The A-Star Puzzle
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Long period oscillations in roAp stars

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Abstract. We present the results of observations made over three weeks using the UCT CCD Photometer on the 0.75-m telescope at the South African Astronomical Observatory. Candidate long period roAp stars were identified from their positions on the H-R diagram and observed for a typical period of 4 hr to test for the existence of pulsations, with particular emphasis on pulsations with periods in excess of 15 min. Although 13 stars were successfully observed, none exhibited significant pulsations.

Keywords. Stars: oscillations

1. Introduction

Observations of pulsations in the roAp stars have yielded periods of between 5 and 15 minutes. However, Cunha (2002) predicted an instability strip that includes oscillations with periods of greater than 20 min (see Fig. 1).

Although no pulsations of such low frequency have yet been detected using photometric techniques, this is likely to be due to a selection effect of how candidate stars are chosen. Traditionally, only stars with a δc_1 index less than zero have been considered as candidates due to this being a good indication for peculiarity. But for the giant stars which are predicted to exhibit longer period oscillations the δc_1 index generally appears to be normal.

Using $uvby\beta$ calibrations from Crawford (1979) and Hipparcos parallaxes, candidate long period pulsators were identified from their position in Fig 1. Temperatures were calculated using the calibration of Moon & Dworetsky (1985). The candidates came from stars identified as Ap by Renson *et al.* (1991) and from stars in Hauck & Mermilliod (1998) which had a peculiarity index, δp, (Masana *et al.* 1998), defined from the $uvby\beta$ photometry, of greater than 1.

2. Observations & data analysis

The observations were made with the 0.75-m telescope at the South African Astronomical Observatory (SAAO) in Sutherland, South Africa using the University of Cape Town CCD Photometer with a Johnson B filter. The high speed photometry observations were made using the frame transfer mask with integration times of 10 s, which allowed stars with V magnitudes fainter than 7.75 to be observed.

Thirteen stars were observed over a three week period (2004 March 30 – April 12 and 2004 May 4 – 10). While the amount of time for some stars was limited to less than four hours, many were observed for longer than this, and in some cases more than one set of observations could be taken. The properties of the stars investigated are shown in Table 1.

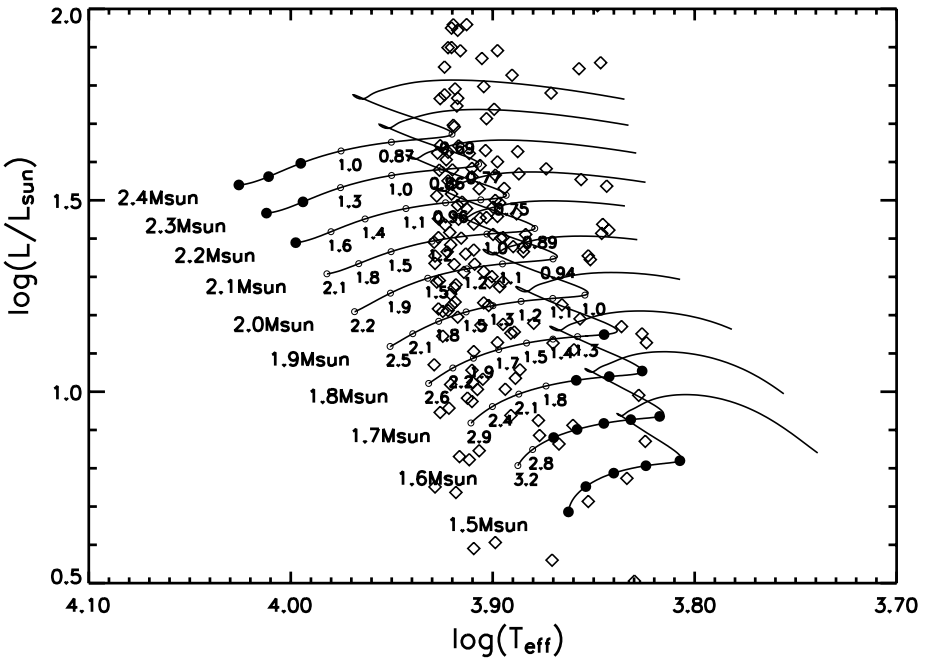

Figure 1. An H-R diagram adapted from Cunha (2002) showing the positions of Ap stars with known Hipparcos parallaxes. The lines refer to evolutionary models with the mass in solar masses shown next to each model. Filled circles indicate a model where pulsations are not excited whereas unfilled circles indicate that pulsations were present in the model and the associated peak frequency in mHz is noted beneath each circle.

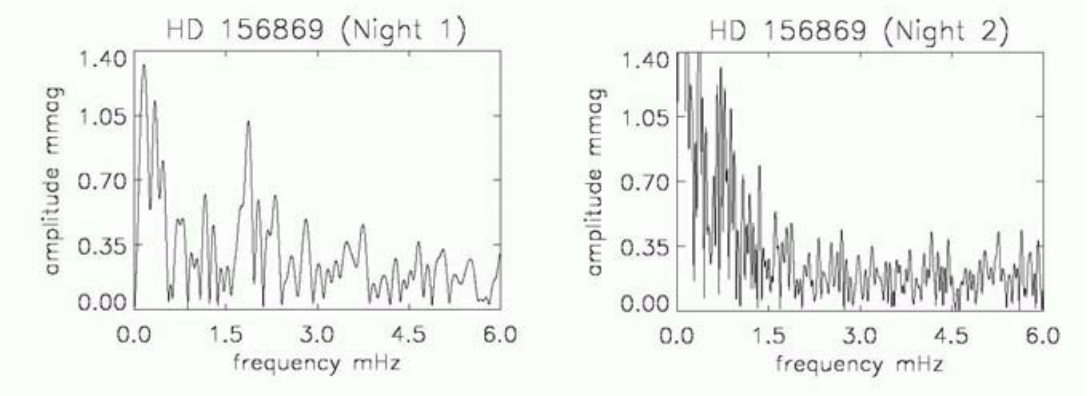

Figure 2. The amplitude spectrum of the light curve of the star HD 156869 taken on two separate nights. The left panel (Night 1) shows a peak at a frequency of 1.882 mHz with an amplitude of 0.925 mmag. However, further in-depth observations on the same star several nights later (shown in the right panel) over 6 hr show no signal with the spectrum consistent with pure noise.

3. Results & discussion

Of the 13 stars several showed initially interesting features in the amplitude spectra. However, after follow-up observations on all these stars it was concluded that the peaks seen were due to noise in the amplitude spectrum, rather than real features.

There are several interpretations of these results, the first of which is that no higher luminosity Ap stars exhibit these types of pulsations. However, the sample is not large

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Table 1. The 13 candidate stars observed using the UCT CCD Photometer on the 0.75-m at SAAO

HD	δp	$\log T_{\rm eff}$	$\log\left(\frac{L}{L_\odot}\right)$
62556	0.389	3.92	1.50
63759	0.102	3.93	1.48
86592	4.751	3.90	1.32
95699	1.587	3.92	1.48
100357	0.202	3.89	1.21
103302	-0.490	3.93	1.55
106215	0.010	3.92	1.41
132322	1.940	3.93	1.44
135728	2.160	3.90	1.28
137160	-0.927	3.91	1.34
156869	-1.133	3.91	1.45
159009	3.079	3.89	1.32
171771	-0.075	3.92	1.44

enough to rule out the possibility of future photometric detection of such pulsations. The second interpretation is arrived at from the nature of the models reported in Cunha (2002). While the frequency of pulsation can be calculated for each mass, it is impossible to predict the amplitude of these oscillations. As a result it is entirely possible that the pulsations may be present in the sample, but the amplitudes are too low to allow for photometric detection using current ground-based techniques.

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