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DO EC 14026 STARS EXIST IN CLUSTERS?

M. D. Reed[1], D. Kilkenny[2] and D. M. Terndrup[3]

[1] *Missouri State University, Springfield, MO 65804, U.S.A.*

[2] *South African Astronomical Observatory, Cape Town, South Africa*

[3] *The Ohio State University, 140 W. 18th Avenue, Columbus, OH 43210, U.S.A.*

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Abstract. We have began a program to search for pulsating sdB stars in open and globular clusters. Detection of pulsators in clusters would aid the understanding of their evolution, since the masses and metal content of the main-sequence progenitors would be known. Here we describe the beginning of our search during which we plan to observe about 100 sdB stars. A failure to detect any pulsators would suggest differences between sdB stars in clusters and in the field of the Milky Way (e.g., metallicity, binarity) which would need to be taken into account by any pulsation/evolution scenario.

Key words: stars: AGB and post-AGB, variable: general – clusters: individual (NGC 6791, NGC 188, NGC 6571, M 13, M 15, NGC 2808)

1. OBSERVATIONS AND ANALYSIS

To date we have observed more than 50 stars during 54 short data runs. Data were obtained for the open clusters using McDonald Observatory's 2.1 m telescope and for the globular clusters using the MDM Observatory's 2.4 m and the SAAO 1.9 m telescopes. All data were obtained using high-speed CCDs and processing was done using standard IRAF routines.

Differential light curves were produced using MOMF (Kjeldsen & Frandsen 1992). The accuracy of the photometry depended on several factors including the signal-to-noise (brightness) of the target and comparison stars, the number of available comparison stars, and of utmost importance for globular cluster fields, the seeing and how crowded the fields are compared to the resolution. A selection of some of the light curves and temporal spectra for sdB stars in NGC 6752 are provided in Figures 1 and 2. The dotted lines in Fig. 2 is the detection threshold discussed below.

Limits on time-series photometry can be a bit tricky as even noisy data can result in relatively flat temporal spectra (Howell 1992; Breger et al. 1994). To quantify the detection limits of our data, we used the 4σ approach of Breger et al. (1994). However, it is actually easier to detect pulsations than it might seem as during short data runs, the power can combine into unresolved peaks. (Likewise, unresolved pulsations can also cancel each other during a "beat.") For example, the highest amplitude mode of the known pulsator Feige 48 is about 5 mma when

Table 1. Detection limits for the target stars. Column 1 gives the star designation, column 2 the 4σ limit and column 3 indicates the percentage of (24) known pulsators that would be detectable at our threshold limit.

Target	Limit (mma)	%	Target	Limit (mma)	%	Target	Limit (mma)	%
				NGC 6791				
B3	3.9	92	B5	5.8	75	B9	4.6	92
B4	4.8	92	B6	3.0	92	B10	3.2	92
				NGC 188				
II-91	3.1	92	D702	1.9	96			
				NGC 1904				
Hill11	3.1	92	Hill34	3.1	92	Hill70	1.9	96
				NGC 2808				
6022	3.1	92	6816	1.9	96	6849	2	20
8750	3.1	92	9301	1.9	96	9863	2	20
14040	3.1	92	18899	1.9	96			
				ω Cen				
10123	3.1	92	C521	1.9	96	BC77702	4	20
D16003	3.1	92						
				NGC 6752				
S3616	3.0	92	S23768	2.2	92	S3936	2.0	96
S3422	2.5	92	S23665	2.0	96	S24268	2.0	96
S31695	3.0	92	S23407	5.0	75	S5610	4.5	92
S30963	3.2	92	S12087	7.0	58	S23975	25	8
S3008	2.8	92	S11517	3.9	92	S5719	14	25
S29988	3.0	92	S9135	3.0	92	S27622	3.8	92
S29704	2.2	92	S7935	3.0	92	S6224	3.3	92
S28234	3.5	92	S7860	4.3	92	S28073	2.0	92

resolved, but typically appears close to 8 mma in nightly runs that do not resolve the pulsations. Therefore, we examined our own observations of known sdBV stars, as well as those of the literature to estimate pulsation amplitudes of known sdBV stars from 2 hour data runs. This provides two detection limits:

(1) the 4σ limit, and

(2) a "likelihood" that we would detect pulsations. The percentage of known pulsators that would be detected at our 4σ limit from a 2 hour data run (of 24 known sdBV stars). These values are given in Table 1 and show that we are far more likely to have detected pulsations, were they occurring, than to have missed them for the majority of our targets.

2. RESULTS

Though this is a work-in-progress, we have already made significant progress and achieved some success. We have observed more than half of our goal of 100 stars, but have yet to ensure that all targets have appropriate temperatures and gravities for EC 14026-type pulsators. We have also not completed our photometry and analysis, yet are already aware that some stars will not have useful detection limits. During the 2004 January SAAO observing run, we became aware that

NGC 2808 was too faint for the seeing conditions and scampered for back-up targets. These stars were chosen on the basis of color, so should be EHB stars, but may not be sdB stars. In contrast, during our 2004 July SAAO observing run, the seeing was excellent and we obtained useful limits for nearly every target star on our list.

At this point in our analysis, we have not detected any pulsating stars, but it is too early to determine how significant our non-detection is. Yet we can state with some certainty that previously suspected open cluster pulsators B5 and D702 (Yong et al. 1998; Bailyn 1998) do not pulsate. We also examined our data for PG 1716-type pulsations. However, our observing runs were typically too short to discern, with any accuracy, whether or not such variations exist. In no case did we detect long period variations, even though the star B4 is known to vary with a period near 19 hours; far too long for us to detect. (However, for contrast we refer readers to the paper by Kilkenny et al. (2006) where a PG 1716-type pulsator *was* detected with just 2 hours of data!)

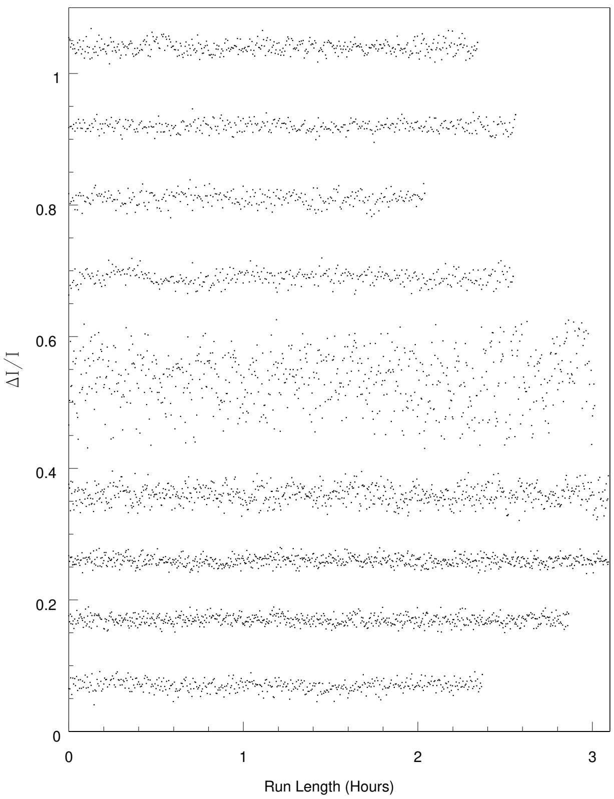

Fig. 1. Sample light curves for nine stars in NGC 6752 observed from SAAO.

Our efforts have been somewhat hampered by the fact that most of our targets are in the Southern Hemisphere, yet telescope time is very difficult to obtain there. The SAAO 1.9 m, though readily available and an excellent telescope, is a bit too small for most clusters while 4 m telescopes either lack appropriate instrumentation (CTIO) or are heavily constrained by queue schedules and allocation procedures (ESO).

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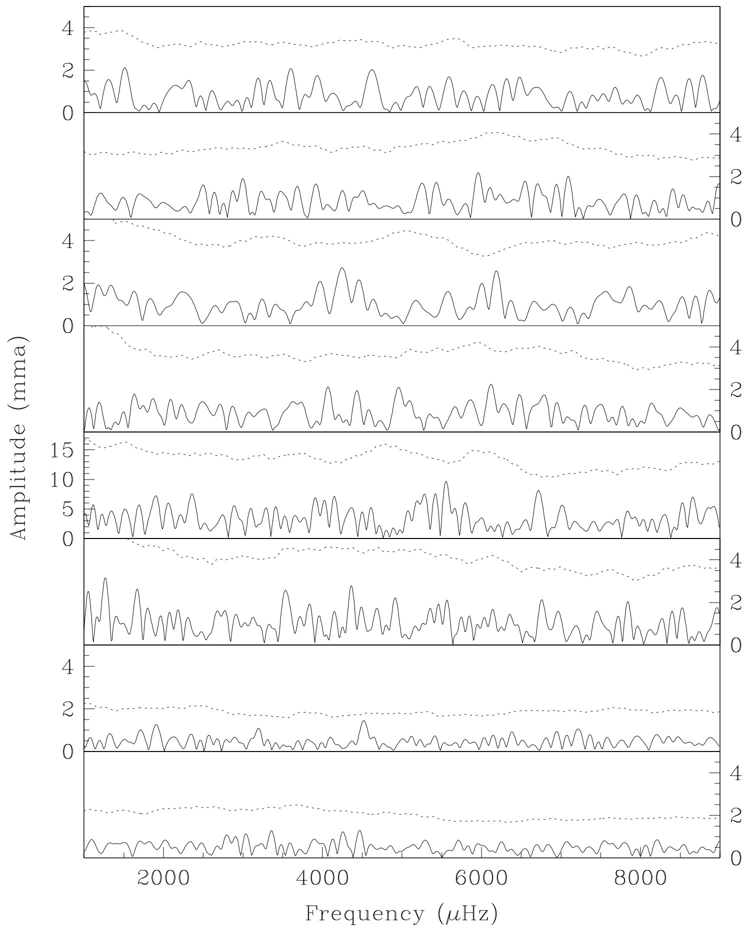

Fig. 2. Fourier transforms of the light curves in Fig. 1. Dashed lines are the 4σ detection limit.

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