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Hot pulsators in the Magellanic Clouds

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Abstract. We present results of the search for B-type pulsators in the Magellanic Clouds using OGLE-II and MACHO databases. We found 92 β Cephei-type candidates, mostly multiperiodic, in the LMC and six in the SMC. Some multiperiodic SPB candidates (59 in the LMC and 11 in the SMC) were also found. We show that there is a significant decrease in the incidence of β Cephei-type stars going from the Galaxy to the LMC and further, to the SMC. We also present several unexpected results obtained during this search: (i) The presence of a large sample of variable stars showing short period(s) and, additionally, also period(s) about twice longer. (ii) The short-period variability of Be stars in the SMC.

Key words. Stars: early type – Stars: pulsations – Magellanic Clouds

1. Introduction

At present, we know 107 β Cephei-type stars (Stankov & Handler 2005; Pigulski 2005) and about 100 SPB-type stars (De Cat et al. 2004) in the Galaxy. They fall within the instability strips predicted by the theory. The κ-mechanism driving pulsations in β Cephei and SPB stars strongly depends on the abundance of the iron-group ions. Theoretical models predict that pulsations of β Cephei and SPB-type stars vanish for Z smaller than 0.01 and 0.006, respectively (Pamyatnykh 1999).

Large and Small Magellanic Clouds (LMC and SMC) are less abundant in heavy elements than the Galaxy and have relatively well known distance. These galaxies are among the best objects for the study of dependencies of different astrophysical parameters on metallicity.

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2. Observations and analysis

As the main source of the time-series photometry we used OGLE-II data in 32 fields in both Magellanic Clouds (Soszyński et al. 2002) supplemented by the MACHO photometry (Allsman & Axelrod 2001). We selected about 215,000 stars with $V - I_{\rm C} < 0.5$ mag and brighter than 18.5 mag in V from the catalogues of Udalski et al. (1998) and Udalski et al. (2000). For all these objects we performed frequency analysis by means of the Fourier periodograms calculated in the range between 0 and 20 d^{-1}.

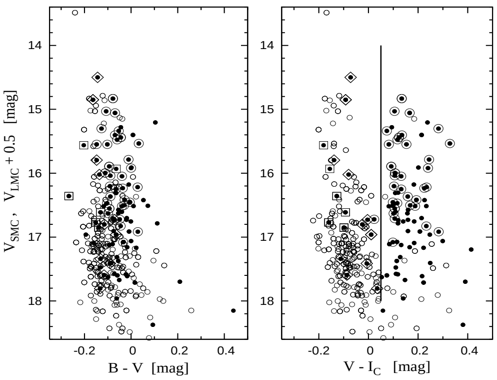

Fig. 1. Colour-magnitude diagrams for multiperiodic stars in the SMC (dots). Known Be stars (Meyssonier & Azzopardi 1993; Evans et al. 2004; Keller et al. 1999) are shown with encircled dots. Six β Cephei candidates are indicated with dots in open squares, 11 SPB candidates, with dots in diamonds. For comparison, positions of multiperiodic variables from the LMC are shown with open circles. Due to the circumstellar extinction, Be stars are generally redder than similar stars without emission. All but one known Be stars locate right of the vertical line, which separates Be and non-Be stars in the right panel. It is evident that Be and non-Be stars differ more in the $(V - I_C)$ colour than in $(B - V)$.

3. The results

We found 92 β Cephei and 59 SPB-type candidates in the LMC. The median period of the β Cephei sample in the LMC is much longer (0.27 d) than in the Galaxy (0.18 d). The longer mean period is consistent with the theory, but only if larger-than-average metallicity ($Z \sim 0.0125$) is assumed for the LMC pulsators. This is possible as there is a large spread in the metallicities in the young population of the LMC stars. In addition, the ranges of periods observed in the LMC β Cephei-type candidates are much narrower than in the Galactic pulsators, as expected from the theory. Surprisingly, a large sample of β Cephei candidates in the LMC ($\sim$ 50%) shows both short period(s) that can be attributed to the p-mode pulsations and about two times longer period(s), characteristic for g-mode pulsations.

As far as the SPB stars are concerned, multiperiodic SPB candidates were found in the whole range of the V magnitudes searched for pulsations. In fact, they are mostly early B or even late O-type stars. This is, however, due to the selection effects, as for mid-B and late-B type stars the photometry is worse than for early B-type stars. Some SPB candidates show nearly doubled periods too. The presence of both long and short periods and the location in the two-colour and colour-magnitude diagrams lead to some problems with the unambiguous classification of the hot pulsators found in the Magellanic Clouds.

In the SMC, we have discovered about 100 multiperiodic variable stars with periods shorter than 1 day. However, these are mostly emission-line stars. From this sample, we selected six multiperiodic β Cephei candidates and 11 multiperiodic SPB candidates. The candidates for hot pulsators can be distinguished from Be stars because: (i) They separate quite well in the $(V - I_C)$ vs. V diagram (Fig. 1), (ii) The photometric variability is different: Be stars exhibit erratic amplitude and period changes, while the brightness variations in hot pulsators are stable and coherent.

A simple comparison with the number of non-pulsating stars indicates that the incidence of β Cephei stars becomes smaller and smaller when going from the Galactic clusters to the LMC and SMC.

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