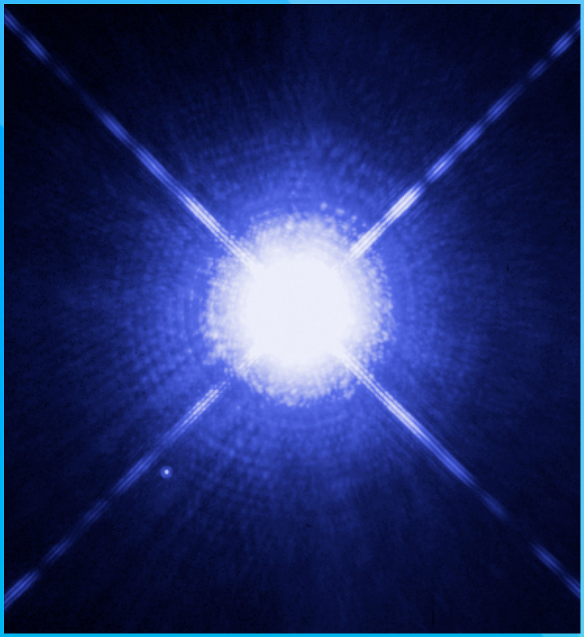
The Predicted Range of Observable Pulsation Periods in Extremely Low-mass White Dwarf Stars

J. Aguilar-Landaverde, A. Rostopchina, M.H. Montgomery, D.E. Winget

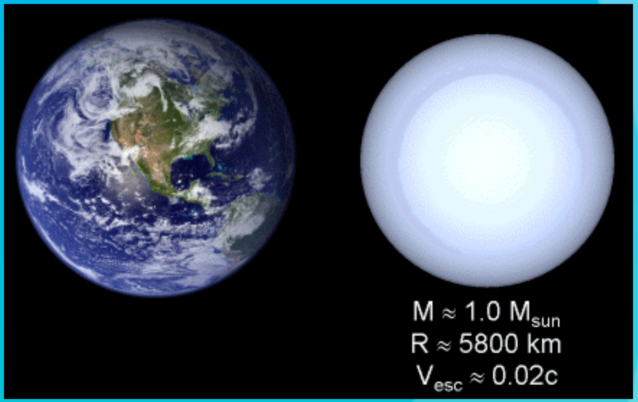
Department of Astronomy, The University of Texas at Austin

Background

- What is a white dwarf (WD)?
  - Masses comparable to Sun (0.6-1.3 Msun)
  - No nuclear thermonuclear fusion**
  - Electron degeneracy pressure
- What makes them so interesting?
  - 'Simple' in their evolution
  - Cosmochronology
  - Particle physics 'laboratories'
  - Pulsations



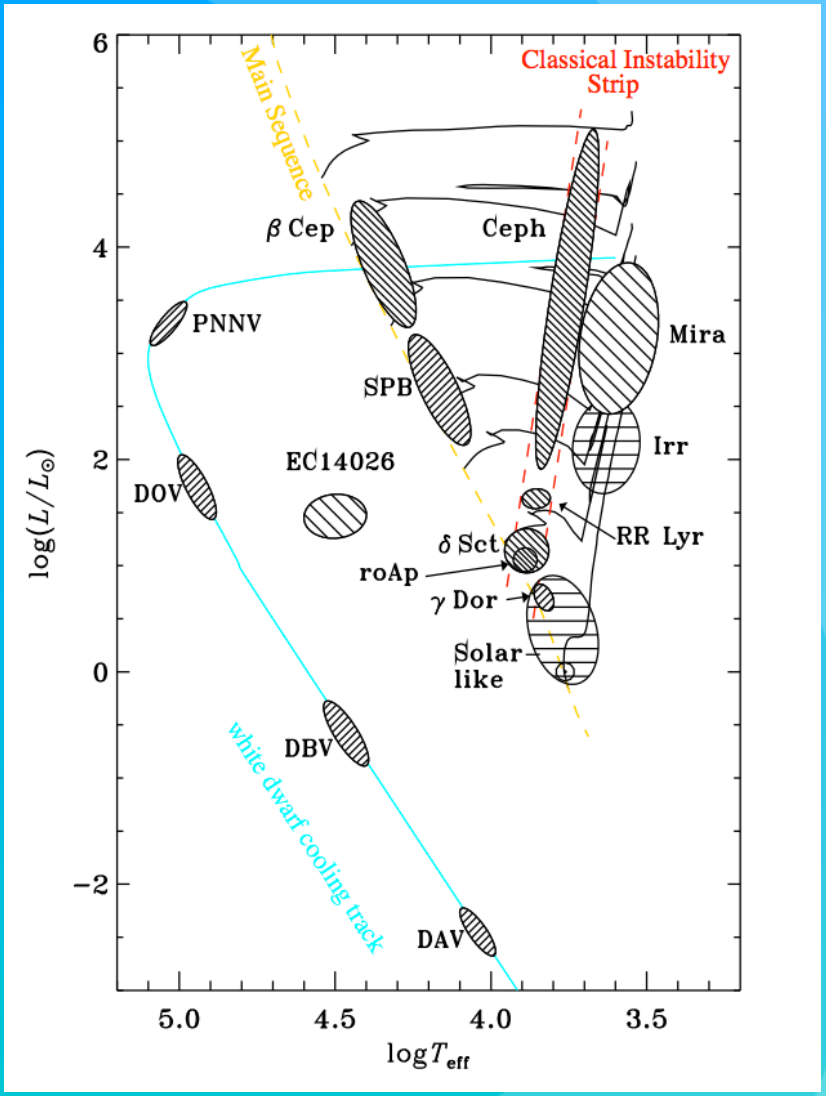
Credit: NASA, ESA



Pogge, 2006

Stellar Pulsation

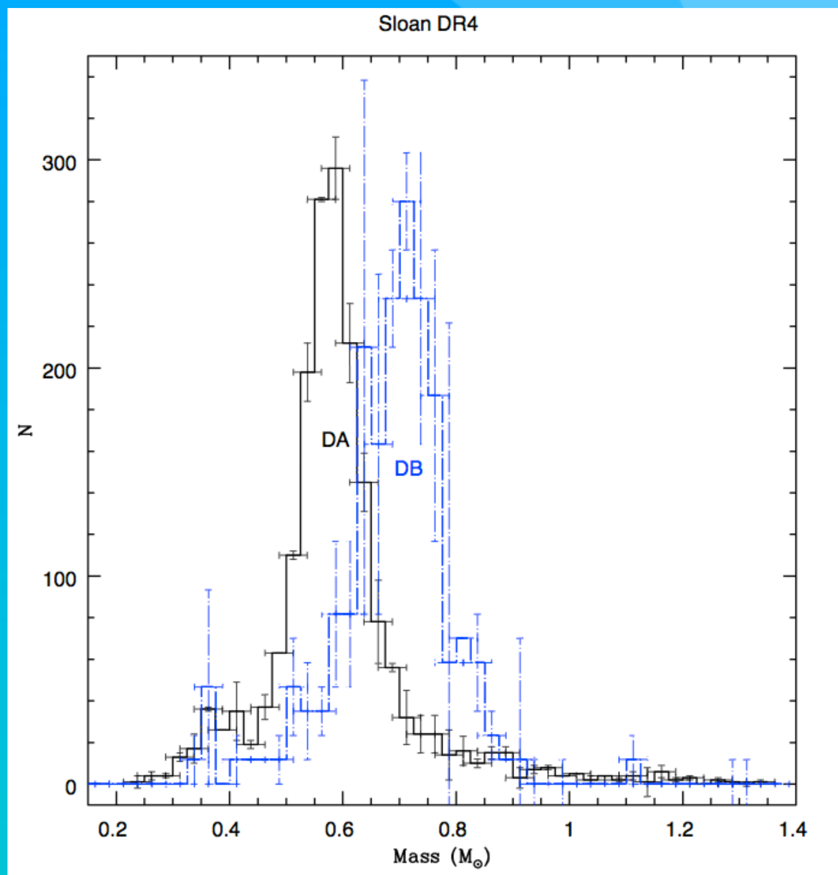
- Some WDs →non-radial oscillations
  - Global eigenmodes
  - Sinusoidal in time*
  - Pressure or Gravity
  - Instability strip
- Asteroseismology: using observed frequencies to infer interior structure



Christensen-Dalsgaard, 2003

Low-Mass White Dwarfs

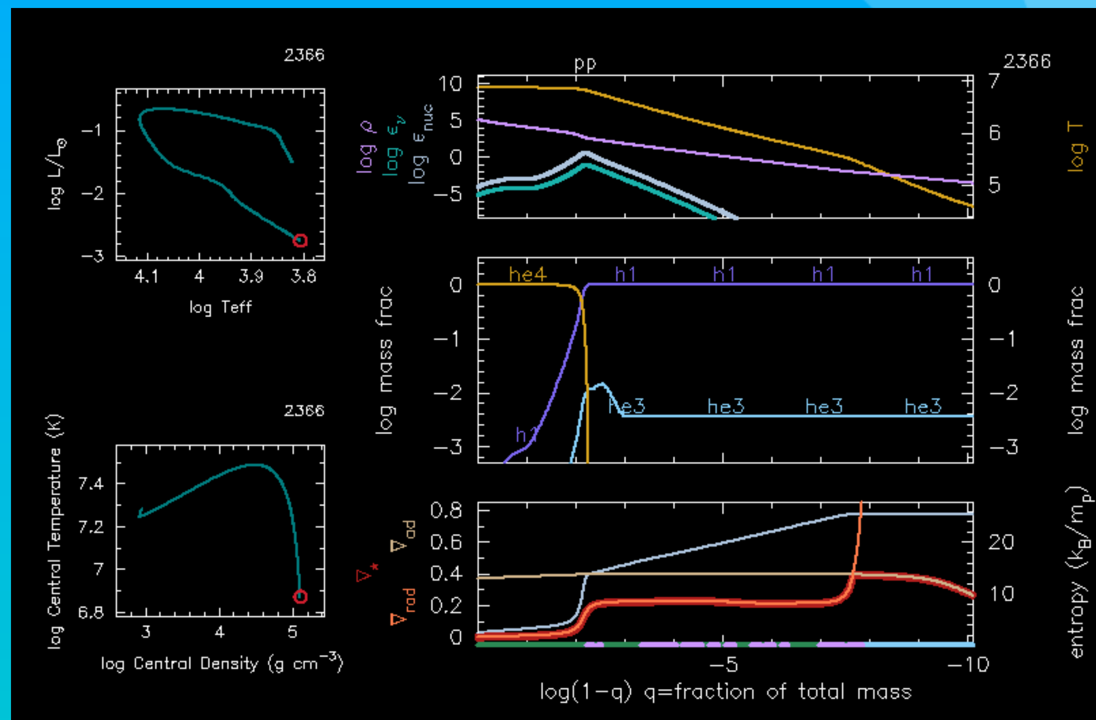
- Mean mass of observed pulsating WDs is ~0.6 Msun (Kepler et al., 2007)
  - C/O core
  - Thin (~10e-4) Hydrogen (DAV) or He (DBV) envelope
  - Extensively studied for decades
- Recent discoveries of LMWD (Kilic et al. 2007) spark new research**
  - How did these objects form?
  - Do they also pulsate?
    - Are these pulsations <u>observable</u> with modern technology?



Kepler et al., 2007

Modules for Experiments in Stellar Astrophysics (MESA)

- Open source stellar evolution code
- Used to model observed lower extreme of low-mass WD (NLTT 11748*)
- Code output→ Input for pulsation code

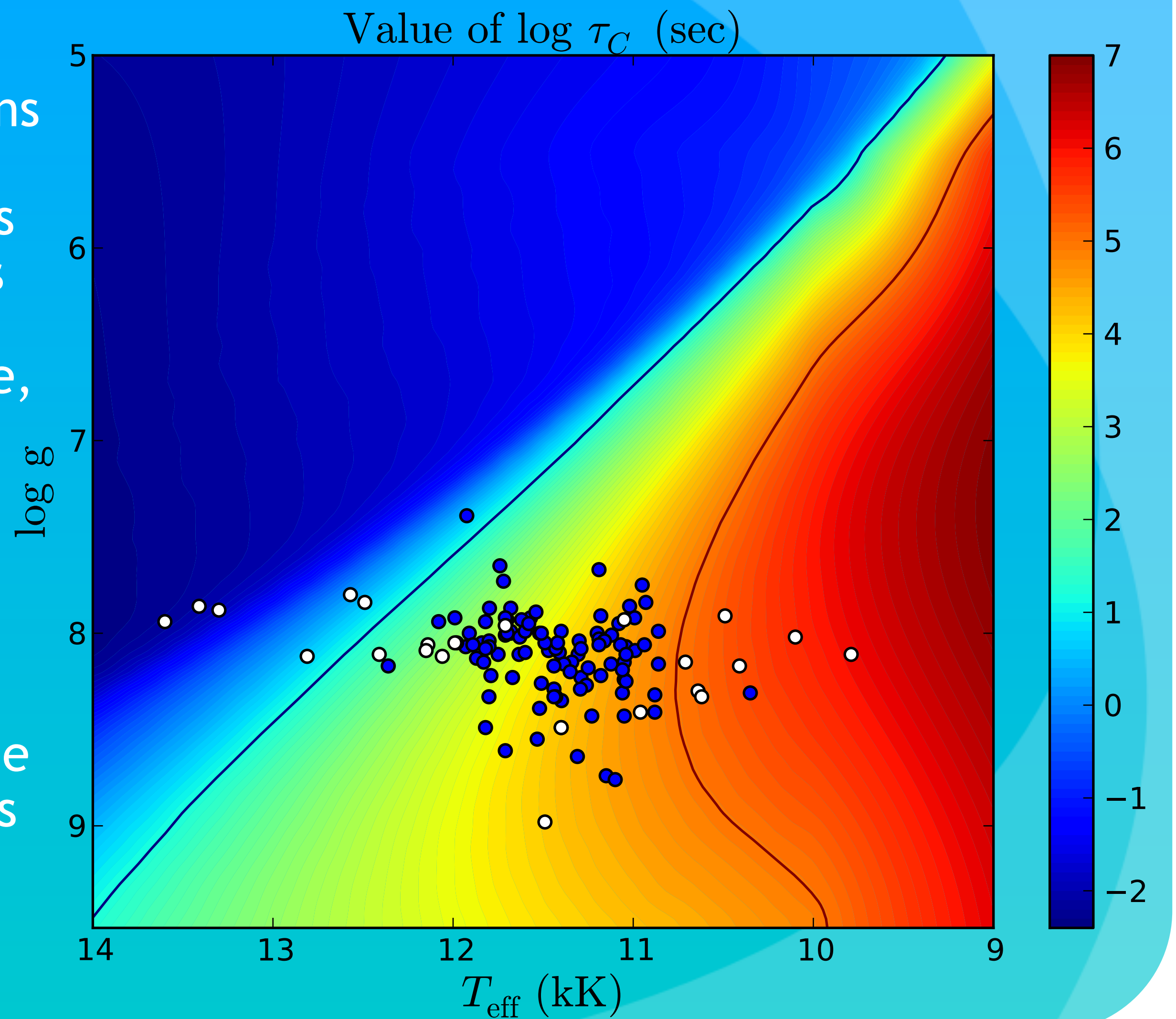


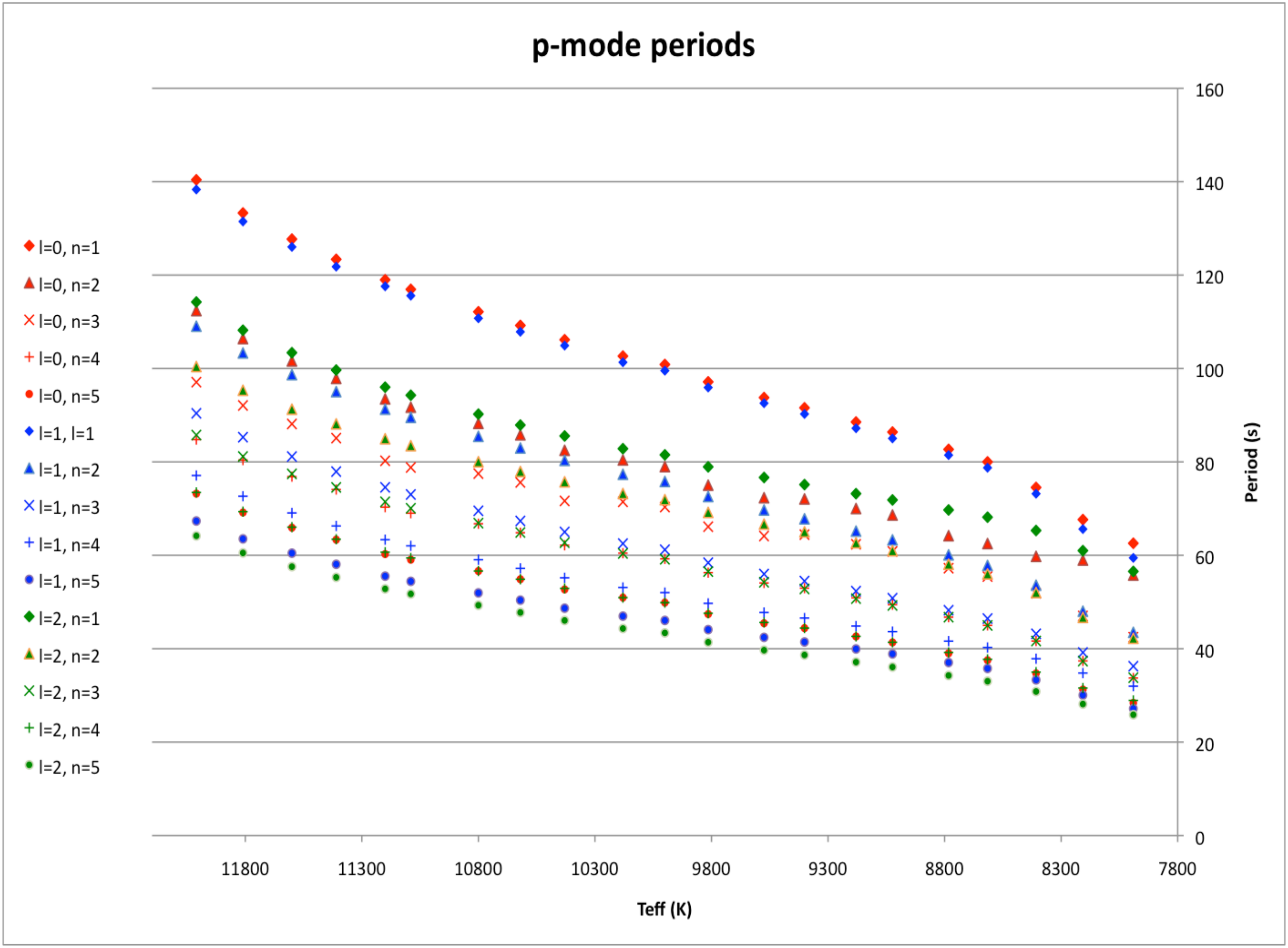
0.17 Msun WD Model

MESA

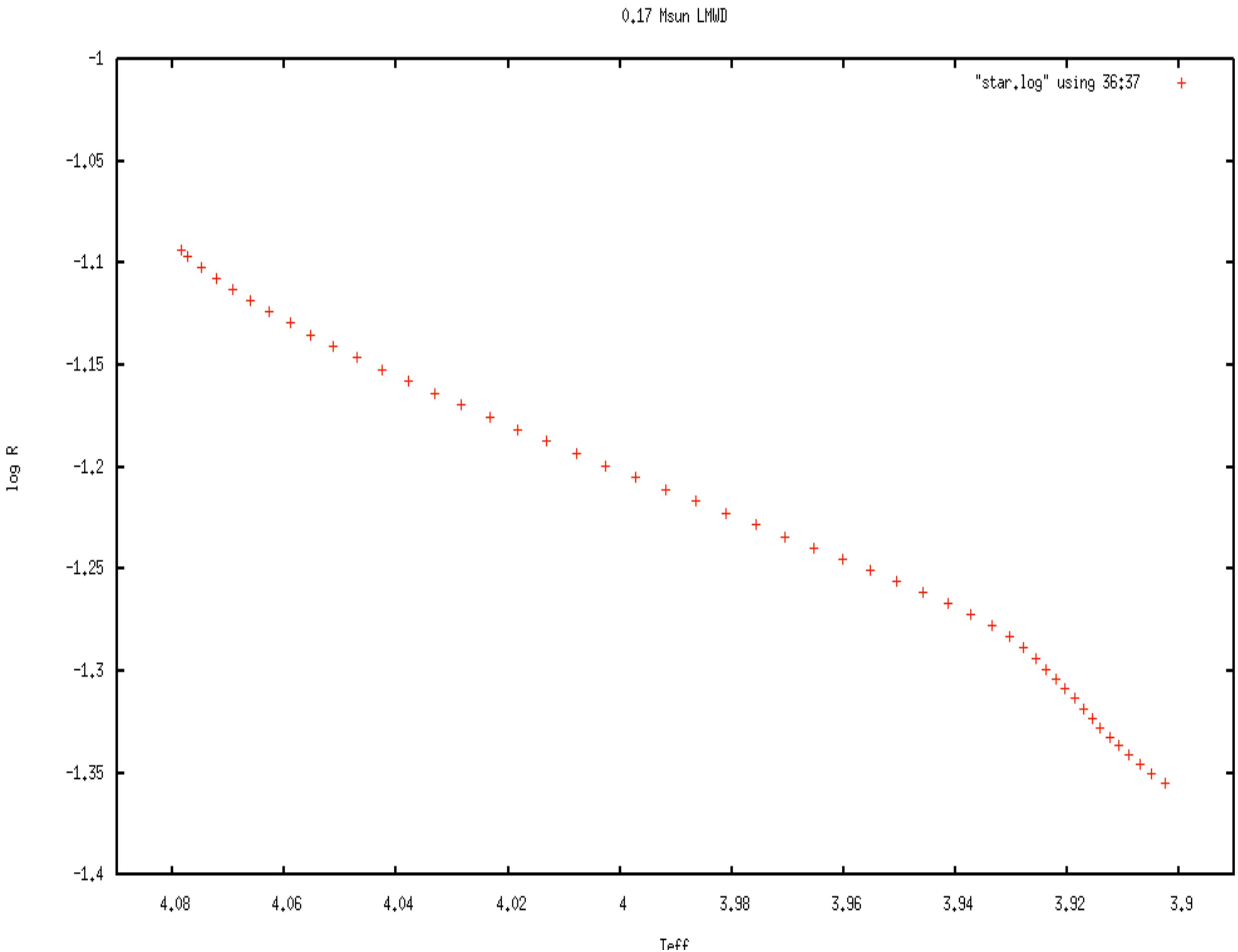
Why MESA?

- Stellar oscillations and model can help astronomers see 'inside' stars
- For the first time, we are able to make low-mass WD models
- We were able to perform first studies of p-mode periods in LMWDs

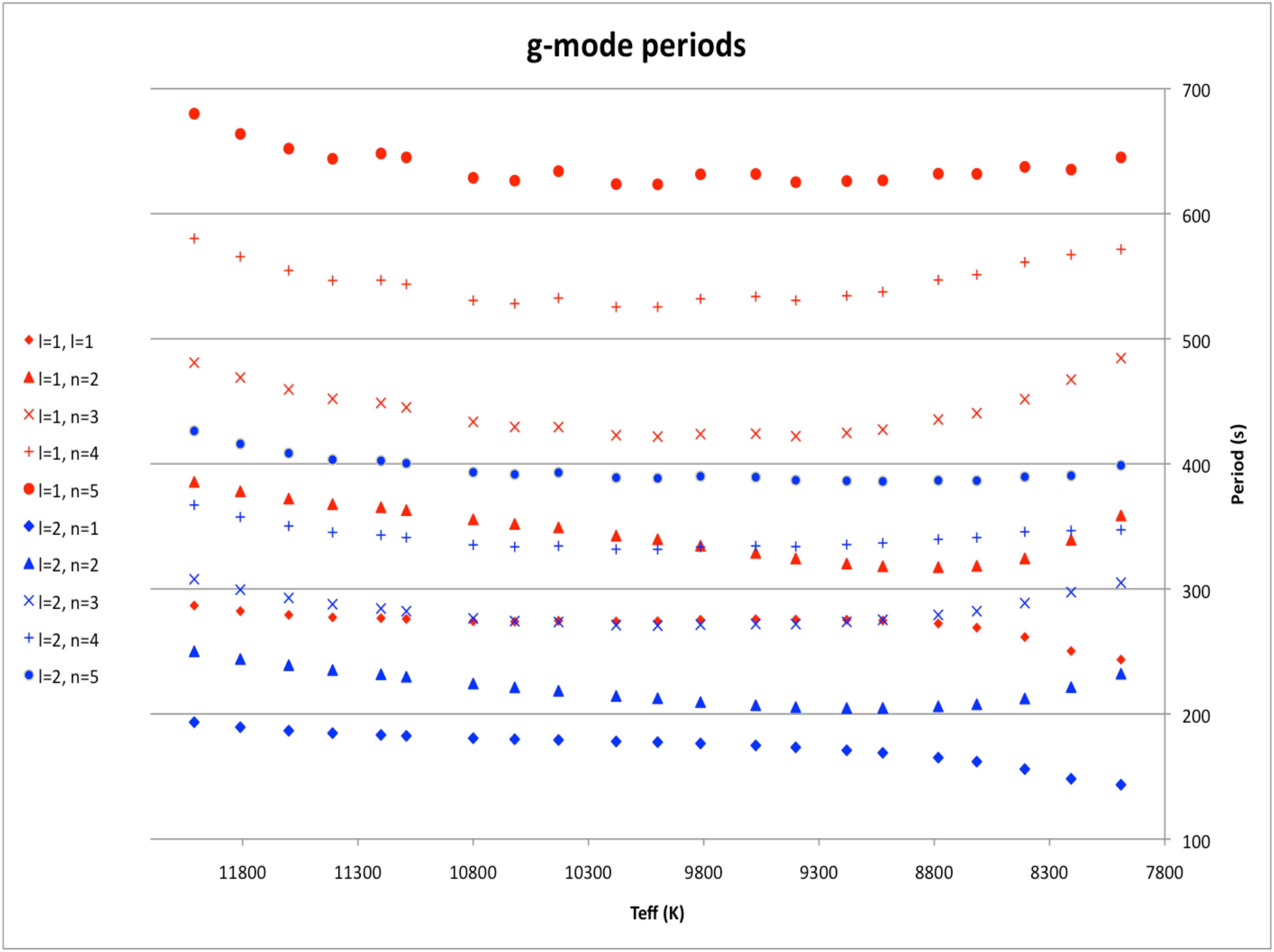




p-mode periods
l=0, n=1
l=0, n=2
l=0, n=3
l=0, n=4
l=0, n=5
l=1, l=1
l=1, n=2
l=1, n=3
l=1, n=4
l=1, n=5
l=2, n=1
l=2, n=2
l=2, n=3
l=2, n=4
l=2, n=5
160
140
120
100
80
60
40
20
0
Period (s)
11800
11300
10800
10300
9800
9300
8800
8300
7800
Teff (K)



0.17 Msun LMWD
"star.log" using 36:37
log R
Teff
-1
-1.05
-1.1
-1.15
-1.2
-1.25
-1.3
-1.35
-1.4
4.08
4.06
4.04
4.02
4
3.98
3.96
3.94
3.92
3.9


g-mode periods
l=1, l=1
l=1, n=2
l=1, n=3
l=1, n=4
l=1, n=5
l=2, n=1
l=2, n=2
l=2, n=3
l=2, n=4
l=2, n=5
700
600
500
400
300
200
100
Period (s)
11800
11300
10800
10300
9800
9300
8800
8300
7800
Teff (K)

Conclusions

- Using MESA, able to model lower limit of observed LMWDs (NLTT 11748) [previously unable]
- Stellar evolution calculations and observational work predict pulsations of LMWDs at higher Teff
- These are the first studies of p-mode periods in low-mass WDs