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Stellar variability in the sub-horizontal branch region of the LMC

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Abstract. We present the initial results from an in-depth re-examination of the MACHO project Large Magellanic Cloud database to identify and characterize stellar variability near the intersection of the instability strip and the main sequence. This dataset's long time-series and uniform photometry is an unprecedented resource for describing the frequency and regions of incidence of various radial and non-radial modes of excitation. The raw MACHO photometry has been investigated to identify factors responsible for most of the residual photometric variance and increase the sensitivity to small amplitudes. We present details of the search method used, the δ Scuti variables detected thus far and discuss the implications for the completed survey.

1. Introduction

The region of the colour-magnitude diagram where the Cepheid instability strip approaches and meets the main sequence is populated by a variety of variable star types. These objects are difficult to detect in current LMC surveys: typical amplitudes are less than 0.1 magnitudes, periods are as short as a few hours and they have typical magnitudes that place them near the photometric detection limit.

Of particular interest are the δ Scuti pulsators, especially those of high amplitudes ($A_V \geq 0.1 - 0.3$) also known as HADS. Analysis of a significant sample of LMC HADS would provide a valuable complement to studies of these objects in our Galaxy and nearby dwarf galaxies and could allow us to:

- test P-L relations on a sizeable sample at a uniform distance
- examine the fraction of such stars that show double and multi-mode pulsation and investigate the period ratios at a different metallicity
- possibly detect the theoretically predicted period change due to evolution. The long time-baseline and uniform coverage of the MACHO data are ideal for this.

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2. MACHO Photometry

There are a number of factors that contribute additional scatter to the lightcurves especially at fainter magnitudes. To compensate we correlated the residuals and reduction flags for over 15 million observations defining limits for various flags beyond which the scatter was too great. Observations with flags beyond these limits were excluded. The most significant factors were found to be crowding, poor sky subtraction and chunk overlap. This process re-

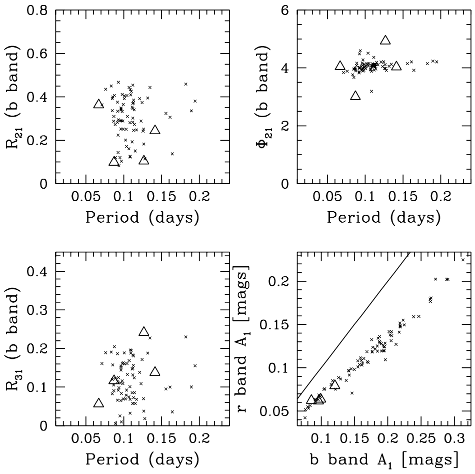

Fig. 1. Lightcurve properties based on the Fourier fits to the 4 δ Scutis detected so far (open triangles) compared to the Alcock et al. (2000) sample of δ Scutis in the Galactic bulge (crosses).

duced the scatter by a statistically significant amount in 80.8% of the systems.

3. Search and Results

The search thus far has covered all systems from 24 tiles of Field 81 of the MACHO LMC database. Initial cuts selected systems with instrumental r magnitudes less than -5 and with colours in the range of $-0.6 < b - r < 0.2$ and likely variables were selected by their Welch-Stetson index (Welch & Stetson 1993). Periodic variables were identified by computing the Lomb-normalized periodogram for all systems using the *fasper* algorithm of Press et al. (1992). For systems with periods less than 0.35 days the Discrete Fourier Transform was computed and the window function removed using the CLEAN algorithm. Systems possessing peaks with $S/N > 3.0$ were kept. A Fourier series was fit to both the r and b light curves of each system and those with appropriate R_{21} and Φ_{21} values (31 systems) were identified as possible δ Scutis. Confirmation as δ Scutis was reserved for those systems whose amplitudes in the r and b bands were in the expected ratio. Only 4 systems met this final criterion (open triangles in Fig. 1).

4. Discussion

The four confirmed systems represent only 15% of the expected number of HADS based on the local space density calculated from the catalogue of Rodríguez & Breger (2001). The use of both bandpasses in selecting δ Scutis may be too stringent given the amount of scatter in the lightcurves.

The results presented here represent 24 out of 169 tiles from Field 81 (which contains regions with very young stellar populations). The completed survey will also encompass and compare Fields 77 (in the LMC bar) and 47 (outside the bar).

This work has focussed on the HADS but many other types of variable star are expected to be recovered. The most significant at these short periods a are likely to be eclipsing binaries particularly W UMa type. Rucinski (2004) estimates that W UMa binaries are 8 times less common than δ Scutis in the solar neighbourhood but twice as common as the HADS.

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