A SEARCH FOR NEW FAST PULSATING HOT SUBDWARFS: RESULTS FROM OUR LAST 4 OBSERVING CAMPAIGNS

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Abstract: Our last photometric campaigns, intended for looking for new pulsating B-type hot subdwarfs, specially those with the shortest periods, are presented. As a result, four new pulsating objects have been discovered, thus increasing by about 10% the number of V361 Hya stars known to date. As a byproduct, a new eclipsing binary system has also been discovered in the course of the campaigns. The new pulsators have physical parameters and frequencies of oscillation in agreement with other hot subdwarfs of the same class.

Keywords: Hot Subdwarfs – Asteroseismology.

1 Introduction

Hot subdwarfs are identified with stellar models burning He in the core (or in shell subsequently), with a canonical mass of $0.5M_\odot$ [1, 2]. They have such a thin H layer, that they are unable to ignite H-shell burning and therefor do not proceed through the Asymptotic Giant Branch. On the other hand, hot subdwarfs go directly to the White Dwarf cooling track after He-core exhaustion [3].

Roughly, hot subdwarfs can be spectroscopicaly classified in two groups: B-type (sdBs), and O-type (sdOs), based on the absence or presence of HeII [4], although the He abundance within each group varies enormously. Their evolutionary status and their possible connection are still a matter of debate, although several evolutionary scenarios involving binary interaction must be considered.

Nowadays, two classes of pulsating sdBs have been reported. V361 Hya stars have periods of oscillation of the order of 2–5 min, with amplitudes of 1–50 mmag. They are theoretically explained as p-modes of low radial order n, driven by an opacity bump due to a local enhancement of heavy elements [5, 6]. On the other hand, V1093 Her stars have longer periods ($\sim$1 h) and lower amplitudes of oscillation [7]. They have also slightly lower effective temperature and surface gravity than V361 Hya objects. Their variability is caused by g-modes of high n driven by the same κ mechanism operating in V361 Hya stars [8].

The presence of stellar oscillations allows the study of hot subdwarfs by means of asteroseismology. Crucial stellar parameters can be derived with this technique, hardly obtained by other approaches, which can help to better understand the evolutionary status of hot subdwarfs.

2 Observations

With the aim of increasing the number of pulsating sdBs, so that the stars subject to a seismological study is statisticaly significant, four photometric campaigns have been carried out so far. The main source of candidates was the catalog of [9], the most up to date compilation of hot subdwarfs. The targets were selected according to suitable coordinates and magnitude to each epoch and telescope. They were also selected trying to match the physical parameters of known pulsating sdBs, since they tend to cluster around certain temperature and gravity values.

The observations consisted on meassuring the flux as function of time for each object in the candidate list. The short periods of V361 Hya stars make fast photometry required, but, on the other hand, the temporal series do not need to be very long in order to detect such periodicities. Sampling times between 10 and 40 s were employed during the campaigns and the light curves obtained have a total length of $\sim$20 min or more.

The amplitude spectrum of each star was computed by fitting the light curves to sinusoidal functions. A particular star is considered to be pulsating if its amplitude spectrum displays a frequency with an amplitude higher than 3.7 times the noise level.

Table 1 includes the list of observed stars, their magnitude, date of observation, length of the acquired light curve, telescope used, and the results on their pulsating behaviour. In case a star does not show any frequency with amplitude above the threshold level, 3.7 times the noise level is included, which indicates the target is not pulsating *above this amplitude level*.

3 Results

Four stars out of 36 observed turned out to be new pulsating sdBs. Their physical parameters agree with those of other V361 Hya stars (see Fig. 1, left panel). Besides, the frequency ranges of the oscillations agree with the values of other pulsating sdBs, as seen in Fig. 1 (right panel). However, a comparison of the number of detected modes to other V361 Hya objects with similar parameters suggests that PG 1657+416, HE 2151-1001 and HS 2125+1105 might have additional excited modes. Further photometric campaigns are needed to more precisely resolve their amplitude spectrum.

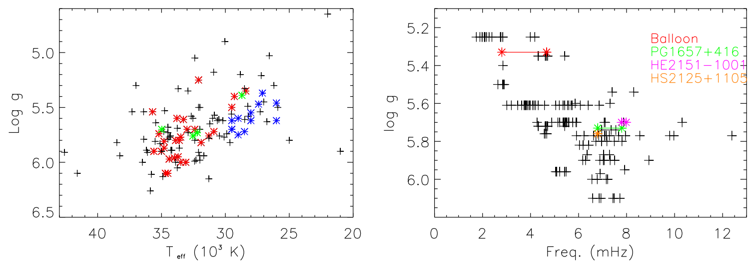

Figure 1: Left panel: $\log g - T_{\rm eff}$ diagram for a sample of sdBs. Crosses correspond to stars not observed to vary, red (blue) asterisks to sdBs with short (long) period oscillations, while the new pulsating sdBs discovered are represented as green asterisks. Right panel: range of detected frequencies for V361 Hya stars as function of their $\log g$ value, in colors for the sdBs detected within the frame of this work.

References

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Star	Magnitude	Date	Length	Telescope	3.7*Noise
PG2226+094	14.1	30 Ag. 2003	2h46m40s	IAC80	2 mmag
PG0032+247	13.8	31 Ag. 2003	1h50m40s	IAC80	4 mmag
PG2059+013	14.8	31 Ag. 2003	3h29m00s	IAC80	3.1 mmag
Balloon 090100001	11.8	4 Sept. 2003	4h27m50s	IAC80	Yes
HIP65388	12.7	23 May 2004	16m15s	NOT	1.1 mmag
HIP67396	11.4	24 May 2004	15m00s	NOT	1.5 mmag
Balloon83500005	13.8	24 May 2004	14m45s	NOT	2.7 mmag
PG1530+057	14.2	24 May 2004	18m00s	NOT	2.2 mmag
PG1021-029	15.3	24 May 2004	27m00s	NOT	3 mmag
PG1050-065	14.0	24 May 2004	21m15s	NOT	4.5 mmag
HE1415-0309	16.3	24 May 2004	40m00s	NOT	5 mmag
		10 Jun 2006	1h0m25s	NOT	2.6 mmag
HE1441-0558	14.4	24 May 2004	27m45s	NOT	3.1 mmag
PG 1657+416	15.9	25 May 2004	32m00s	NOT	Yes
PG1448-052	14.4	25 May 2004	27m15s	NOT	2.1 mmag
PG1519-071	15.6	25 May 2004	30m45s	NOT	1.9 mmag
PG1536+097	15.9	25 May 2004	31m15s	NOT	2.3 mmag
HS1710+1614	15.7	25 May 2004	26m45s	NOT	2.5 mmag
SJ1548-0049	16.4	25 May 2004	29m00s	NOT	2.9 mmag
PG1532+522	13.8	4 May 2005	1h16m40s	IAC80	2.6 mmag
PG1449+653	13.7	5 May 2005	1h32m00s	IAC80	2 mmag
PG1154-070	14.2	30 May 2005	35m40s	NOT	1.2 mmag
PG1407+005	15.2	30 May 2005	31m40s	NOT	1.6 mmag
PG1549-001	15.0	30 May 2005	36m40s	NOT	2.4 mmag
		1 Jun 2005	1h8m45s	NOT	0.7 mmag
HS2125+1105	16.3	31 May 2005	38m30s	NOT	3.4 mmag
		11 June 2006	47m20s	NOT	Yes
PG1644+404	15.2	31 May 2005	19m30s	NOT	1.4 mmag
HE2151-1001	15.6	31 May 2005	59m30s	NOT	Yes
PG1636+216	14.7	31 May 2005	33m20s	NOT	2.1 mmag
KPD1901+1607	14.3	31 May 2005	21m45s	NOT	1.2 mmag
PG1647+252	14.1	31 May 2005	22m40s	NOT	1.5 mmag
PG1544+601	16.8	31 May 2005	41m25s	NOT	2.3 mmag
SJ1642+4403	16.7	31 May 2005	28m40s	NOT	2.5 mmag
PG1645+610	14.3	1 Jun 2005	30m20s	NOT	1.4 mmag
PHL189	17.0	1 Jun 2005	33m20s	NOT	4.2 mmag
HS2231+2441	14.1	1 June 2005	1h37m45s	NOT	Eclip.
HE1459-0234	14.9	1 Jun 2005	36m40s	NOT	1.6 mmag

Table 1: Log of observations, including 3.7 times the noise level in case the star does not show signs of variability.