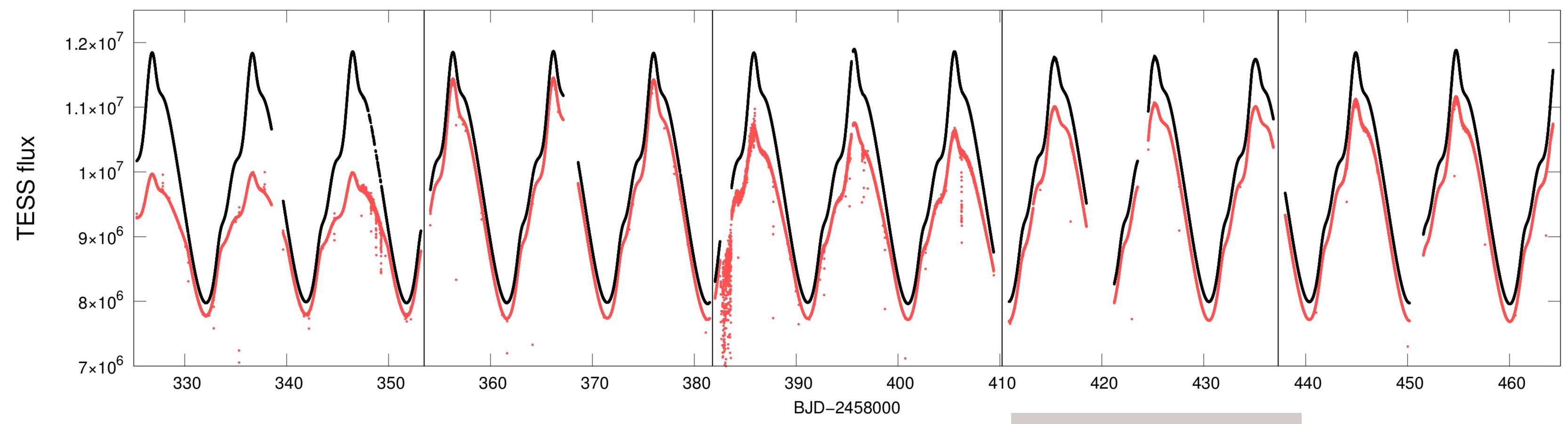
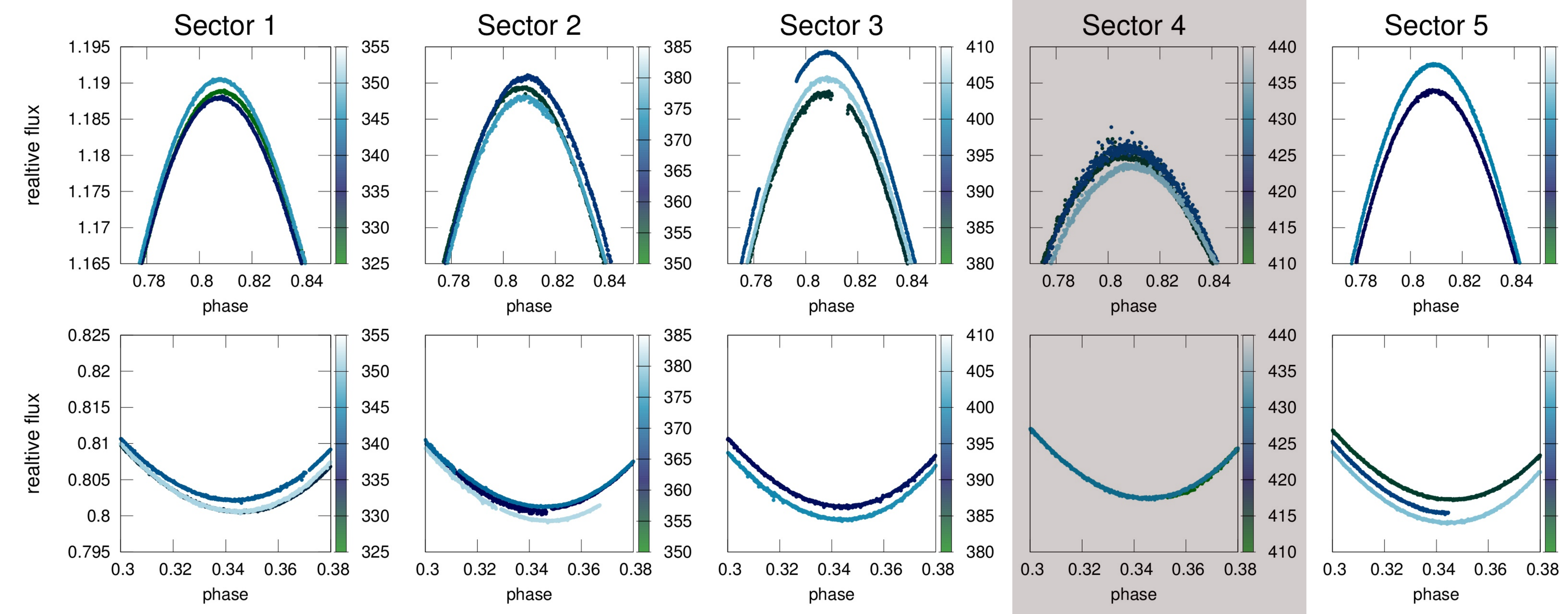
Beta Doradus - a 3-mag Cepheid in the CVZ

This is one of the brightest classical Cepheids in the sky. Large pulsation amplitude modulates the length of the saturation column, so we had to do custom photometry with `lightkurve` (red: SAP aperture, black: ours).

Contamination, like the star in the bleed column in S1, is minor, and as the saturation column rotates on the sky with the sectors, affecting sources can be measured in other sectors.





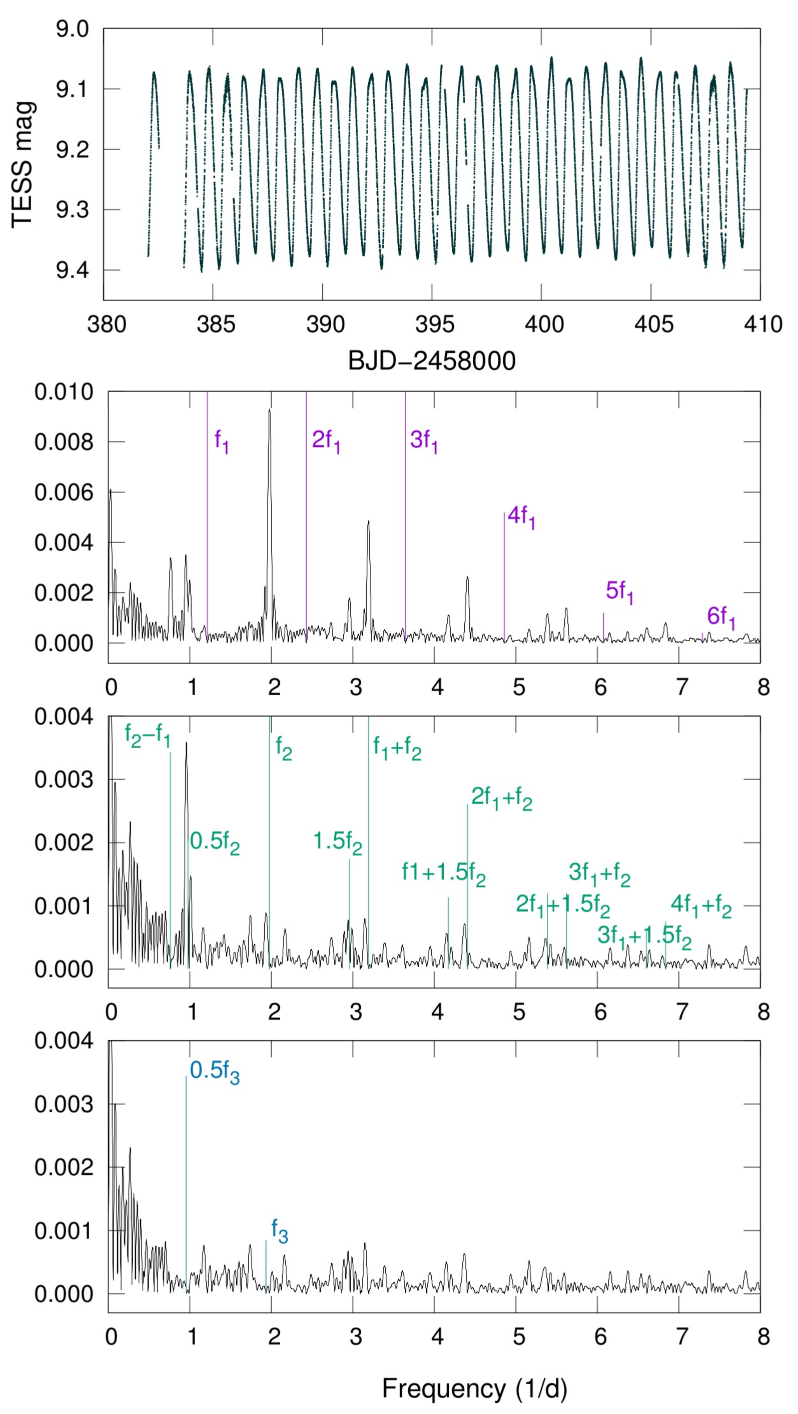


Red: SAP photometry, black: our custom photometry. Zooms show differences between minima and maxima in each sector. In S4 the bleed column extended beyond the SC mask, causing slight flux loss.

We see no additional modes beyond the fundamental so far, but a 5-10 mmag variation in the extrema is apparent. Convective cells, or else?

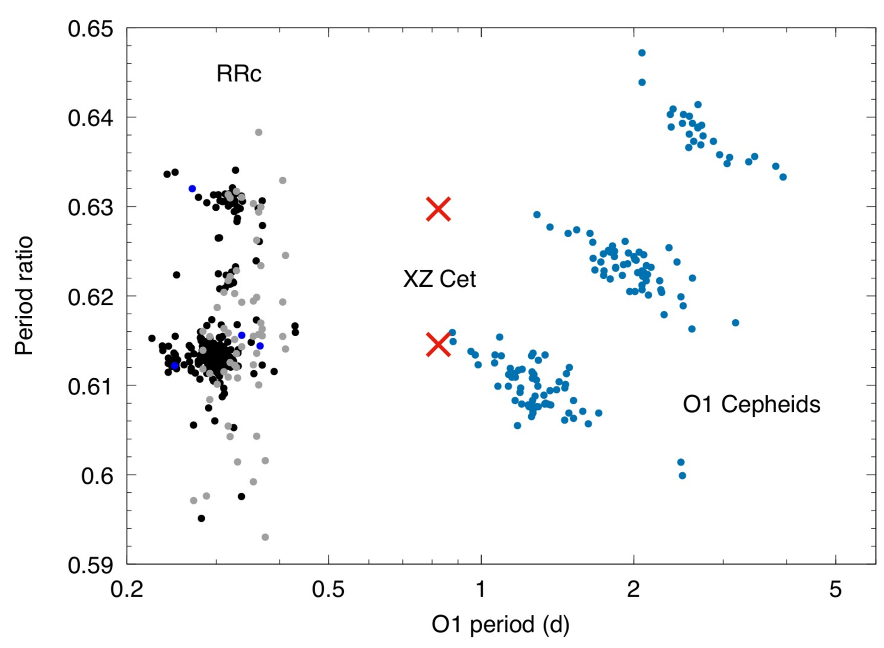
XZ Cet - a prototype anomalous Cepheid that intrigues

Anomalous Cepheids (ACs) lie between RR Lyraes and Cepheids in the period-luminosity relation. XZ Cet was the second to be discovered in the Milky Way. They are the massive siblings of RR Lyraes but it is still debated if they evolve as very metal-poor single stars or through binary interactions. TESS provided us the first really detailed look:



XZ Cet is not really a single-mode first overtone AC star. It has a strong secondary mode exactly where it appears in overtone RR Lyrae and classical Cepheid stars, at the 0.60-0.65 period ratio range.

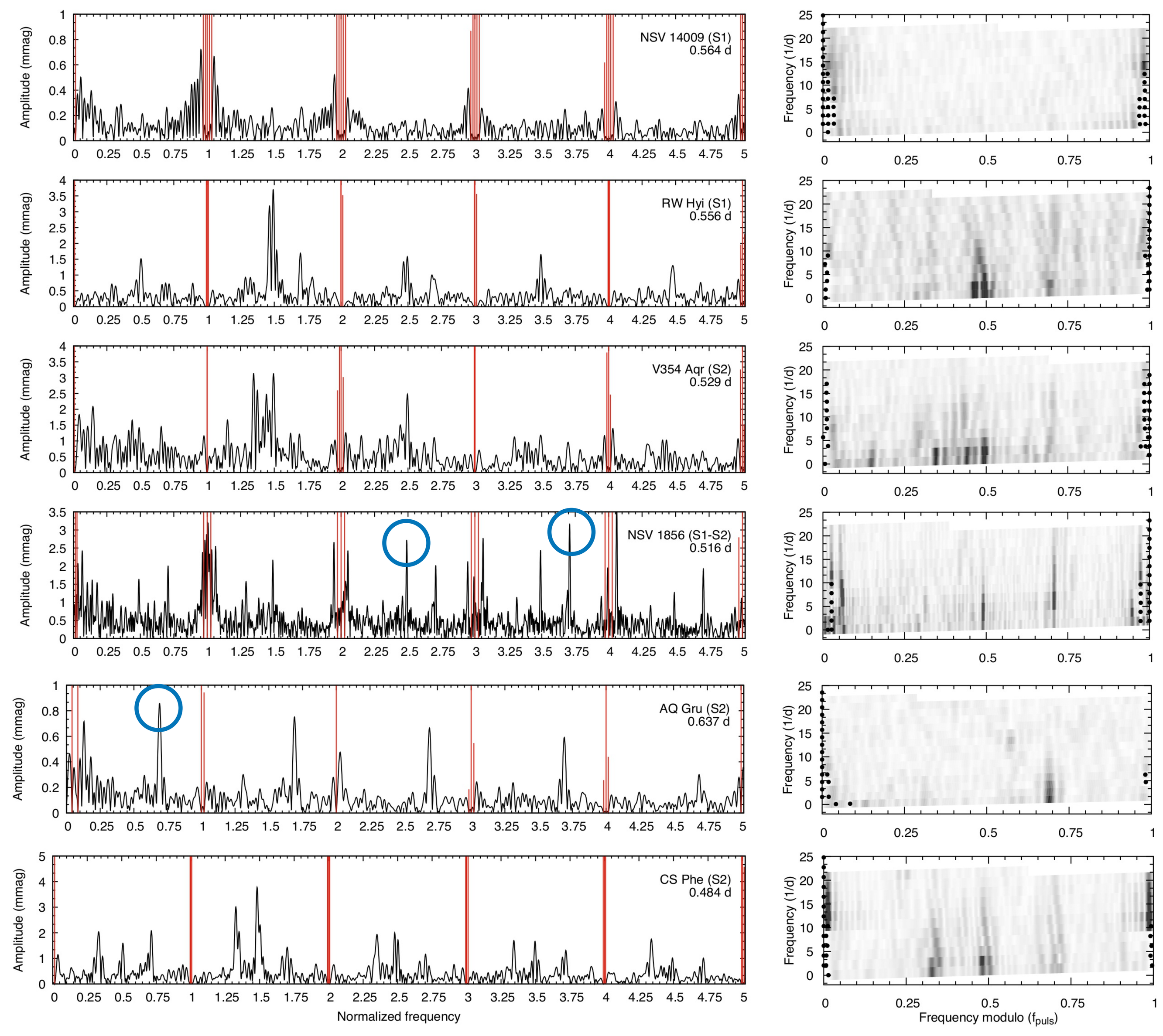
These secondary modes seem ubiquitous, yet not actually omnipresent across three classes of first-overtone pulsating stars. And we do not know yet how and why they are excited.



Echelle diagrams for RR Lyraes

Classical echelle plots are based on the (near-)repetition of patterns with the large separation. We can construct something similar for RR Lyraes. Modes are coupled to the main radial mode, creating repeating combination frequencies ($f + n\,f_{rad}$). We first remove the main mode and the modulation side peaks if necessary.

Patterns and distributions show surprising diversity: similar ridges but different peak amplitude frequencies complicate mode identification.

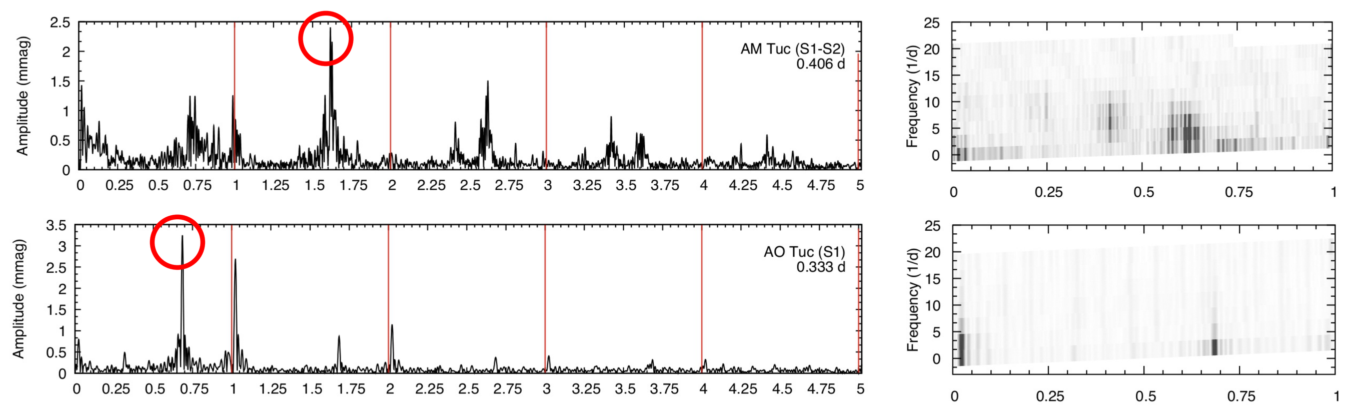


These are RRab stars. Some are empty.

Some have weird patterns, with different coupling strengths (~ridge length) to the fundamental mode.

Others have thin and simple ridges but the strongest peak is at higher or lower frequencies, outside the f_0-$2f_0$ range.

Why does CS Phe have skewed ridges?



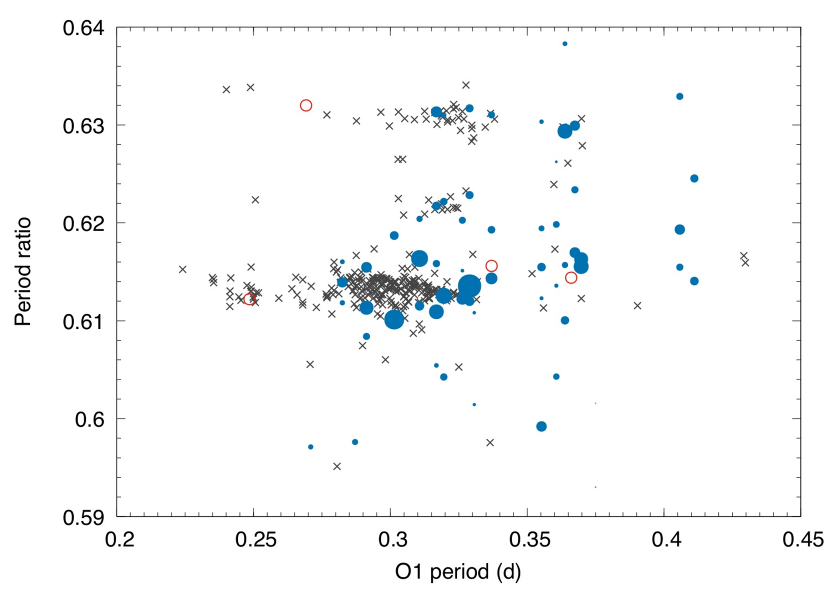
Most overtone (RRc) stars have similar additional modes in them at ~0.6-0.65, but there are exceptions where a different mode shows up.

Asteroseismic differences between field and Bulge stars

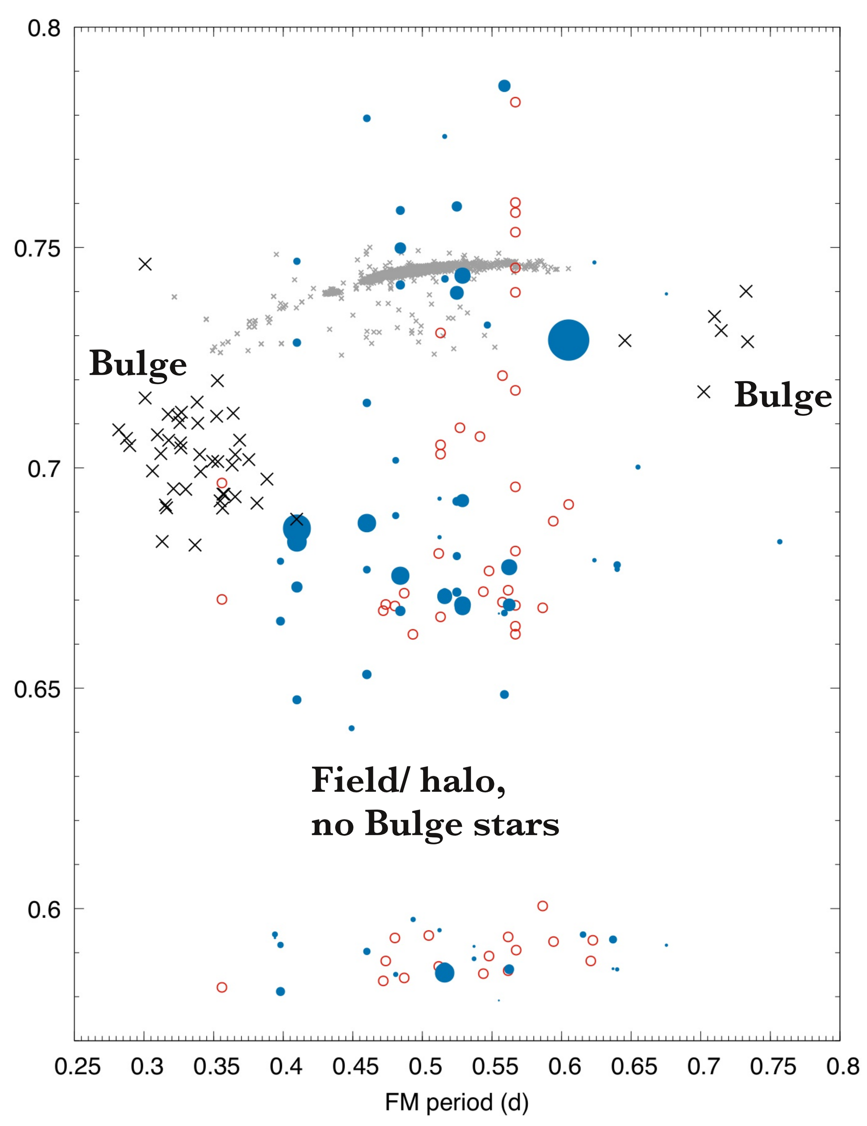
Additional modes in RR Lyrae stars have been detected almost exlusively via space-based photometry or by the OGLE survey. We compared the TESS and OGLE Bulge collections, and found some striking differences between the distributions.

Physical differences between RR Lyrae populations apparently manifest as differences in asteroseismic signatures as well, affecting the excitation and/or frequencies of additional modes.

Note especially the lack of medium-period RRab stars with extra modes in the Bulge.



RRc stars. Crosses: OGLE Bulge, red circles: Kepler, blue dots: TESS. For TESS, size marks Fourier amplitude.



RRab stars. Crosses: OGLE Bulge, red circles: Kepler/CoRoT, blue dots: TESS, small grey crosses: RRd stars.

References

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