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Constraining convection parameters from the light curve shapes of pulsating white dwarf stars: the cases of EC 14012−1446 and WD 1524−0030

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Abstract. Montgomery [1] developed a method to probe convection in pulsating white dwarf stars which allows the recovery of the thermal response time of the convection zone by fitting observed nonsinusoidal light curves. He applied this method to two objects; the Whole Earth Telescope (WET) observed the pulsating DB white dwarf GD 358 for just this purpose. Given this WET run's success, it is time to extend Montgomery's method to pulsating DA white dwarf (ZZ Ceti) stars. We present observations of two ZZ Ceti stars, WD 1524−0030 and EC 14012−1446, both observed from multiple sites. EC 14012−1446 seems better suited than WD1524−0030 for a future WET run because it has more pulsation modes excited and because it pulsation spectrum appears to be more stable in time. We call for participation in this effort to take place in April 2008.

1. Introduction

The physics of convection is still poorly described in stellar models, mostly because of a lack of observational constraints. The uncertainties in our present descriptions of convection have several important consequences, for instance on our understanding of the main sequence life times of stars. For the coolest white dwarf stars, the treatment of convection is the largest single source of error in surface temperature determinations, which is directly related to age determinations of single white dwarfs.

Pulsating white dwarf stars often show nonsinusoidal light curves that are believed to originate in their surface convection zones. Under this assumption, Montgomery [1] demonstrated that the thermal response time scale of the convection zone (directly related to its depth) and the type of the underlying pulsation mode(s) can be inferred from modelling high-precision light curves. In May 2006, the Delaware Asteroseismic Research Center (DARC) undertook a WET run for the pulsating DB white dwarf star GD 358 for just this purpose. A light curve obtained during this

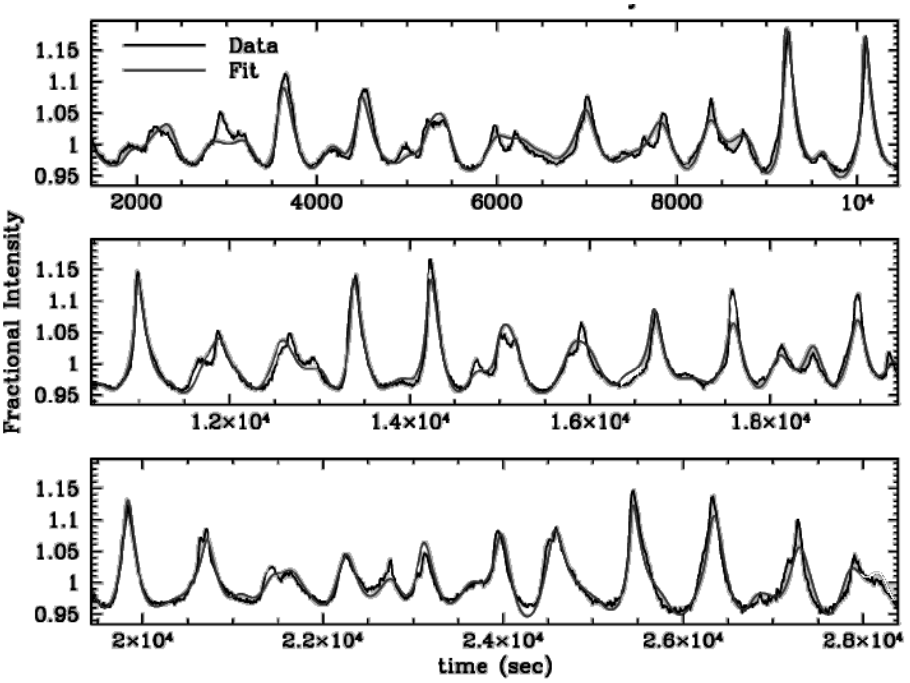

Figure 1. Light curve fit to large telescope measurements of the pulsating DB white dwarf star GD 358. Reproduced with permission from Provencal & Shipman [2].

run and the convective fit to it, that reproduces the data as well as a purely phenomenological fit does, but with considerably less free parameters, is shown in Fig. 1.

After this initial success, it is time to apply Montgomerys method to pulsating white dwarfs of spectral type DA. The requirements for a successful study of this kind in connection with asteroseismology are: a well-resolved rich pulsation spectrum of the target star high S/N light curves from large telescopes to perform the light-curve fitting to high accuracy.

2. Observations and results

To find the best targets among pulsating DA white dwarfs, we carried out test observations of two objects that have promise in this direction. Our first target was EC 14012−1446, discovered to pulsate by Stobie et al. [3]. We acquired single and multisite observations of this star in 2004, 2005 and 2007, and we compare the resulting amplitude spectra from 2004 and 2007 in Figs. 2 and 3.

Our second target was WD 1524−0030, discovered from the Sloan Survey by Mukadam et al. [4], and observed from the CTIO and Vienna observatories by us. The amplitude spectrum of the combined light curves is shown in Fig. 4.

3. Conclusions

Compared to WD 1524−0030, EC 14012−1446 is more suitable for an upcoming effort to determine surface convection parameters of pulsating white dwarfs in connection with asteroseismic analyses. It has higher amplitudes, which gives higher S/N for light curve fitting. It has more known pulsation modes, collected by us during measurements over several seasons. Its amplitude spectrum is more stable in time, aiding in the frequency determination and mode identification.

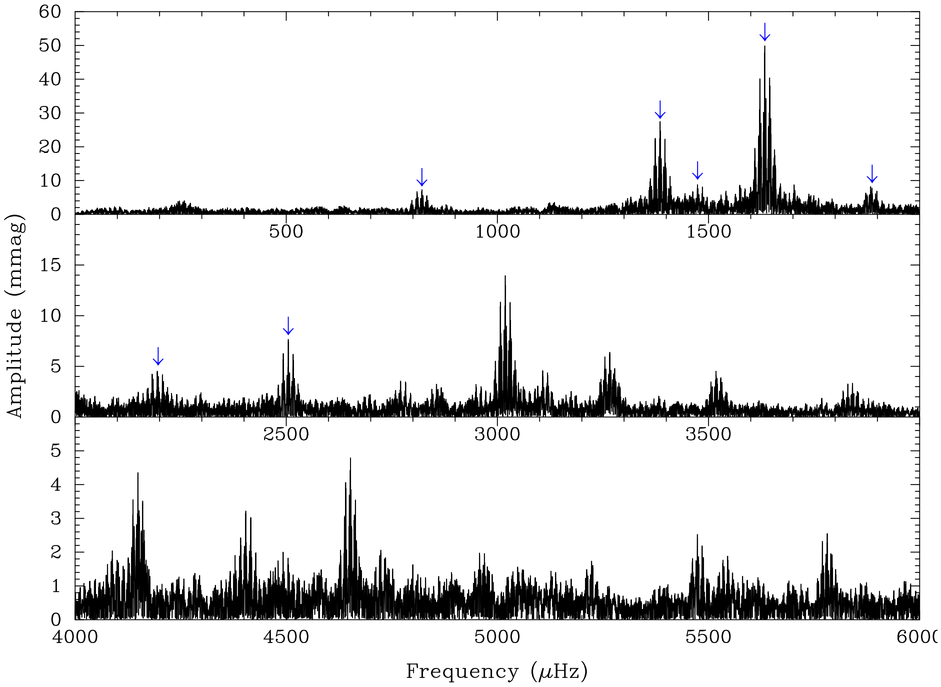

Figure 2. Amplitude spectra of our single-site observations of EC 14012−1446 in April 2004. Independent pulsation modes are indicated by blue arrows; all other peaks are due to combination frequencies.

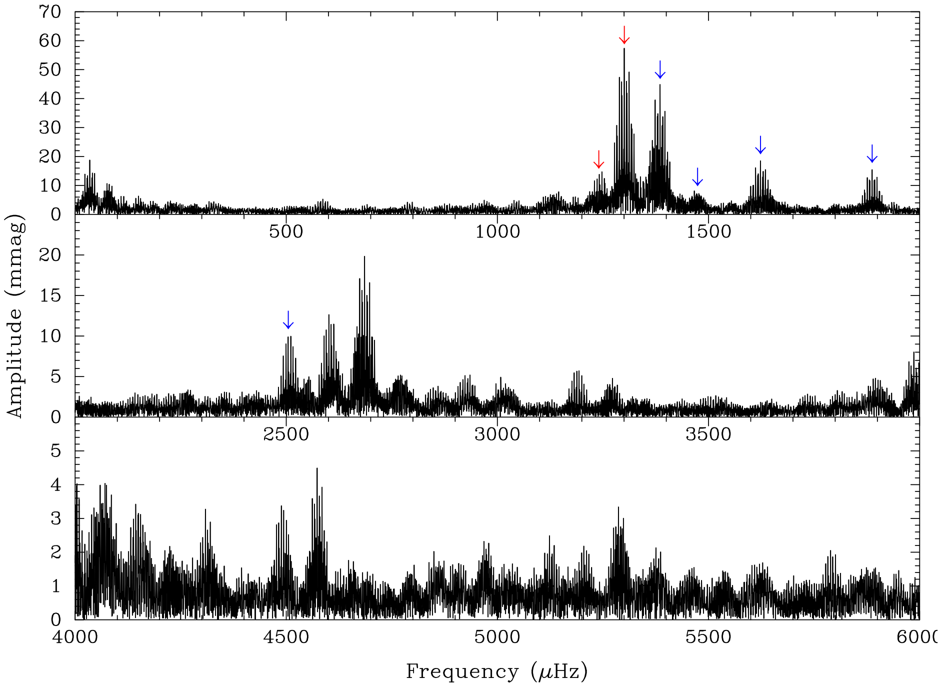

Figure 3. Amplitude spectra of single-site observations of EC 14012−1446 in 2007. Independent pulsation modes are indicated by arrows; the blue arrows show modes already known, whereas the red arrows label newly discovered pulsation modes. Note the apparent shift of the main pulsation periods compared to the earlier measurements.

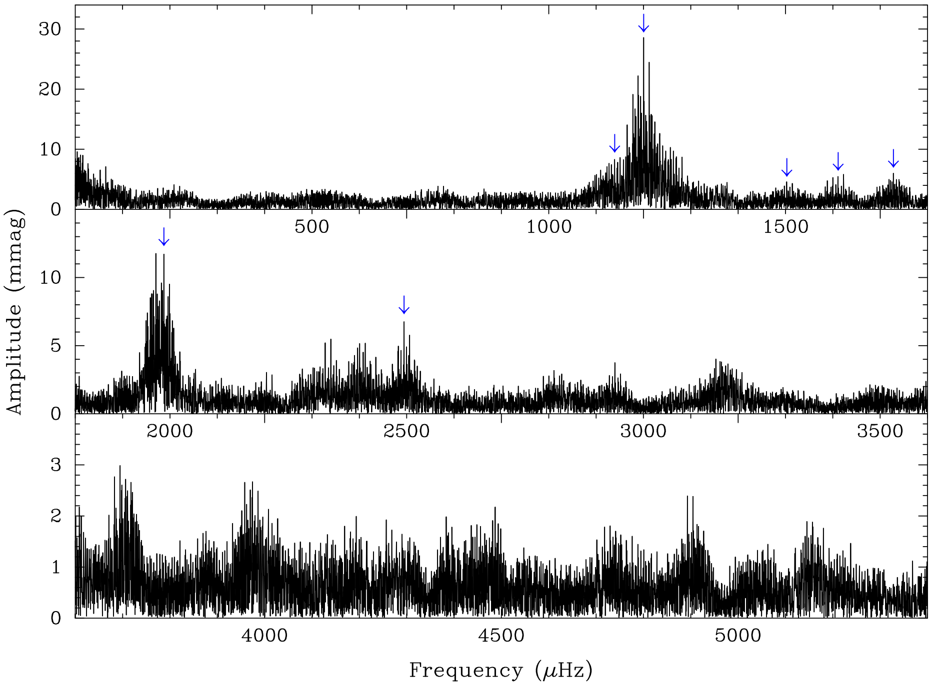

Figure 4. Amplitude spectrum of our test observations of WD 1524−0030. Independent pulsation modes are indicated by blue arrows; all other peaks are due to combination frequencies.

Consequently, the next DARC/WET campaign will be devoted to EC 14012−1446, taking place in the first two weeks of April 2008. Everyone interested to contribute to this and future efforts is invited to contact the first two authors of this manuscript.

Acknowledgments

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