KIC11911480: Probing deep into the interior of a pulsating white dwarf star

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**ZZCeti Instability Strip**

- Why GD1212?
  - We have data
  - Simplest of the “complicated” DAVs

Handler et al.(2008)

Fontaine et al.(2008)
LIGHT CURVE PROCESSING

- Kepler K2 test run
- 9 days

See also Hermes et al. 2014 and poster 65
13 independent modes extracted (for structure)

19 components of rotationally split multiplets (for rotation)
THE FORWARD METHOD

- Comparison:
  - observed frequencies
  - Theoretical frequencies from static, parameterized models

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_{\text{eff}}$</td>
<td>Effective temp.</td>
</tr>
<tr>
<td>$\log g$</td>
<td>Surface gravity</td>
</tr>
<tr>
<td>$q_H$</td>
<td>H layer mass</td>
</tr>
<tr>
<td>$q_{He}$</td>
<td>He layer mass</td>
</tr>
<tr>
<td>Core comp.</td>
<td>Homogeneous C-O mix</td>
</tr>
<tr>
<td>$P_{f_1}$</td>
<td>Parameterized param. for the chemical profile at H/He transition</td>
</tr>
<tr>
<td>$P_{f_2}$</td>
<td>Parameterized param. for the chemical profile at He/C-O transition</td>
</tr>
<tr>
<td>Conv.</td>
<td>Convective efficiency (MLT)</td>
</tr>
</tbody>
</table>
**TECHNIQUE: DOUBLE-SCHEME OPTIMISATION**

\[ T_{\text{eff}}, \log g, q_H, q_{\text{He}}, \text{core comp.}, P_{f1}, P_{f2}, \ldots \]

Using a multimodal optimizer based on a genetic algorithm

- **An optimal model:**
  \[ T_{\text{eff}}, \log g, q_H, q_{\text{He}}, \text{core comp.}, P_{f1}, P_{f2} \]

The OBSERVED frequency spectrum

Mode Id.

Merit function \( S^2 \)
WHAT CAN WE INFER?

- Independent measure of:
  - Surface gravity (Mass),
  - Temperature,
  - Layering: D(H), D(He)

- Extra:
  - Bulk core composition
  - Internal rotation profile
**SOLUTION: PROJECTION LOG g – $T_{\text{EFF}}$ PLANE**

Spectroscopic solution:

$$T_{\text{eff}} = 11,035 \pm 194 \text{ K}$$
$$\log g = 8.08 \pm 0.05$$

Sismic solution:

$$T_{\text{eff}} = 11,244 \text{ K}$$
$$\log g = 8.10 \ (0.65 \, \text{M}_\odot)$$

Error estimate:

200 K
0.01 dex

Color scale -> log $S^2$
SOLUTION: PROJECTION D(H) – D(He) PLANE

Sismic solution:
D(H) = -6.04
D(He) = -2.82

Color scale -> log S^2
HOMOGENEOUS VS NON-HOMOGENEOUS CORE

- $S^2 = 28$
- $S^2 = 252$
Which parts of the star contribute the most to the pulsations?

- Weight functions:
  - Determination of the bulk core composition

- C/O = 47-53%
COMPARED TO EVOLUTIONARY MODEL, WHERE DO WE STAND?

- What we find:
  - C/O = 47-53%

- Compared to profiles from Salaris et al. (2010)
  - C/O = 43-58%
GD1212: ROTATION KERNELS

- Going deep into the interior
GD1212: ROTATIONAL SPLITTINGS

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**Graph 1: Frequency vs. Amplitude for GD1212**

- Frequency range: 1100 to 1400 $\mu$Hz
- Amplitude range: 0 to 0.1%

**Graph 2: Frequency vs. Amplitude for GD1212**

- Frequency range: 800 to 1100 $\mu$Hz
- Amplitude range: 0 to 0.3%
INTERNAL ROTATION PROFILE

- Solid-body rotation test
HOW DOES IT COMPARE TO OTHER ZZ CETI?

GD1212

R548

0.15
HOW DOES IT COMPARE TO OTHER ZZCETI?

GD1212

R548

0.15
CONCLUSION

IT WORKS!!

We have been able to determine for GD1212:
- Mass (Surface gravity)
- Temperature
- Chemical stratification: H/He layering

Extra:
- Bulk core composition
- Internal rotation profile

Future prospects:
- Analysis of other Kepler 1-2 WDs
  (See Greiss et al. Poster 6)