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# ASTEROSEISMOLOGY OF MASSIVE PULSATING DA WHITE DWARF STARS WITH FULLY EVOLUTIONARY MODELS

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**We performed the first asteroseismological study for 42 massive DA variable white dwarf, or ZZ Ceti stars, based on detailed and fully evolutionary models representative of these stars.**

ZZ Ceti (or DAV) stars are the most numerous class of degenerate pulsators. These stars have hydrogen atmospheres and are located in a narrow range in effective temperature $10\,500 \lesssim T_{\rm eff} \lesssim 12\,300$ K. Their photometric variations are due to spheroidal, non-radial $g$-mode pulsations with low harmonic degree ($\ell \leq 2$) and periods in the range 70−2000 s, with amplitude variations of up to 0.3 mag.

In this work we perform an asteroseismological analysis of all ZZ Ceti stars, with spectroscopic masses in the range $0.72-1.05 M_{\odot}$, expected to have carbon−oxygen cores. To perform our seismological study we employ a grid of full evolutionary models representative of white dwarf stars discussed in Romero et al. (2012, 2013) which have consistent chemical profiles for both the core and the envelope for various stellar masses, particularly intended for detailed asteroseismological fits of ZZ Ceti stars. Our parameter space is build up by varying three quantities: stellar mass ($M_*$), effective temperature ($T_{\rm eff}$) and thickness of the hydrogen envelope ($M_{\rm H}$).

In Figure 1 we present the envelope thinckness distribution for the 42 stars analyzed from asteroseismological fits. In line with previous works (Castanheira & Kepler 2009; Romero et al. 2012), we find that the values of the hydrogen envelope mass span over a large range ($10^{-4} - 10^{-10} M_*$). The distribution is not homogeneous, but shows three peaks at $\log(M_{\rm H}) \sim -5.5$, mostly composed by models with canonical envelopes, at $\log(M_{\rm H}) \sim -7.5$ and $\sim -9.5$,

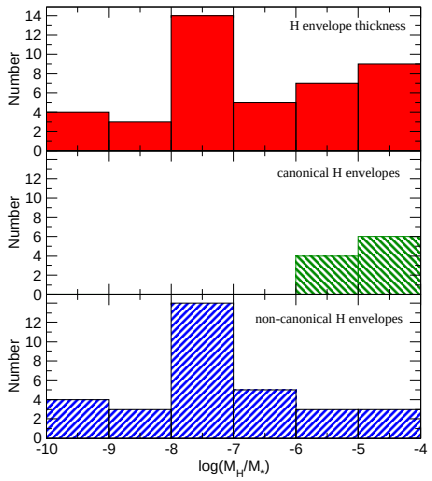


Fig. 1. Upper panel: histogram showing the hydrogen envelope thickness distribution. Middle panel: histogram for models with canonical values of the hydrogen envelope thickness, as predicted by stellar evolution theory. Lower panel: histogram for models with non−canonical values of the hydrogen envelope thickness.

corresponding to thin solutions. We find that 32 out of the 42 ZZ Ceti stars analyzed have a best fit model characterized by an hydrogen envelope thinner than predicted by standard evolutionary theory, with a strong component between $\log(M_{\rm H}) = -7$ and $-8$. Finally, the mean hydrogen envelope mass of our sample is $\langle M_{\rm H}/M_* \rangle = 5.24 \times 10^{-6}$. These results indicate that an important fraction of DA white dwarf stars might be formed with an hydrogen envelope much thinner than that predicted by standard evolutionary theory. This result should have a strong impact on the derived ages from white dwarf cooling sequences for globular clusters.

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