Amplitude Modulation of δ Scuti star HD118660

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Abstract

HD 118660 is a δ *Scuti* pulsator that shows multi-periodic behaviour. The asteroseismic study of HD 118660 using TESS data reveals the star is pulsating in (4) radial and (3) non-radial orders with a large frequency separation ($\delta\nu$) 6.465 c/d. Amplitude modulation at frequency 24.38 c/d is observed due to close frequency beating, further no modulation in frequency is seen. HD 118660 is seen to be in the ZAMS phase of evolution.

Introduction

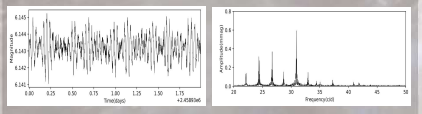
Transiting Exoplanet Survey Satellite (TESS) is launched in 2018 for it's primary goal to search exoplanets. As secondary, TESS data can be used to study the internal variability of star. In 2 years of TESS mission it covers the entire sky into 26 sectors and observes in (2-mins) short cadence and (30-mins) long cadence mode. It observes each sector in 27 days.

HD 118660 is first observed in *Joshi et. al. (2006)* using 1.04m Sampurnanand Telescope, ARIES, classified as a δ *scuti* pulsator and predicted to have a multi-periodic behaviour.

δ *scuti* stars are intermediate mass A- and F- type stars. It is located at the intersection of classical instability strip and H-R diagram. The pulsation is responsible by opacity driven κ mechanism.

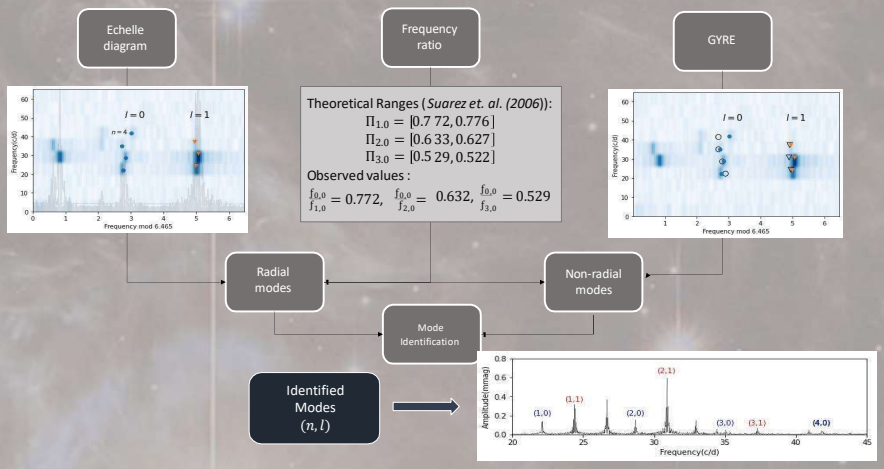
Observation and Data Reduction

TESS observed HD 118660 in sectors 23 and 50. We downloaded 2-min cadence PDCSAP flux from MAST archive using python module *lightkurve*. The outliers are removed using 3σ clipping criteria. We used PERIOD04 to calculate DFT and separated the frequencies having SNR > 5 using pre-whitening, for the purpose of mode identification.



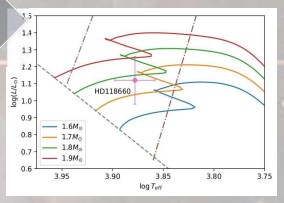
Mode Identification

We identified the pulsation (radial and non-radial) modes using echelle diagram, frequency ratio and modelling with GYRE.



Evolution Stage

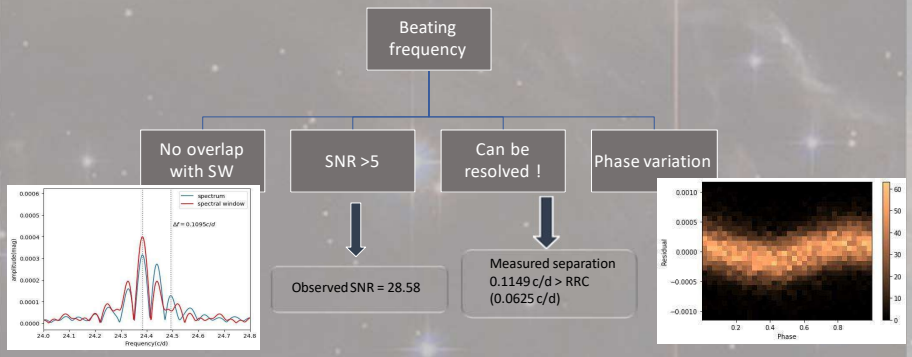
Theoretical isochrones are calculated using *Modules for Experiments in Stellar Astrophysics (MESA)*. The input parameters used are mixing length ($\alpha_M = 1.5$), metallicity ($z = 0.0134$) (Joshi et. al. (2017)) and mass varies from 1.6 to 1.9 $M_\odot$ in step of 0.1. The star position is overplotted in the H-R diagram, and the star is found to be in the ZAMS phase of evolution.



Amplitude Modulation

We observed periodic change of amplitude at frequency 24.38 c/d from sector 23 and 50 data, with a corresponding phase variation. The reason behind the modulation is close frequency beating (*Bowman & Kurtz (2014)*). The observed modulation frequency is 0.1149 ± 0.005 $\frac{c}{d}$

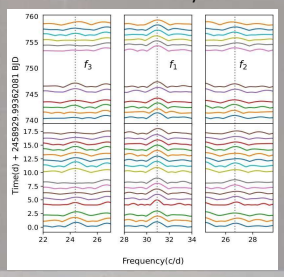
We found the close frequency by comparing the spectrum with the Spectral Window (SW), evaluating its SNR and satisfying the Rayleigh Resolution Criteria (RRC).



Measured Separation = 0.1095 ± 0.0010 c/d

Pulsational Models

TESS observed each sector in approx. 24 days, we divided the entire data into 1 day apart and vertically stacked them to see if there is any shift with time.



Results

- HD 118660 is pulsating with (4) radial modes($l = 0$) and (3) non-radial modes($l = 1$).
- Amplitude modulation is observed at frequency 24.38 c/d due to close frequency beating.
- The mass and metallicity values evaluated from the best GYRE matching models are 1.8 $M_\odot$ and 0.0124 respectively.
- From MESA the evaluated parameters are $M = 1.8 \pm 0.1\ M_\odot$, $\log\left(\frac{R}{R_\odot}\right) = 0.34 \pm 0.05$.
- No frequency modulation takes place implies no significant change in cavity.

References

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