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Variability analysis of δ Scuti candidate stars

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Abstract. The Hipparcos catalogue contains stars suspected to be δ Scuti variables for which extensive groundbased observations and characterisation of variability are **desired**. We obtained 24 215 CCD images with the 35/51 cm Maksutov-type robotic telescope at the Molėtai Astronomical Observatory (MAO, Lithuania) of thirteen δ Scuti candidates selected from the Hipparcos catalogue in order to characterize their variability. We confirm that twelve of them are variables and pulsate with frequencies typical for δ Scuti-type stars. Five of them may be hybrid δ Scuti-γ Doradus pulsators. One more candidate is a variable star with longer periods of pulsations which are intrinsic to γ Doradus-type pulsators.

Key words: oscillations (including pulsations) – stars: variables: delta Scuti

1. Introduction

Though δ Scuti type stars belong to one of most numerous group of pulsators, much more observational information about this type of stars is necessary in order to improve their models and uncover details about processes happening beneath their surfaces. Therefore we selected 13 δ Scuti candidates from the Handler (2002) study suitable for observations with telescopes of the Molėtai Astronomical Observatory (MAO) in Lithuania.

2. Observations

Observations were performed with the 35/51 cm Maksutov-type MAO telescope and the Apogee Alta U47 CCD camera. We used the Y filter of the medium-band Vilnius photometric system. Its effective wavelength is at 466 nm and the width is 26 nm. The observations were carried out in a semi-robotic mode, i.e. the telescope was changing the pointing and took exposures of different fields of the sky according to the beforehand prepared script. This mode allowed us to observe light variations of stars in 5–7 different fields of the sky during the same night with a cadence of 15–30 minutes. We obtained 24 215 CCD images.

3. Data reduction and analysis

The observed images were first processed with the Muniwin program (Hroch 2014), which is built on the basis of a software package DAOPHOT for doing stellar photometry in crowded stellar fields (Stetson 1987). The LCs were analysed using a process of their Fourier decomposition into sinusoidal components (Fourier 1822). We used a software Period04 (Lenz & Breger 2005) for decomposition of LCs, obtaining amplitude spectra and for prewhitening procedures in order to find all frequencies, amplitudes and phases of pulsations in light curves, spectral windows (SW) and a noise level. As single-site observations were used for analysis, SWs have high side-lobes of 1 c/d aliases. The length of the LCs also differs, thus the FWHM of the central peak in SWs vary between 0.0374 c/d (HIP 106223) and 0.1558 c/d (HIP 11090). The worst SW was obtained for HIP 74155, since it had the smallest set of data points and big (2–5 days) gaps between runs.

First of all we calculated an amplitude spectrum with Period04 and identified the highest amplitude peak at frequencies higher than 2 c/d assuming that the low frequencies may be caused by instrumental or weather instabilities. After that we calculated a sinusoid with the identified frequency and used a least square fitting method improving the amplitude and phase, simultaneously. Then we checked a significance of the extracted frequency by comparing an amplitude of the signal with the mean amplitude of residual in a box ± 10 c/d around the extracted frequency, i.e., we calculated a signal-to-noise ratio (S/N) at the extracted frequency. The signal was assumed as significant if its S/N$\geq$4, according to Breger et al. (1993).

4. Results

In Table 1 we listed the extracted frequencies according to their extraction succession. Considering the amplitude spectra of pulsations we confirm that twelve of investigated stars are variables and pulsate with frequencies typical for δ Scuti type stars. Moreover, five of them (HIP 2923, HIP 5526, HIP 11090, HIP 115856, and HIP 106219) may be hybrid δ Scuti-γ Doradus pulsators, as they simultaneously show high-frequency pulsations typical for the δ Scuti stars and significant low-frequency oscillations (between 0.5422 c/d and 1.3778 c/d) characteristic for the γ Doradus stars. Yet, the firm detection of low frequencies needs more observational data. One more star, HIP 106223, pulsates just with low frequencies typical for variables of γ Doradus type stars. Positions of these stars in the $\log L/L_{\odot}$ versus $\log T_{\rm eff}$ diagram (the values were taken from the *Gaia* DR2) confirm our conclusions. A more detailed description of the analysis was published in Pakštienė et al. (2018).

Table 1. Observed signals in amplitude spectra.

Freq. c/d	Ampl. mmag	Phase	Noise mmag	S/N	Freq. c/d	Ampl. mmag	Phase	Noise mmag	S/N
		HIP 2923					HIP 74155		
15.0271	8.41	0.764	1.45	5.81	11.7619	14.15	0.847	2.99	4.73
16.0973	7.28	0.277	1.25	5.84			HIP 101473		
11.7260	6.24	0.987	1.26	4.94	6.0374	7.24	0.997	1.79	4.04
6.7078	6.02	0.845	1.40	4.30	4.3081	5.64	0.038	1.34	4.20
11.4043	4.71	0.262	1.09	4.32			HIP 106219		
		HIP 5526			11.3007	6.66	0.113	0.74	8.95
9.3431	24.19	0.806	4.77	5.07	10.8018	2.91	0.042	0.69	4.19
5.1385	20.46	0.557	4.23	4.84	14.2773	2.45	0.210	0.52	4.74
8.5147	17.92	0.788	3.26	5.50			HIP 106223		
9.7283	13.21	0.291	2.70	4.89	1.1429	31.09	0.194	2.84	10.95
5.5947	12.46	0.849	2.58	4.82			HIP 107786		
12.5515	8.22	0.255	1.86	4.41	15.4817	9.87	0.932	2.08	4.75
		HIP 5659					HIP 113487		
9.4932	16.45	0.049	2.90	5.67	21.9102	23.01	0.327	3.73	6.16
10.2439	11.49	0.629	2.45	4.69	17.2064	11.40	0.012	2.82	4.04
9.8508	12.46	0.674	1.98	6.30			HIP 115093		
7.0028	8.95	0.814	1.82	4.92	11.4318	10.61	0.784	2.18	4.87
		HIP 11090					HIP 115856		
15.8617	11.30	0.387	1.63	6.94	9.1109	14.08	0.917	1.75	8.06
28.7418	5.34	0.453	1.19	4.47	16.9660	7.48	0.068	1.28	5.86
		HIP 17585			18.6810	5.81	0.676	1.11	5.24
13.1631	13.99	0.887	3.33	4.20					

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