Confining the Edges of the GW Vir Instability Strip

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Abstract. Ground based optical spectroscopy as well as EUVE and HST observations are used for model atmosphere analyses of PG 1159 stars in order to confine the GW Vir instability strip.

1. Introduction

The PG 1159 stars are hydrogen-deficient post-AGB stars within their hottest stage of late stellar evolution. They probably are descendants from the Wolf-Rayet central stars of planetary nebulae and will evolve into helium-rich white dwarfs. The origin of the H-deficiency remains unclear, but we argued that a late thermal pulse causes the removal of the outer stellar layers. The PG 1159 stars span a wide range in $T_{\rm eff}$ and $\log g$ (Fig. 1). Most of the 26 known objects of this spectroscopic class have photospheres which are dominated by helium, carbon, and oxygen and about every other star is associated with a planetary nebula. During the past years we have analyzed almost completely the whole ensemble of PG 1159 stars, for a recent review see Dreizler et al. (1995).

2. The GW Vir Instability Strip

Eight PG 1159 stars, including the prototype PG 1159-035 (alias GW Vir), are known as multimode nonradial g-mode pulsators. The pulsation driving mechanism is the $\kappa - \gamma$ effect of carbon and oxygen (Starrfield et al. 1984). Large amounts of C and O, a low amount of He as well as the complete absence of H in subphotospheric layers are necessary conditions for driving pulsations. Since these conditions meet the observed photospheric compositions it is widely accepted that C and O opacities are responsible for the instabilities. However, detailed non-adiabatic pulsation modelling (Stanghellini et al. 1991) appears at variance with the observations, because the theoretical instability strip extends too low in $T_{\rm eff}$. It is therefore highly desireable to confine the instability strip by means of spectroscopic analyses of pulsating and non-pulsating members of the PG 1159 group.

Figure 1 shows the results of our analyses, together with the positions of related objects. The grey hatched area comprises the locations of the GW Vir stars (filled symbols). The red and blue edges of the instability region at $\log g = 7$

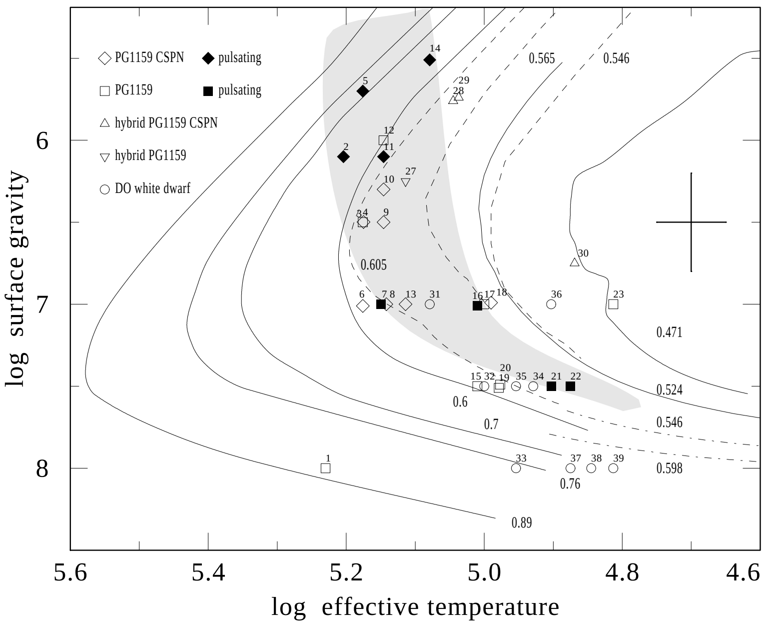

Figure 1. Location of the GW Vir instability strip, comprising the pulsating PG 1159 stars (filled symbols). Evolutionary tracks are labeled with the respective stellar mass. A typical error bar is shown. For details and object identification see Dreizler et al. (1995).

are quite well defined by pulsating/non-pulsating pairs of objects with similar $T_{\rm eff}$. In particular, the blue edge divides PG 1159-035 with $T_{\rm eff}$=140kK from its non-pulsating counterpart PG 1520+525 with $T_{\rm eff}$=150kK. Very precise analyses enabled by HST (UV) and EUVE spectra were required since optical spectroscopy alone is too insensitive to detect such small differences in $T_{\rm eff}$. A word of caution is appropriate. The precise limits of the instability region certainly depend on the total amount of C and O in the driving region as well as on the relative abundance ratio of these species. Several non-pulsating objects are located within the instability strip. This might be a consequence of compositions differing from those in the pulsating stars. Object #27 (HS 2324+3944) for example is a hybrid-PG 1159, i.e. it has detectable traces of H in its atmosphere. If present in the deeper layers, too, hydrogen would poison the pulsations. Photometric observations are still lacking for this recently discovered star.

Acknowledgments. This research was supported by grants from the DFG (He 1356/16-2, We 1312/6-1) and the BMFT (50 OR 9409 1).

References

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