Precise seismology with TESS CVZ data

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Introduction

The release of TESS light-curves gives us the opportunity to perform all-sky seismology for many stars. The long dwell time for targets in the Southern Continuous Viewing Zone (SCVZ) has yielded high-quality light curves that are our best opportunity to conduct precise seismology. In this work we present the first attempt to precisely measure the evolutionary status of a large number of red giants stars with TESS data, which demonstrates the potential of TESS for precision asteroseismology.

Results analysis

The machine-learning methods returned the largest number of detections, while the direct methods were most efficient in the red clump. However, there were a significant number of false positives for one of the machine-learning methods (JK, see Figure 1), reinforcing the advantage of using multiple methods.

Merging the results gives coherent results with the clump and RGB structure and the star's log(g) and T_{eff} APOGEE values. This demonstrates the potential of TESS for precise asteroseismology (Figure 2).

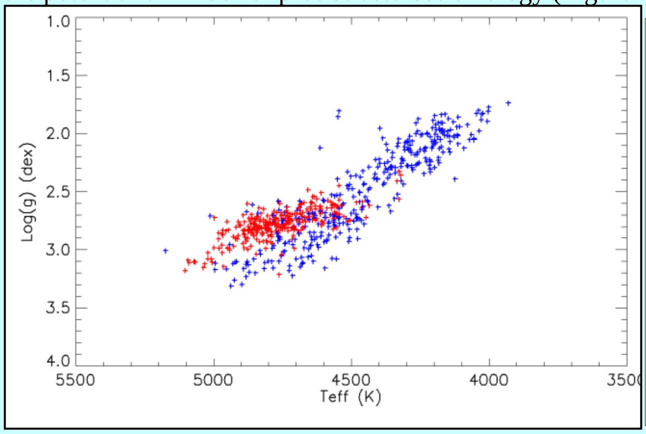

Figure 2: HR diagram for the stars for which the evolutionary status is sucessfully determined. **RGB** stars are in blue and **clump** stars in red. Only 533 stars, for which the APOGEE log(g) and T_{eff} values are available, are plotted.

The fraction of targets that can be classified increases with the time-series length and decreases with the magnitude (Figure 3). However, the machine learning methods from MH and JK are still effective for short time series with low signal-to-noise, which explains our ability to detect states even for short time series.

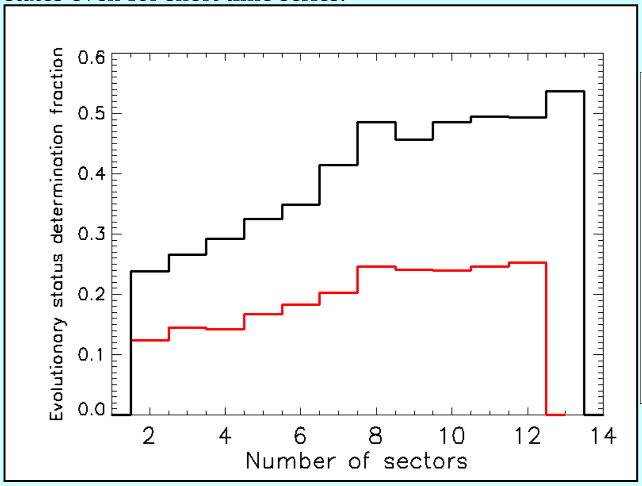

Figure 3: Ratio of stars with a determined evolutionary status (red) and the gold sample (black) compared to the original full SCVZ sample as a function of the number of observation sectors.

Methods

Data: We use light curves for the 5578 SCVZ stars in the gold sample of Mackereth et al. (2021). These targets had consensus global asteroseismic measurements from three distinct methods.

Several asteroseismic methods have been developed to separate He-burning stars (the red clump, or RC) from H-shell burning stars (the red giant branch, or RGB. In this work, we used 4 of these methods. Two are machine-learning techniques: **MH** based on spectra recognition (Hon et al. 2017, Hon et al. 2018) and **JK** based on the light-curve characteristics identification (Kuszlewicz et al. 2020). Two are using the mixed modes in the star spectra: **YL** and **MV** (Vrard et al. 2016).

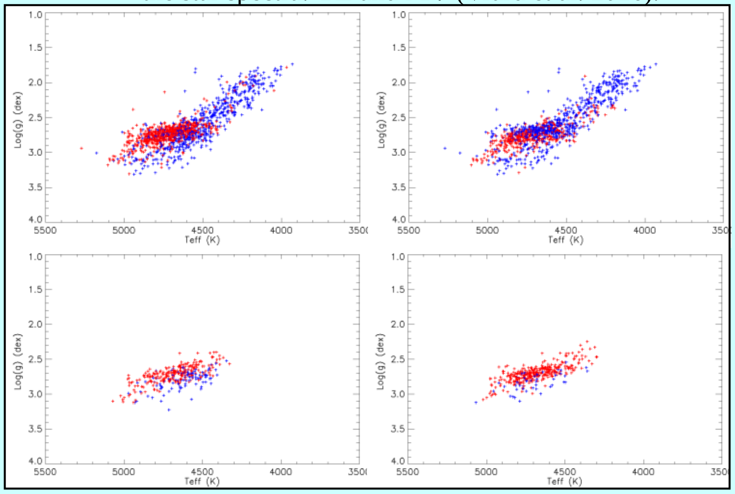

Figure 1: HR diagram with the evolutionary status determination from the different techniques. **RGB** stars are in blue and **clump** stars in red. T_{eff} and log(g) comes from APOGEE DR16. Top-left correspond to MH method top-right to JK, bottom-right to MV and bottom-left to YL

Agreement	MV	MH	YL	JK
MV	/	23.8%	13.2%	57.7%
MH	23.8%	/	28.3%	21.7%
YL	13.2%	28.3%	/	43.2%
JK	57.7%	21.7%	43.2%	/

Table 1: Agreement between the evolutionary status we obtained from the different methods.

We consider an evolutionary state to be confirmed when at least 2 methods agree and none disagree. Our total sample is 2275 stars.

Summary and Conclusion

We measured the evolutionary status of 2275 red giants present in the TESS SCVZ data by merging different methods. Overall, there was a good level of agreement. However, there was a significant subset of targets with discordant estimates, which illustrates the value of using multiple techniques. If the results are less numerous for short light-curves and low magnitude objects, they are still obtained for an important number of objects due to the machine-learning methods that are effective at low signal-to-noise. This work demonstrates that TESS data can be used for precision asteroseismology studies and pave the way for further use of TESS light-curves for that purpose.

References

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