Pulsation stability of helium-rich subdwarfs

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Abstract

We present results of the pulsation monitoring of helium-rich subdwarf stars using high speed differential photometry observations made with the SAAO (1.0m), NOT (2.6m) and the IAC80 (0.8m) telescopes. We do not find any conclusive sign of pulsation in the twenty helium-rich subdwarf B stars monitored although in some stars there are hints of pulsation which require further investigation.

Introduction

Helium-rich subdwarf B (He-sdB) stars were originally identified as sdOD stars in the Palomar-Green survey of faint blue stars (Green et al. 1986). Since then they have been called He-sdB, sdB4 and sdB:He4 by different authors. These rare stars have been found both in the disk our galaxy and in globular clusters.

Spectroscopically He-sdB stars show very weak or no Balmer lines and strong HeI absorption lines. Consequently they appear to have similar effective temperatures ($T_{\rm eff}$) and surface gravities ($\log g$) to normal sdB stars, but with a much higher helium abundance.

Pulsation in stars is an important tool for determining their mass, radius and other fundamental parameters. Pulsation in sdB stars was first discovered by Kilkenny et al. (1997a) and is thought to be driven by an iron opacity bump (Charpinet et al. 1997).

Jeffery & Saio (1999) have suggested a systematic variability study of He-sdB stars since they lie near to the theoretical Z-bump instability finger. We have observed a sample of twenty He-sdB stars to determine if they pulsate or not. If pulsations are found in these stars, they would form a new class of hot subdwarf pulsator.

Observations

Twenty He-sdB stars have been monitored for pulsations. These comprise mainly southern targets from the Edinburgh-Cape survey (Kilkenny et al. 1997b).

The observations for this programme were carried out primarily at the SAAO 1.0m telescope with the UCT CCD photometer (O'Donoghue et al. 1999) using the Johnson V filter. Three northern He-sdB have also been observed using the IAC80 and NOT. The observations are listed in Table. 1.

Table 1. Photometric observations of He-sdB stars.

No	*Star*	*V*	*T*	*Date*	*C* [s]
1	CS 22190-0003	14.9	1	2002 11 12	30
2	LB 1766	12.3	3	2003 04 24	25
3	HS 0836+620	15.0	1	2002 11 13	30
4	PG 0902+057	14.4	3	2003 04 22	40
5	PG 0914-037	16.4	3	2003 04 26	30
6	PG 0959-085	16.1	3	2003 04 24	30
7	EC 11198-2203	16.8	3	2003 04 25	60
8	PG 1127+019	13.6	3	2003 04 22	30
9	EC 12436-2134	16.2	3	2003 04 23	30
10	EC 13150-2832	16.0	3	2003 04 24	20
11	EC 13290-1933	14.5	3	2003 04 24	30
12	EC 13342-2739	16.7	3	2003 04 26	30
13	PG 1413+114	16.1	3	2003 04 23	30
14	EC 14316-1908	13.2	3	2003 04 26	30
15	EC 15477-1523	16.3	3	2003 04 22	30
16	PG 1600+171	16.3	3	2003 04 23	45
17	CS 22885-0043	15.6	3	2003 04 24	30
18	CS 22940-0009	14.1	3	2003 04 23	30
19			3	2003 04 26	20
20	LS IV-14°116	13.0	3	2003 04 25	15
21			3	2003 04 26	20
22	CS 22956-0090	14.2	3	2003 04 26	30
23	PG 2321+214	13.6	2	2002 10 11	20

Telescopes used:
1 : IAC80 - Teide 80cm Telescope
2 : NOT - Nordic Optical Telescope
3 : SAAO - 1.0m Elizabeth Telescope

The UCT CCD was used in frame transfer mode to carry out high speed differential photometry of our sample of He-sdB stars. The size of the usable chip on the UCT CCD photometer is ~190×74″ hence for some targets it was difficult to find good comparison stars.

The UCT CCD frames were bias subtracted and flat-fielded using SCANFITS and CLEEN programs (O'Donoghue et al. 1999). The reduced frames were then analysed using the IDL DAOPHOT routines. The IAC80 and NOT data were reduced with RTP software.

Results

We present the light curves for the observed He-sdB stars as differential magnitude in Fig. 1. It should be noted that due to the small size of the UCT CCD, stars close to the target had to be selected as comparison some of which show signs of periodic variations themselves. Such comparison stars were not used for the differential correction.

A Lomb-Scargle periodogram (Scargle 1982) was computed for each light curve using the University of Tübingen's time series analysis IDL routine – SCARGLE. The periodograms were computed from $\omega = 2\pi/T$ to $\omega = \pi N_{\rm o}/T$ with a spacing of $1/T$ where $N_{\rm o}$ is the number of observations and T is the total time of observation. The Scargle periodograms are shown in Fig. 2. The periodogram provides a statistical estimate of the probability of a peak being due to a real periodic variability in the data. No peaks in the data were found with confidence >90% (Fig. 2).

He-sdB stars from Ahmad & Jeffery (2003) which include a few stars from our sample are plotted in Fig. 3 to compare their position with other known sdB pulsators (sdBV stars).

Conclusions

We do not find conclusive evidence for periodic variability in any of the He-sdB stars observed. There are suggestions of significant peaks in the periodograms for LB 1766, EC 12436-2134, EC 13290-1933, PG 1413+114 and CS 22956-0090 but these are not strong enough to be reliable. Further observations are required for these stars to lower the detection threshold.

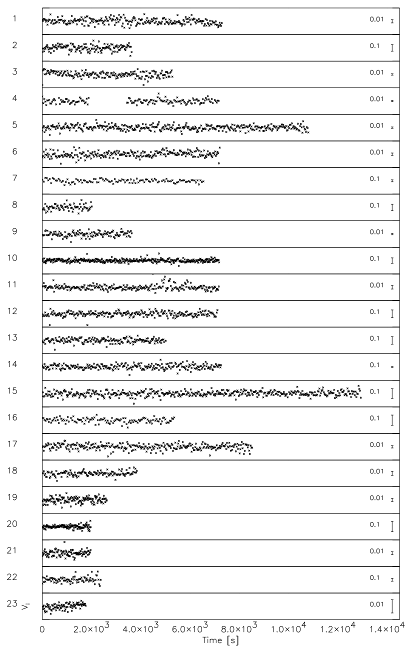

Figure 1. Light curves of He-sdB stars. The vertical bars represent the scale in each panel as the instrumental V magnitude.

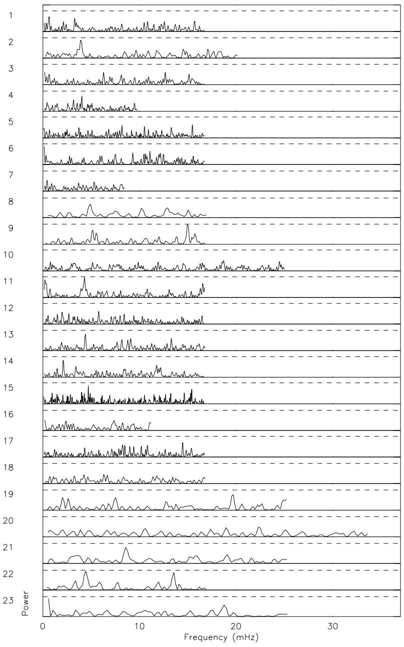

Figure 2. Scargle periodogram He-sdB stars. The vertical plot ranges from 0 to the False Alarm Probability (FAP) corresponding to 99% significance. The dashed line corresponds to the FAP of 90% significance.

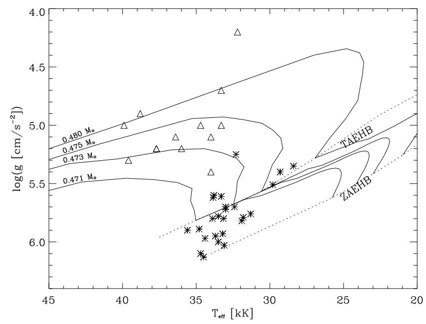

Figure 3. Position of He-sdB stars (triangle) from Ahmad & Jeffery (2003) in comparison to known sdBV stars (asterisk). Evolutionary tracks are taken from Dorman et al. (1993).

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