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Preliminary seismology of the DA white dwarf G 185–32

P.A. Bradley

X-2, MS T-085 — Los Alamos National Laboratory, Los Alamos, NM 87545 USA e-mail: `pbradley@lanl.gov`

Abstract. G 185-32 is a pulsating hydrogen atmosphere white dwarf with a relatively rich pulsation spectrum of 14 modes identified from Whole Earth Telescope data. Castanheira et al. (2004) provide some suggested mode identifications, along with a recent T_{eff} and $\log g$ value of 11,960 K and 8.02 ± 0.04. We present our preliminary seismological results based on evolutionary white dwarf models that match the observed T_{eff} and $\log g$ value. We are able to fit most of the observed periods to within about 1% in period (1 − 3 s) using models having masses of 0.60 to 0.65$M_\odot$. The best fitting hydrogen layer mass is either about $10^{-4}M_\odot$ if the 72.5 s mode is $\ell = 2$ or about $10^{-6}M_\odot$ if the 72.5 s mode is $\ell = 4$.

Key words. Stars: evolution – Stars: individual (G 185–32) – Stars: oscillations – White Dwarfs

1. Introduction

G 185-32 is a pulsating hydrogen atmosphere white dwarf with a relatively rich pulsation spectrum. However, there has been no attempt to seismologically model this star, although (Castanheira et al. 2004) and (Thompson et al. 2004) provide some suggested ℓ identifications. G 185-32 is peculiar due to its relatively small pulsation amplitude given its location in the ZZ Ceti instability strip. (Bergeron et al. 2004) quote a $T_{eff} = 12,130$ K and $\log g = 8.05$, while (Castanheira et al. 2004) quote $T_{eff} = 11,960$ K and $\log g = 8.02 \pm 0.04$.

The observational periods (see Table 1) are from (Castanheira et al. 2004) and show the dominant modes. There are two low amplitude modes at 454.6 and 537.6 s that are not considered here. We note that the 70.9 and 148.5 s modes are intepreted as harmonics rather than independent modes and we do not consider them in our analysis. The ℓ value column can have two entries. The entry not in () is from (Castanheira et al. 2004), while the entry in () is from (Thompson et al. 2004). They agree except for the modes at 141.2 and 141.9 s; more on this later. Several modes appear to have fine structure splitting. The 299.8 and 301.4 s modes are split by 17.8μHz, and we will assume this is the $\ell = 1$ m splitting. The 264.2 and 266.1 s modes are split by 27.9μHz; the ratio of 1.57 (= 27.9/17.8) is close to the asymptotic ratio of 1.60 between $\ell = 1$ and 2 modes. This also agrees with the $\ell = 2$ identification of the 264.2 and 266.1 s modes. The 141.2 and 141.9 s modes are split by 31.6μHz; the ratio of this splitting to the $\ell = 1$ splitting suggests $\ell = 3$ or greater for this mode, which would be consistent with the $\ell = 4$ interpretation of (Thompson et al. 2004). The 72.5 and 72.9 s modes are separated by 70.5μHz,

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Send offprint requests to: P. Bradley

Table 1. Observed Pulsation Modes of G 185–32

Period (s)	Frequency (μHz)	ℓ	Comments	Model Period (s)	Model (ℓ, k)	Δ (s)
70.9	14097.7	2 (2)	Harmonic of 141.9 s	–	–	–
72.5	13784.9	2	70.5μHz between 72.5 and 72.9	72.0	(4,2)	0.5
72.9	13714.4	2	$\Delta m = 2$?	–	–	–
141.2	7080.4	1 (4)	31.6μHz between 141.2 and 141.9	–	–	–
141.9	7048.8	1 (4)	1.43 mma	141.4	(4,8)	0.5
148.5	5497.7	1	$F_{72.5} - F_{141.9}$	–	–	–
212.8	4698.8	1		215.4	(1,2)	2.6
215.7	4635.3	2 (2)	1.93 mma	216.1	(2,5)	0.4
264.2	3785.2	2	27.9μHz between 264.2 and 266.1	256.3	(2,6)	7.9
266.1	3757.3	2	$\Delta m = 1$	–	–	–
299.8	3335.6	1	17.8μHz between 299.8 and 301.4	291.3	(1.3)	8.5
301.4	3785.2	1 (1)	$\Delta m = 1$	–	–	–
370.2	2701.2	1 (1)	1.62 mma	373.6	(1,5)	3.4
651.7	1534.5	2		648.6	(2,20)	3.1

which could be a $\Delta m = 2$ of a 30.7μHz splitting. Again, this is consistent with $\ell = 3$ or greater.

2. White Dwarf Models

Our evolutionary white dwarf models are described in (Bradley 2001) and references therein. Here, we note that the models have a layered structure with a carbon/oxygen core, a helium mantle, and a thin veneer of hydrogen on the surface. We evolve our models from the planetary nebula nucleus phase into the ZZ Ceti region and choose models for our analysis that match the observed temperature range of 11,960 to 12,100 K.

3. Seismological Constraints

Due to space constraints, we will not discuss the $\ell = 2$ option for the 72.5 s mode except to say that it implies a hydrogen layer mass that is very thick ($M_H > 10^{-4} M_\star$) and it does not fit the observed periods very well.

When we consider the 72.5 s mode to be $\ell = 4$, we are able to match most of the observed periods of G 185–32 to within 3 s (see Table 1), although we miss the 299.8 s mode by almost 9 s. This "best-fitting" model has a mass of 0.63M$_\odot$, a $T_{eff} = 11,780$K, a C/O core extending to $0.85 M_\star$, and a hydrogen layer mass of $2 \times 10^{-6} M_\star$. While more work is needed to improve the seismological fit, our preliminary work suggests G 185–32 has a hydrogen layer mass about 100 times thinner than G 226-29, G 117-B15A, R 548, L 19-2, and GD 165. If this result is borne out by improved seismological analysis, then there may well be a range of hydrogen layer masses for the ZZ Ceti stars, consistent with the arguments of (Fontaine & Wesemael 1997).

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