A new instability domain of CNO-flashing low-mass He-core stars on their early white-dwarf cooling branches

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While evolving toward their terminal white-dwarf cooling branches, some low-mass helium-core white dwarf stellar models experience a number of nuclear flashes. Just before the occurrence of each flash, stable hydrogen burning may be able to drive global pulsations that could shed some light on the internal structure of these stars through asteroseismology.

We perform a pulsational stability analysis considering the effects of the ε mechanism in destabilizing gravity-mode periods for sequences of low-mass helium-core stars on their early white-dwarf cooling branches going through CNO flashes. We assess the ranges of unstable periods and the corresponding instability domain in the log g − Teff plane.

Numerical codes: We employed the evolutionary models of low-mass He core WDs generated with the LPCODE stellar evolution code (Althaus et al. 2013).

We carried out a pulsation stability analysis of nonradial dipole (ℓ= 1) and quadrupole (ℓ = 2) g modes employing the nonadiabatic version of the LP-PUL pulsation code (Córsico et al. 2009).

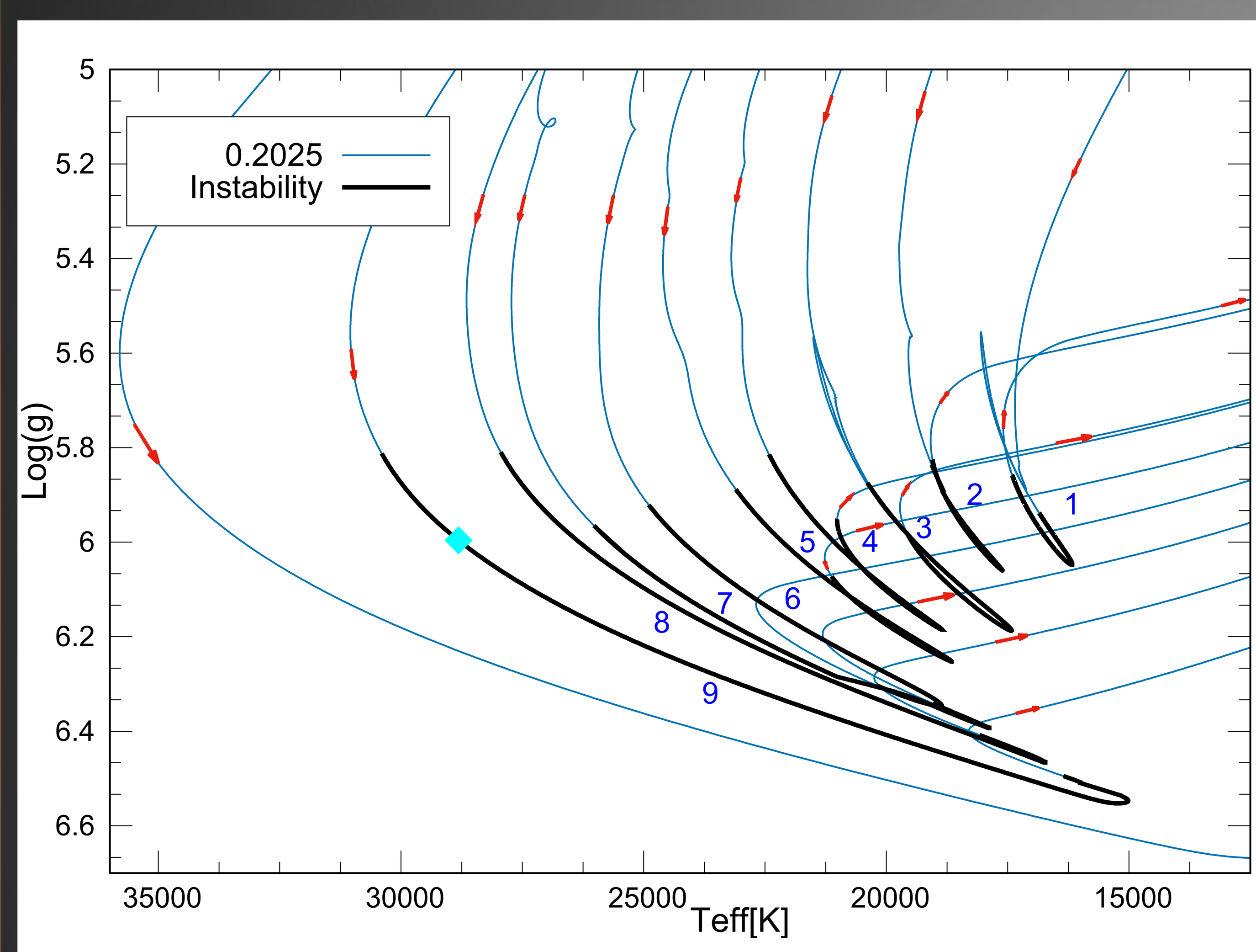


Fig 1. Instability domain corresponding to the ε mechanism on the log g vs Teff diagram for the the low-mass He-core sequence with 0.2025 M⊙ (Althaus et al., 2013). The stages of pulsational instability are emphasized with thick black lines along the evolutionary track. Low-order g modes are driven before each one of the nine CNO flashes. It is clear that the extension of the region of instability in the log g - Teff plane grows with every consecutive flash. The track begins after the end of Roche-lobe overflow (upper right branch of the curve).

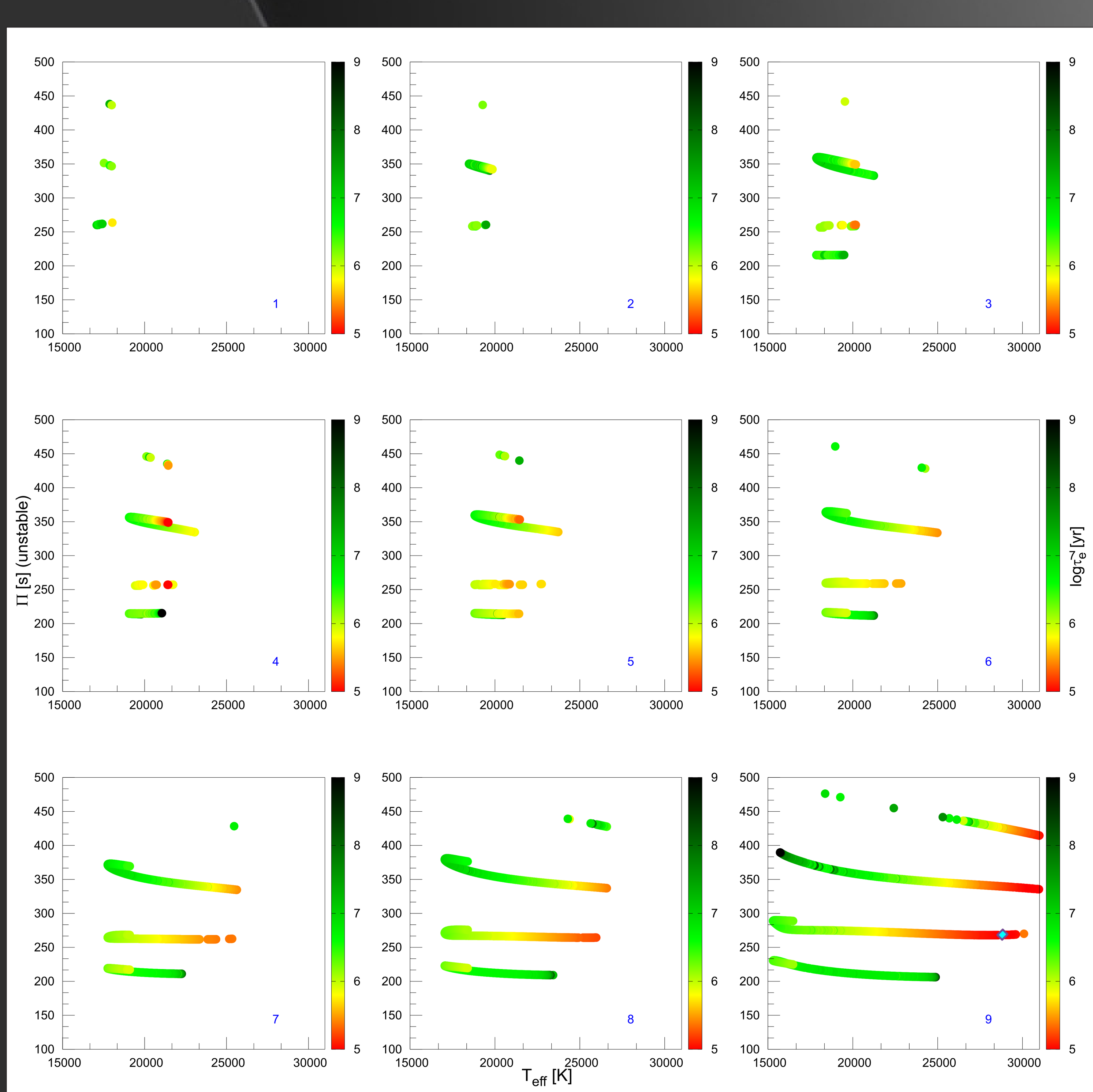
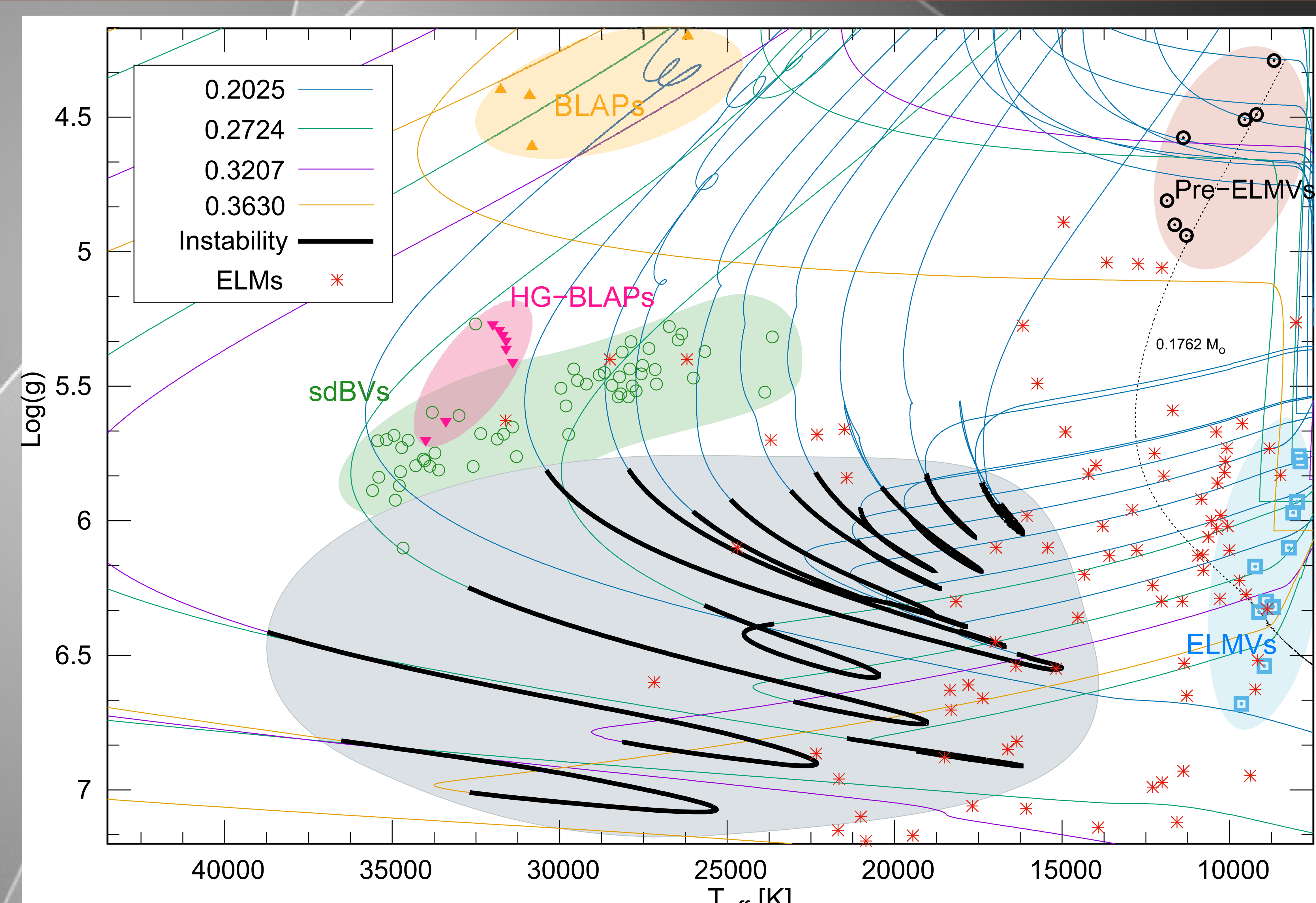


Fig. 2. Periods of unstable ℓ= 1 g-modes in terms of Teff for the nine flashes of the low-mass sequence with 0.2025 M⊙. Color coding indicates the e-folding time of each unstable mode. The instability region becomes wider, and with more modes being destabilized with every flash. The instability domains are considerably extended and the e-folding times significantly shorten, thus these modes may have a larger chance to reach observable amplitudes.

Fig 3. Instability domain (grey shaded area) of low-order g modes excited by the ε mechanism on the log g vs Teff for all low-mass WDs analyzed (with stellar masses between 0.2025 and 0.3630 M⊙). Thick black lines along each evolutionary sequence mark the regions of unstable g-mode periods. Included are the known variables ELMs (ELMVs) and pre-ELMs (pre-ELMVs), along with the location of others pulsating stars.



Every evolutionary sequence has an extended zone of pulsation instability which, altogether, results in a wide region in the log g - Teff plane (gray shaded area) where low-order ℓ= 1 g modes can be destabilized by the ε mechanism. This region covers the ranges in Teff of [15000− 38000] K and log g of [5.8− 7.1] (for ℓ= 2 g modes, the location in the log g − Teff diagram is similar). The range of ℓ= 1 g-mode periods destabilized by the ε mechanism is [150- 500] s, with radial order k between 1 and 4. This new domain of instability does not overlap with the domain of instability of ELMVs and pre-ELMVs, and barely overlaps with the instability domain of the sdBV stars.

Since, in general, the timescales required for these modes to reach amplitudes large enough to be observable are shorter than their corresponding evolutionary timescales, the detection of pulsations in these stars is feasible.

- Althaus, L. G., Miller Bertolami, M. M. & Córsico, A. H. 2013, A&A, 557, A19
- Córsico, A. H., Althaus, L. G., Miller Bertolami, M. M., et al. 2009, ApJ, 701, 1008