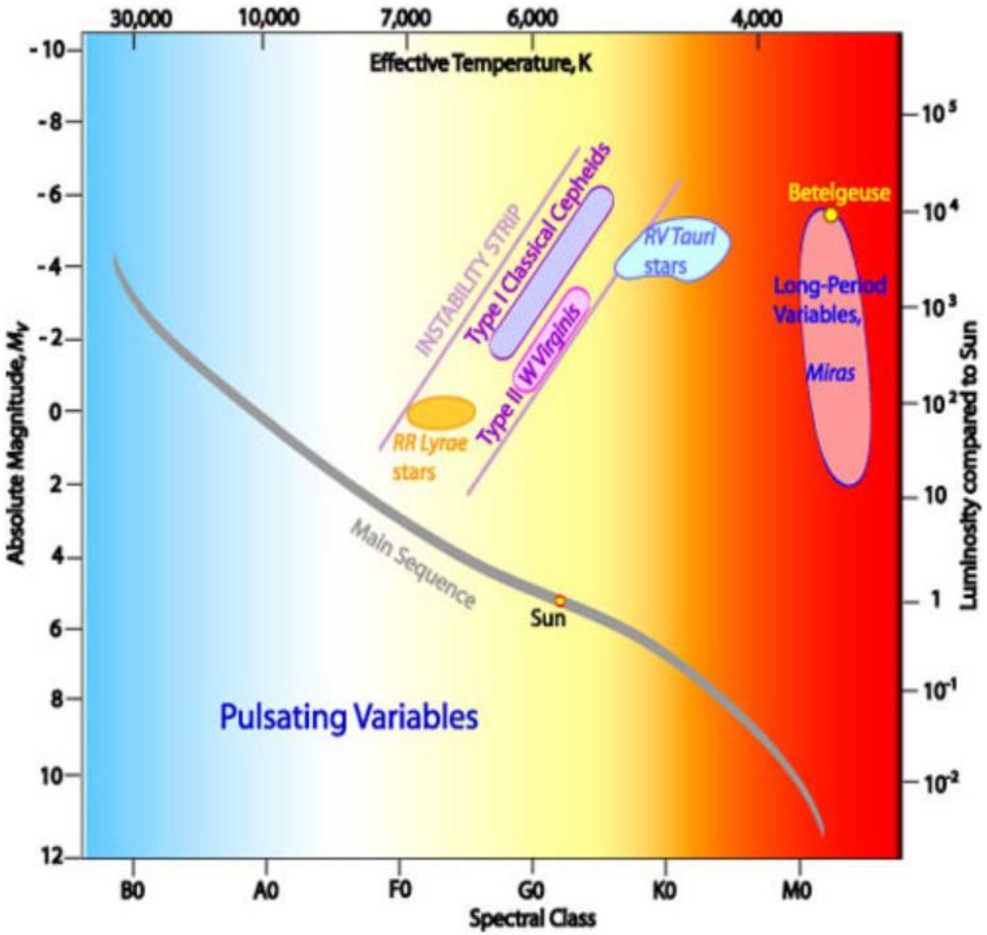
Pulsating Am stars

- **Introduction to Am Stars**
- Am stars are chemically peculiar A-type stars.
- The "Am" stands for metallic-lined stars.
- Display peculiar abundance of metals like zinc, strontium, and barium.
- Slower rotation compared to normal A-type stars, leading to unusual chemical distribution.



The location of types of pulsating variables on the HR diagram.

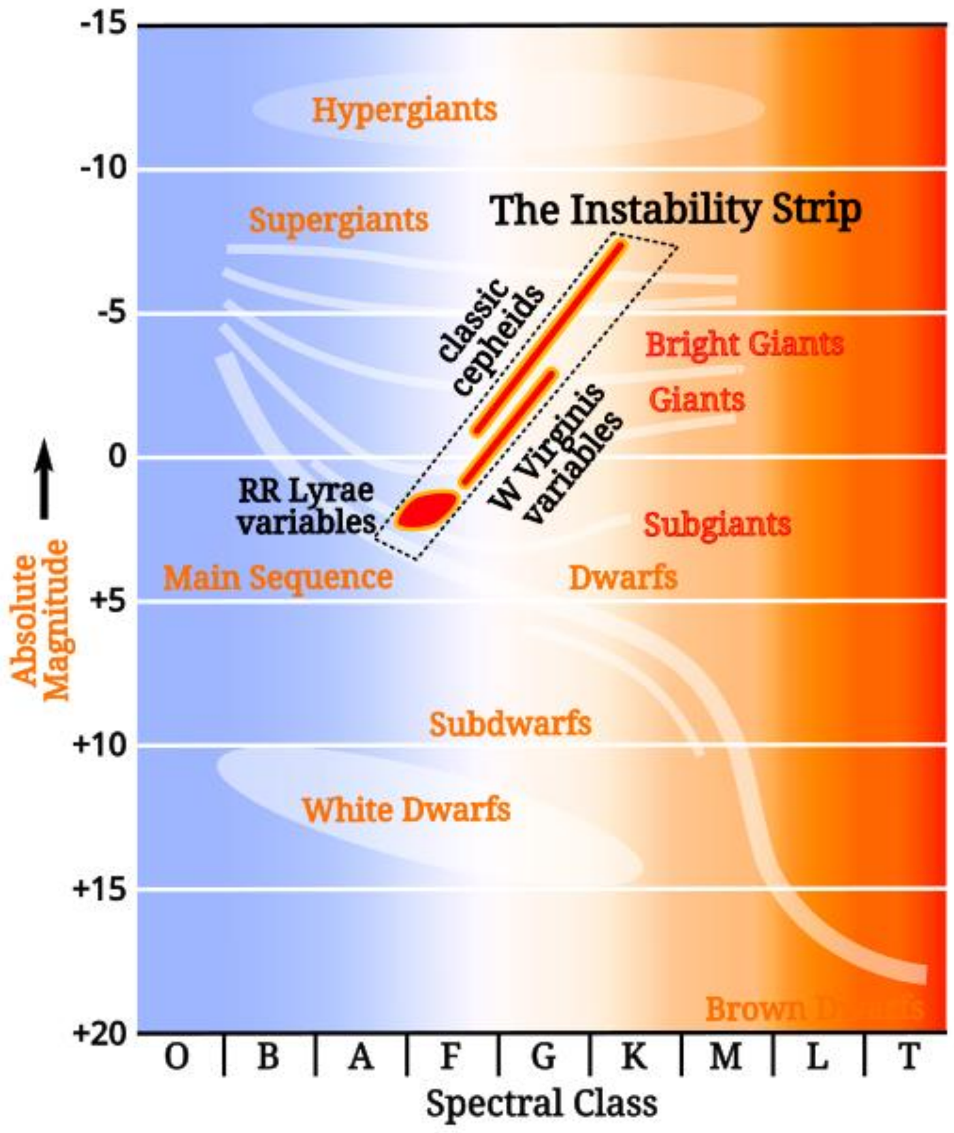
What Are Pulsating Stars?

Stars that undergo periodic expansion and contraction due to internal instability.

Pulsations lead to observable brightness variations.

Common pulsating variables include Cepheids, and RR Lyrae, RV Tauri, Long-Period Variables (LPVs) stars.

The Instability Strip and its important



Pulsating Stars in the Instability Strip

- Stars in this region are subject to pulsations caused by the partial ionization of helium in their outer layers. This ionization creates pressure that causes the star to expand and contract in cycles, leading to brightness variations.

- Delta Scuti variables are one of the main types of stars found in this part of the instability strip. These are A- and F-type stars that are slightly evolved or near the end of their main-sequence life. Their internal structure makes them unstable to pulsations, causing them to vary in brightness on short timescales (hours to minutes).

Am Stars and Their Slow Rotation

- Am stars rotate slower than typical A-type stars.
- Slow rotation allows for atomic diffusion, leading to chemical peculiarities.
- Tidal forces in close binary systems can cause this slow rotation, influencing pulsation behavior.

Pulsating Am Stars

- Pulsating Am stars challenge the traditional view that Am stars don't pulsate due to slow rotation.
- Not all Am stars pulsate, but some are found to pulsate, often exhibiting Delta Scuti-like behavior.

Delta Scuti Stars and Am Stars

- Delta Scuti stars are pulsating variables found near the instability strip.
- Some Am stars show similar pulsations, behaving like Delta Scuti variables
- Pulsations typically have periods of a few hours and small brightness variations.

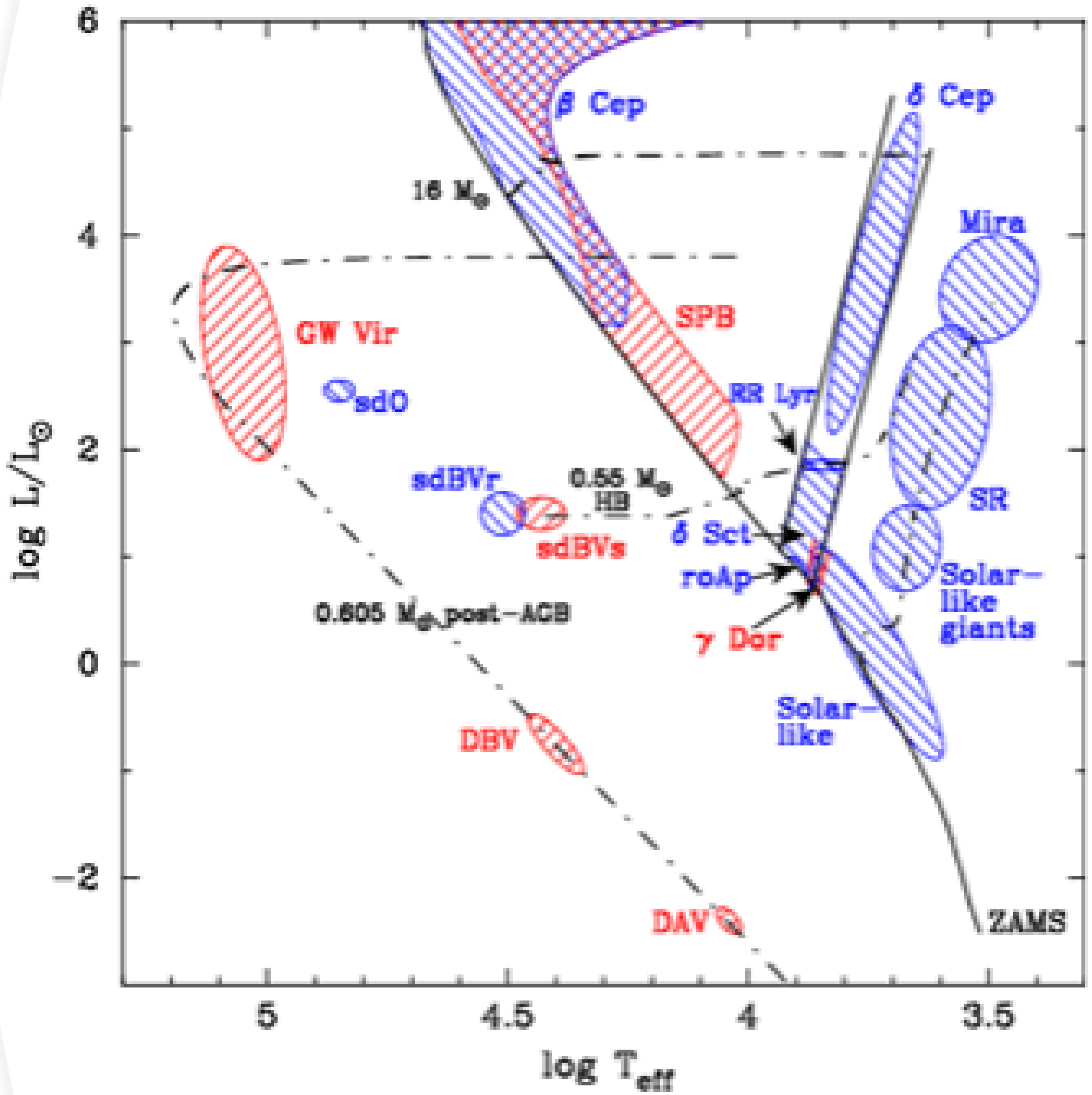


FIGURE 1. The Hertzsprung-Russell Diagram of pulsating

Am stars in Kepler field

- SuperWASP survey overlaps with a large fraction of the Kepler field.
- amplitudes >~1 mmag

Table 2. Am stars with both SuperWASP and *Kepler* data.

KIC	Ren ID	Max Amp (mmag)	Ref
9204718	49340	0.13	Bal
11445913	49650	2.5	Cat, Bal
9272082	49840	<0.01	Bal
12253106	50070	<0.01	
9764965	50230	1.0	
8881697	50420	1.9	
11402951	50670	1.2	Cat,Bal
9349245	51233	<0.1	
8703413	51640	<0.1	Bal
8323104	52260	<0.1	Bal

- the amplitudes found using SuperWASP lightcurves are slightly higher than those from Kepler

Table 3. Comparison between frequencies and amplitudes found in the *Kepler* and SuperWASP data for the four Am stars common to both.

	Kepler		SuperWASP	
	Freq. (d^{-1})	Amp.[a] (mmag)	Freq. (d^{-1})	Amp. (mmag)
Ren ID 49650 (KIC 11445913, 1SWASP J190540.61+491820.7)				
f_1	31.5577 ± 0.0003	2.8	31.5577 ± 0.0001	3.2 ± 0.1
f_2	25.3799 ± 0.0007	1.1	25.3769 ± 0.0001	1.2 ± 0.1
f_3	22.1307 ± 0.0009	0.8	22.1306 ± 0.0002	1.0 ± 0.1
f_4	37.8182 ± 0.0011	0.6		
f_5	29.7394 ± 0.0012	0.6		
Ren ID 50230 (KIC 9764965, 1SWASP J191724.91+463535.2)				
f_1	27.1777 ± 0.0001	1.1	27.1778 ± 0.0001	1.2 ± 0.1
f_2	21.3819 ± 0.0002	0.6	22.3891 ± 0.0001	0.9 ± 0.1
f_3	31.9895 ± 0.0002	0.4	31.9902 ± 0.0001	0.9 ± 0.1
f_4	19.9579 ± 0.0004	0.2		
Ren ID 50420 (KIC 8881697, 1SWASP J192136.03+450706.8)				
f_1	16.5567 ± 0.0003	1.9	16.5565 ± 0.0005	2.1 ± 0.1
f_2	32.0477 ± 0.0004	1.5	32.0481 ± 0.0006	1.6 ± 0.1
f_3	25.2105 ± 0.0005	1.2	25.2064 ± 0.0008	1.2 ± 0.1
f_4	30.0120 ± 0.0006	1.1	30.0111 ± 0.0009	1.1 ± 0.1
f_5	34.3647 ± 0.0007	0.9	34.3661 ± 0.0009	1.0 ± 0.1
f_6	30.6537 ± 0.0008	0.9	30.6569 ± 0.0010	0.9 ± 0.1
f_7	28.8044 ± 0.0009	0.7	27.8049 ± 0.0011	0.8 ± 0.1
f_8	34.0106 ± 0.0009	0.7		
f_9	27.4073 ± 0.0010	0.7		
f_{10}	16.0119 ± 0.0013	0.5		
Ren ID 50670 (KIC 11402951, 1SWASP J192732.81+491523.5)				
f_1	23.8493 ± 0.0004	1.3	23.8464 ± 0.0008	1.4 ± 0.2
f_2	23.2770 ± 0.0004	1.1	23.2790 ± 0.0008	1.4 ± 0.2
f_3	27.4616 ± 0.0007	0.7	27.4643 ± 0.0012	1.0 ± 0.2
f_4	15.1001 ± 0.0007	0.7		
f_4	14.4967 ± 0.0009	0.5		

Notes. [a] Uncertainties on *Kepler* Amplitudes are all <0.05 mmag.

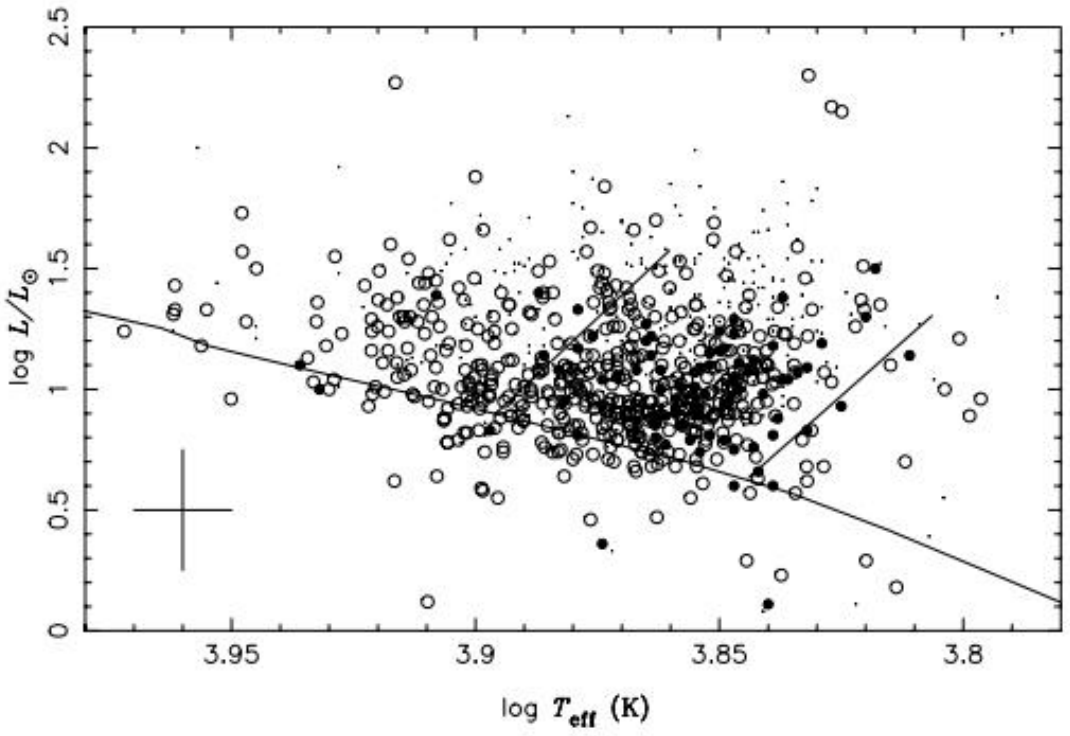


Fig. 3. HR diagram showing the location of Am stars. The filled circles are the Am stars which were found to pulsate, while the open circles are the Am stars which were not found to pulsate. The solid lines indicate the location of the ZAMS and the fundamental radial mode red and blue edges of the instability strip (Dupret et al. 2005). The large cross indicates the typical uncertainties in log $T_{\rm eff}$ and log L. The dots are the δ Sct stars from the catalogue of Rodríguez et al. (2000).

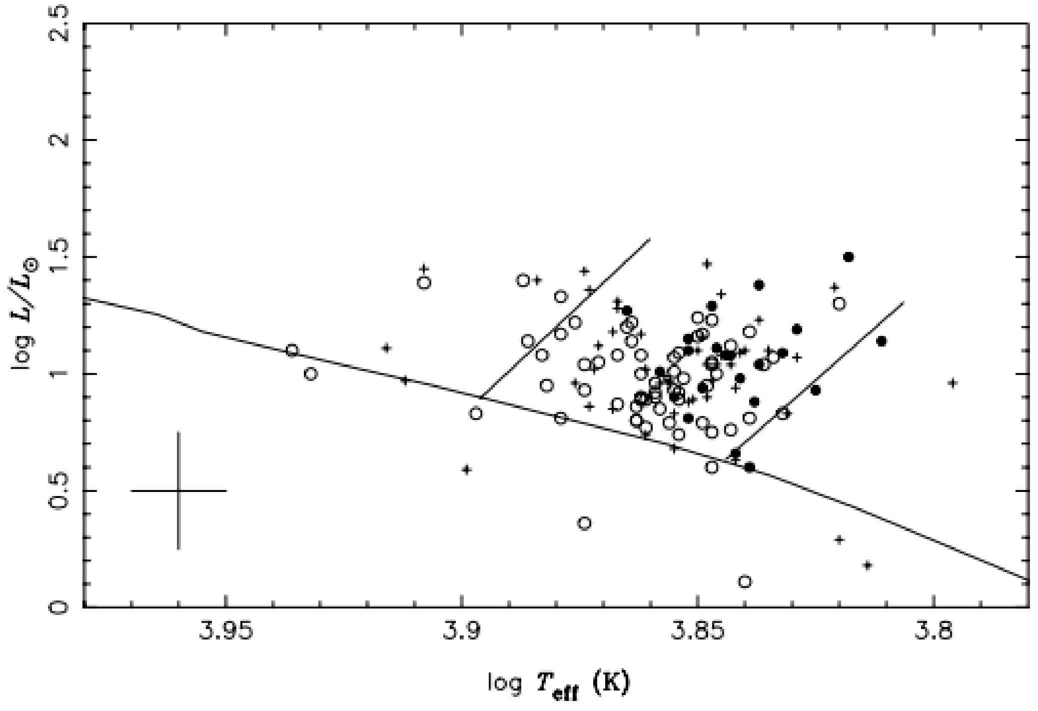


Fig. 4. Location of the pulsating Am stars in the HR diagram. The circles are pulsating Am stars, with the filled circles indicating those with spectral classification noted as δ Del. The crosses are the Fm δ Del stars which were not found to pulsate. The solid lines indicate the location of the ZAMS and the fundamental radial mode red and blue edges of the instability strip (Dupret et al. 2005). The large cross indicates the typical uncertainties in log $T_{\rm eff}$ and log L.

pulsation modes of Am stars are low radial order

pulsation amplitude increases with height and decreases with depth.

In Am stars, the microturbulence velocity is also peculiar

The photometric amplitudes found in Am stars are consistent with atmospheric pulsation radial velocity amplitudes of a few km s−1.

The loss of helium by gravitational settling from the He ii ionisation zone reduces driving, but does not suppress it entirely.

• high-frequency (>~20 d−1) pulsations

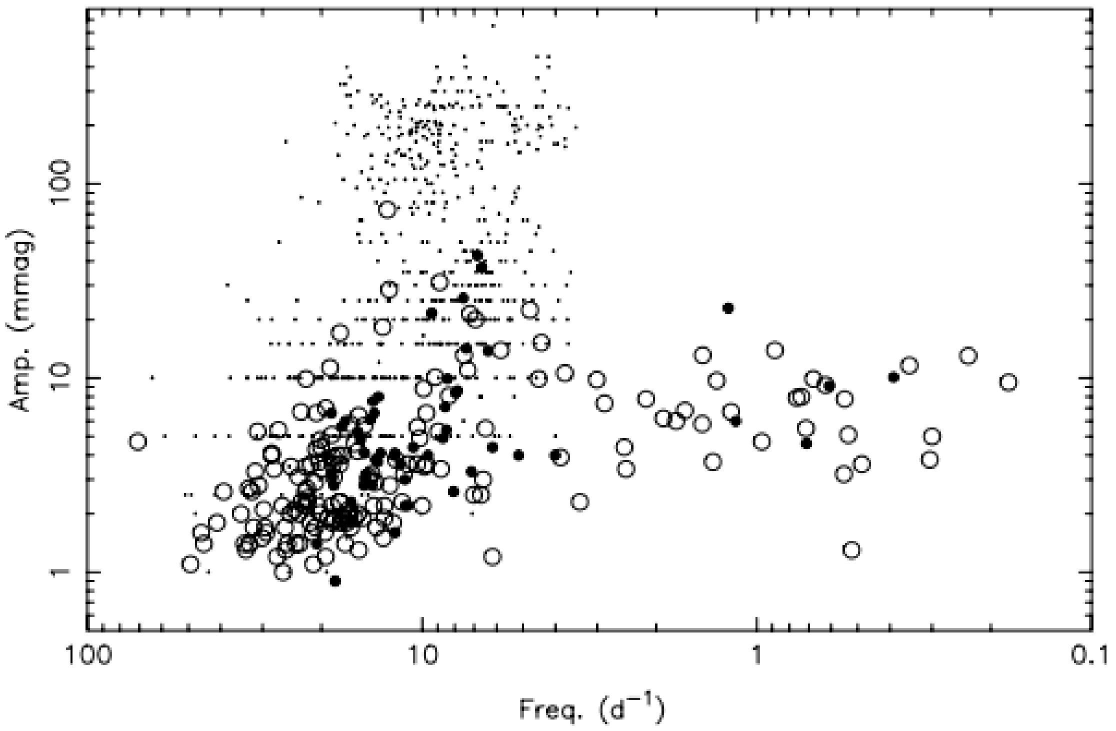
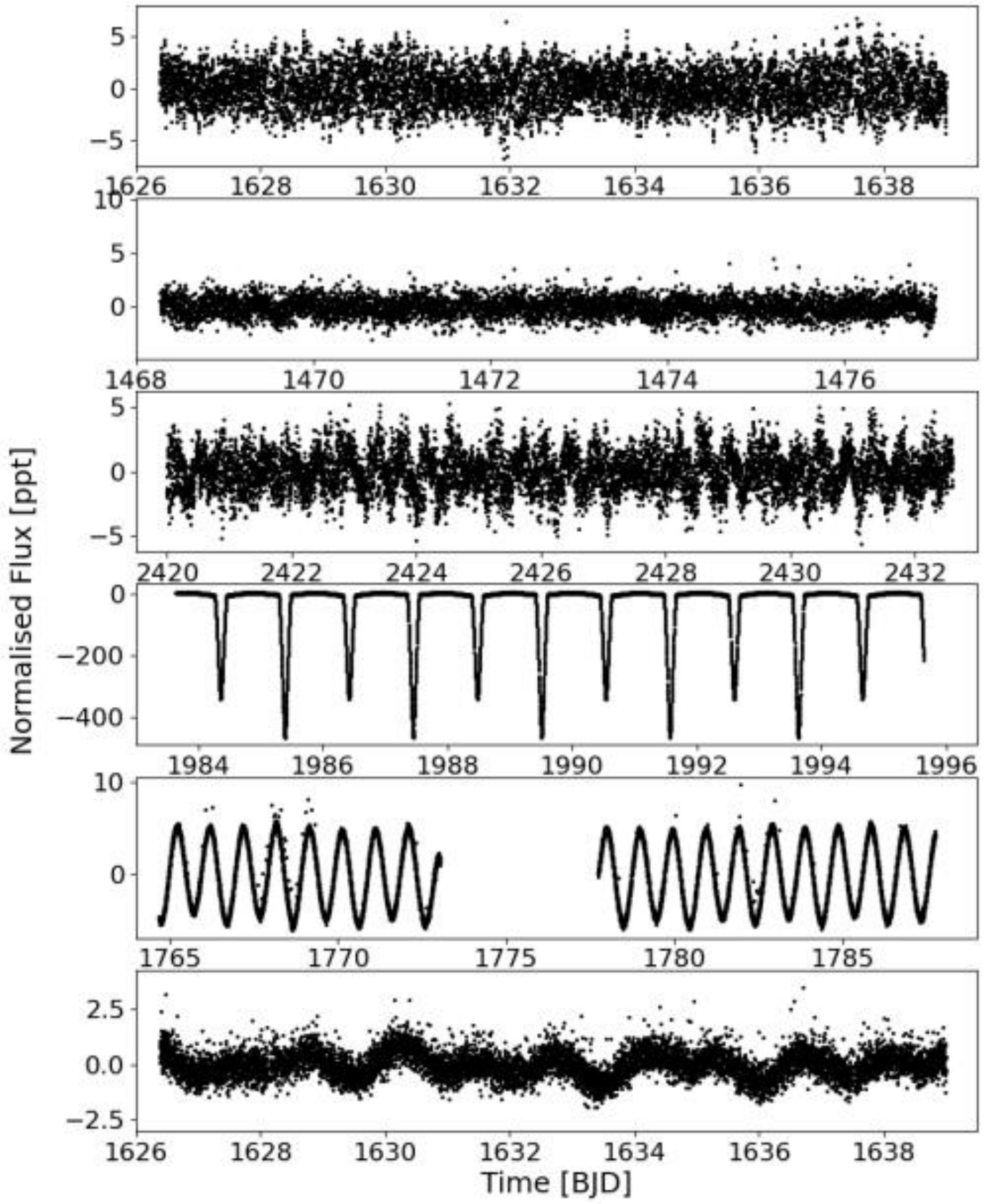


Fig. 5. Frequency-amplitude diagram for pulsating Am stars shown as circles, with filled circles indicating those with spectral classification noted as δ Del. Note that in multi-periodic systems only the frequency of the highest amplitude is shown, as given in Table 1. The dots are the δ Sct stars from the catalogue of Rodríguez et al. (2000).

Am/Fm star categories

- – γ Doradus pulsators
- – δ Scuti pulsators
- – Hybrid pulsators
- – Eclipsing binaries
- – Constant
- – Other variability



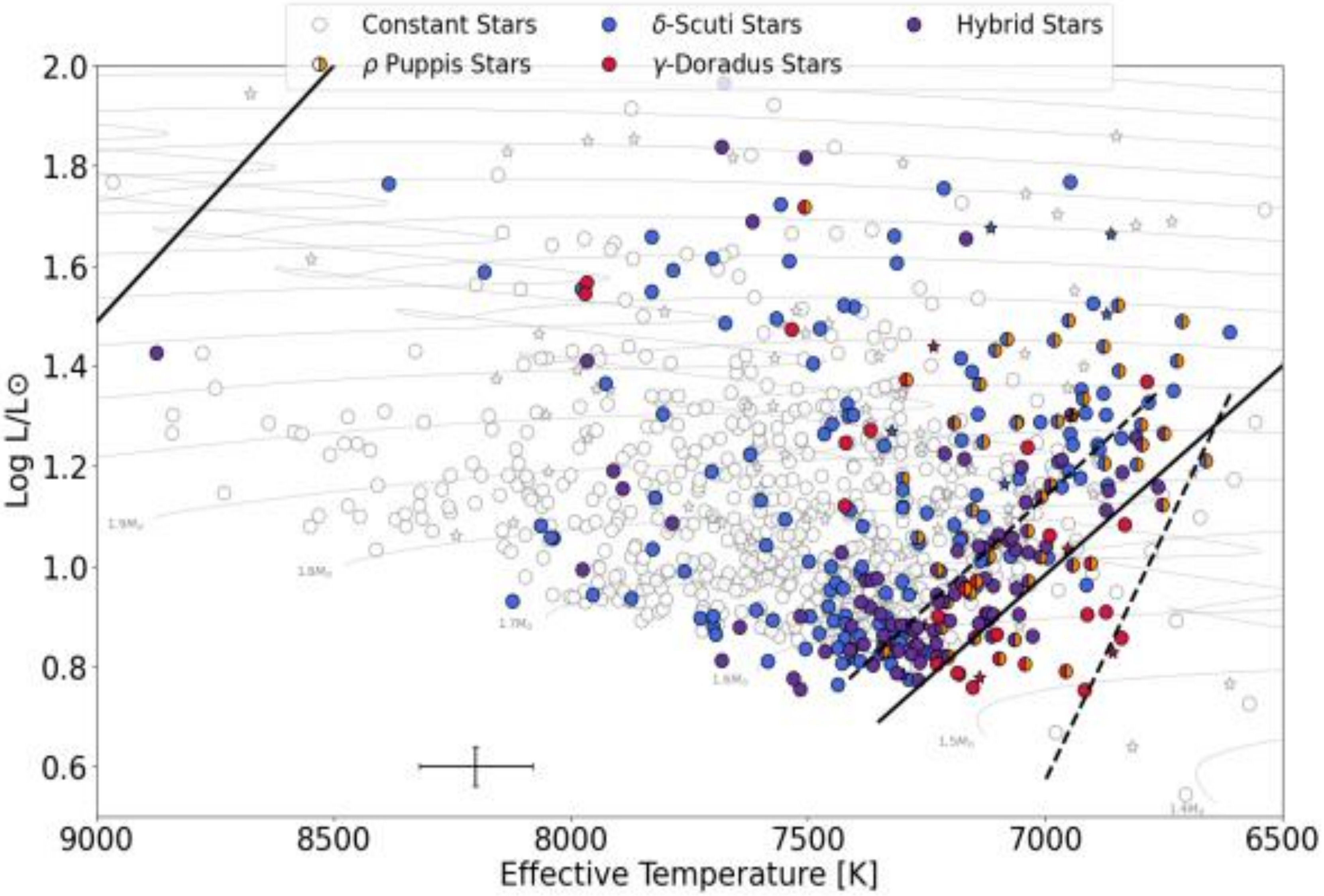
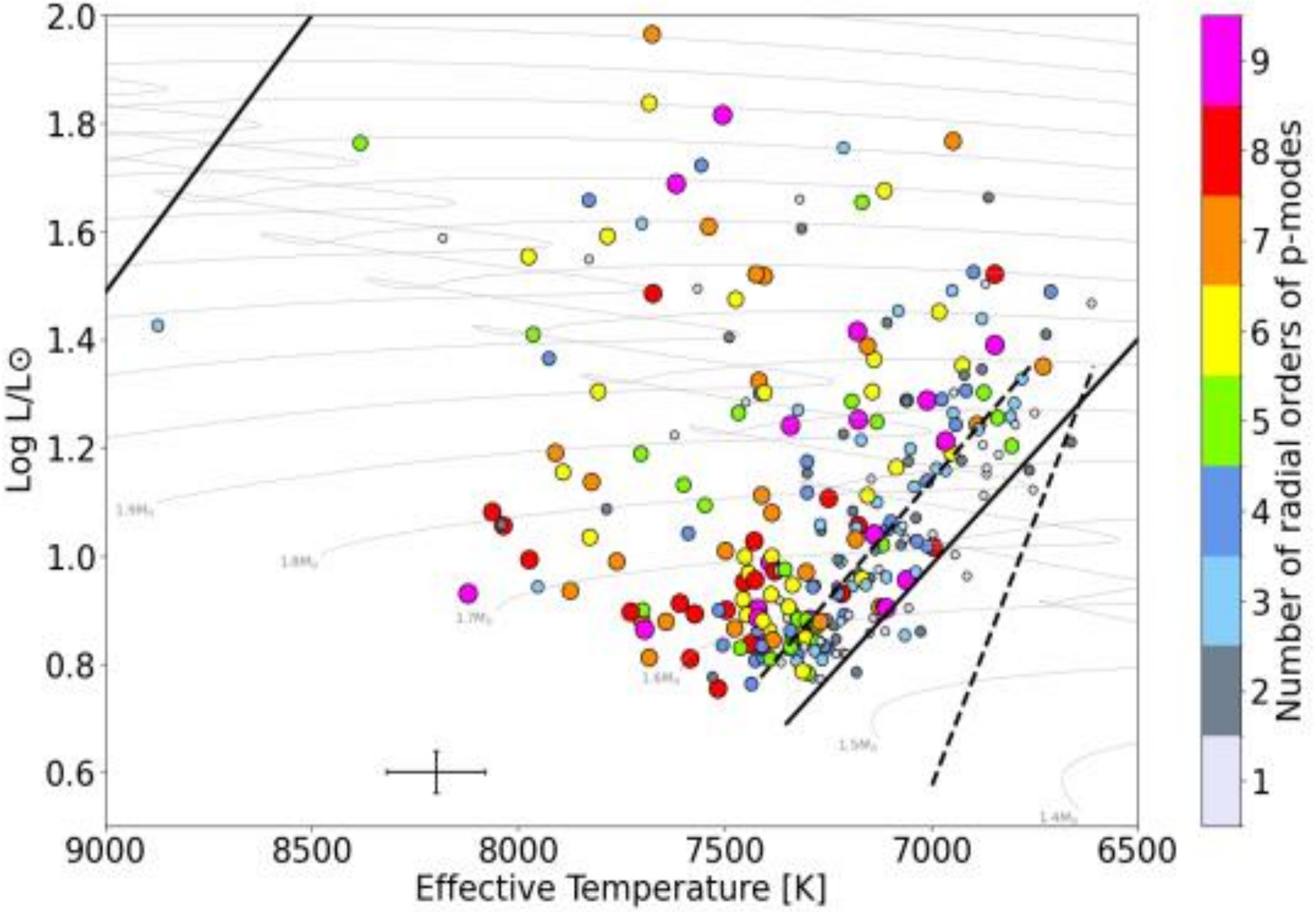
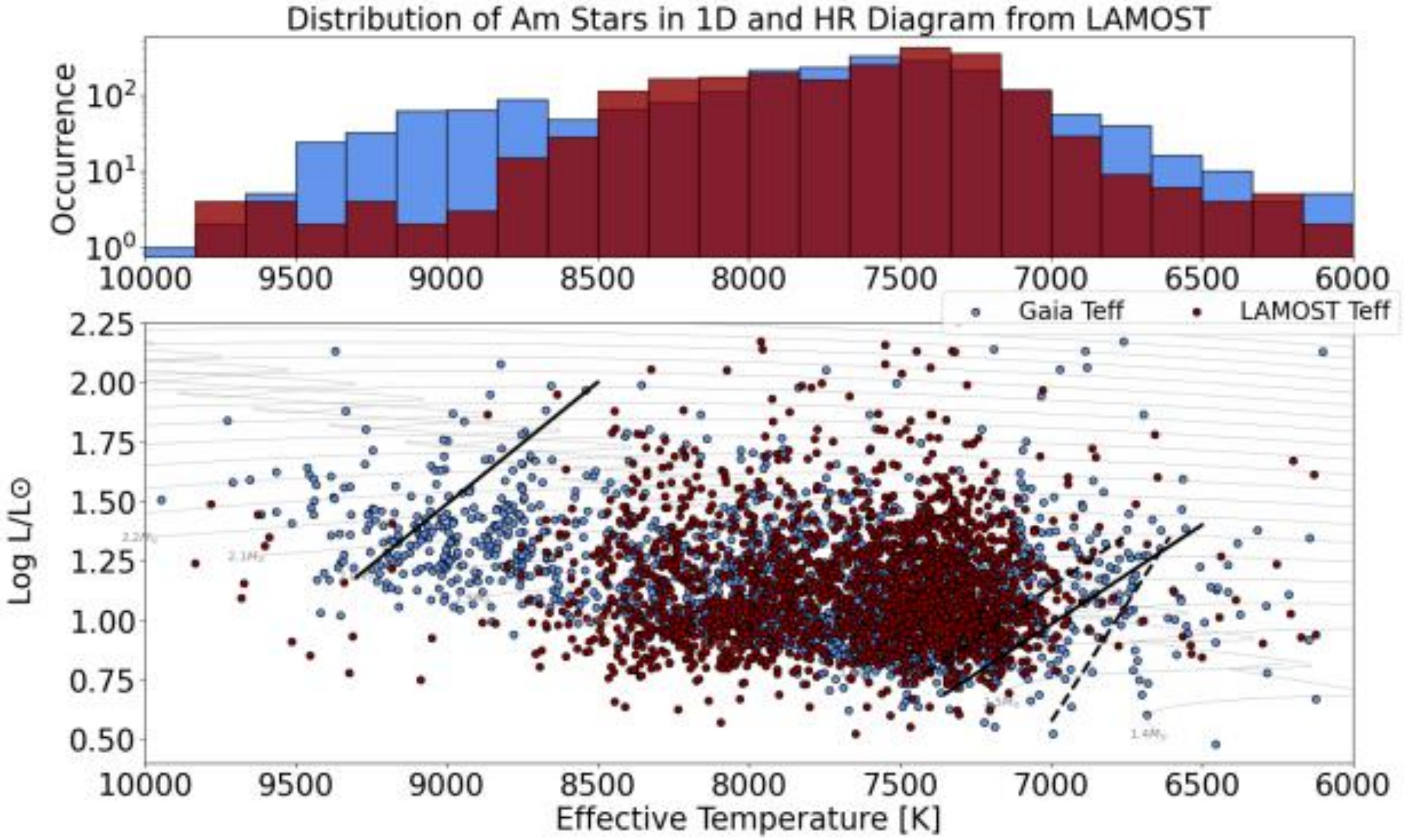


Fig. 6. HR diagram containing all 1276 Am/Fm stars studied using TESS and *Gaia* data. The



The typical uncertainties for Teff and luminosity are shown in the lower part of the plot



LAMOST sample of Am/Fm stars

Discussion