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A.V. Serebryanskiy, E.R. Gaynullina, A.V. Khalikova

Fesenkov Astrophysical Institute, Observatory 23, 050020, Almaty, Kazakhstan
Ulugh Beg Astronomical Institute, Astronomicheskaya Str., 33, 100072, Tashkent, Uzbekistan
aserebryanskiy@yahoo.com, evelina@astrin.uz, ahalikova@yahoo.com

VARIABLE STAR TYC3215-906-1: LIGHT CURVE ANALYSIS AND CLASSIFICATION

Abstract. In this work the analysis of variability of the star TYC3215-906-1 is carried out. This star was used as reference or comparison stars in analysis of well-known binary SW Lac observations in several studies although some authors pointed out that this star might be a variable star. We made an attempt to clarify this situation using method of light curve analysis of photometric observations. The field around SW Lac was observed on Maidanak observatory on Zeiss-600 during 50 nights in seasons of 2013 and 2014. The differential light curves of TYC3215-906-1 have shown intranight variability. We analyzed the light curves utilizing different methods of periodograms computation and made an attempt to classify variability type of the TYC3215-906-1 from the parameters of detected oscillation modes. Our preliminary results showed that this star is the variable star with high probability to be a δSct variable but we did not rule out some possibility that it might be RR Lyrae type pulsating in nor-radial mode. To be more conclusive, more multicolor photometric and spectroscopic observations are needed.
Keywords: variable stars, TYC3215-906-1, SW Lac.

Introduction

Variable stars are valuable source of information about many physical processes including stellar evolution, stellar structure and dynamics and evolution of the Galaxy [15]. Eclipsing binary allows astronomers to determine more precisely parameters of its structure since other usually not well known parameters are known in double systems. On the other hand modes of intrinsic variable stars allow inferring internal structure of the stars by means of asteroseismology [11-14].

Some eclipsing binaries have been observed at Maidanak Observatory in Uzbekistan starting from 2013. Observations are carried out in the frames of the SPAREBIS (Serach for Planets Around Eclipsing Binary Stars) project initiated by Tutukov and Bogomazov [1]. The field around SW Lac ($RA_{2000}=22^h53^m41^s.66$; $DEC_{2000}=+37°56'18''.63$) was observed in August, September and October 2013 (33 nights) and in August 2014 (17 nights). The observations were carried out on the 60-cm telescope Zeiss-600 with focal length of 7200 mm, equipped with FLI MicroLine CCD, the chip is the Kodak KAF-1001E, the scale is 0".687 per pixel which gives the field of view (FOV) of 11'.7×11'.7. Observations were performed in Bessell R band. The exposure times were 5 and 6 seconds in 2013 and 3, 4 and 5 seconds in 2014.

Method

Method used in this study is based on time series frequency analysis. The time series here are time resolved photometric observations. Basic image reduction was performed using standard IRAF software

(IRAF is distributed by the NOAO, which are operated by the AURA, Inc., under cooperation agreement with the NSF). Differential extinction corrections were applied but neither linear nor parabolic trends were removed from the light curves.

We extract multiaperture photometry information for several stars from reduced images with IRAF/DAOPHOT and choose the optimal apertures in order to obtain the light curves with minimal scatter. The identification and general information (coordinates, V magnitudes and Welsh-Stetson variability index [2]) for these stars is provided in the Table. Six of them (S1-S6) were observed in August and September 2013 and are marked on the map in the Figure 1. In October 2013 and August 2014, the stars S2, S3 and S4 were not located in the FOV, but the stars S7, S8 and S9 were on FOV (see the Table). Our first goal was to choose the comparison stars. Taking into account the brightness of the stars, our first choice was the stars S2 and S9. But the star S2 has relatively high Welsh-Stetson variability index. At the same time the differential light curves for the star S3 (check star was S6) did not show intranight or long-term variability and we used it as the comparison star instead of S2 in 2013. In 2014, when the star S9 was not located in FOV, we used the star S7 as the comparison one.

Table – Studied stars

Star	ID	RA_{2000} (hh:mm:ss)	DEC_{2000} (dd:mm:ss)	V (mag)	WS index
S1	SW Lac	22:53:41.46	37:56:18.63	9.5	128.12
S2	TYC3215-1288-1	22:53:48.77	38:04:03.01	10.2	2.07
S3	TYC3215-1234-1	22:53:32.09	38:04:05.79	10.9	0.21
S4	1SWASP J225337.84+380254.3	22:53:37.84	38:02:54.31	-	-
S5	TYC3215-906-1	22:53:35.44	37:55:09.38	11.5	0.97
S6	1SWASP J225322.05+375543.7	22:53:22.05	37:55:43.75	-	-
S7	TYC3215-1586-1	22:53:56.69	37:52:27.76	10.8	0.67
S8	GSC 03215-01406	22:53:26.35	37:51:19.4	10.5	-
S9	BD +374715	22:53:11.73	37:47:14.09	9.1	1.01

Results

Our analysis of the differential light curves has shown that four stars, namely S2, S4, S5 and S8 are variable stars. Three of them, S2, S4 and S8 have long-term variability, which could be, for example, due to rotational spots modulation, and will be analyzed somewhere else. In the literature, the star S5 is sometimes used as the comparison or check star, although Derekas, Kiss and Bebesi [3] shown that this star changed its brightness by roughly 0.05 magnitude during 6 hours and could be a pulsating variable. In our observations the light curves of the star S5 have shown the variability with peak amplitude about 0.08 magnitudes (August 2 of 2013). We plot some of light curves of the star S5 obtained in 2013 in the Figure 2. The total data set contains 71248 and 64866 data points in 2013 and 2014 respectively. We plot only data points and show typical error bars in the panel of August 1st.

We analyzed light curves for 2013 and 2014 observation periods separately because of long gap between two seasons of observations. Analyses of light curves of the star S5 were based on various methods to compute periodograms. Results using FAMIAS [4] shows the presence of two modes in the data set of 2013: f_1=1.8259±0.0003 cycles per day (c/d) with amplitude A_1=20 mmag, and f_2=3.674±0.009 c/d with amplitude A_2=9.5 mmag. As for 2014 the results are: f_1=1.8195±0.0013 c/d with amplitude A_1= 11.8 mmag, and f_2=3.674±0.002 c/d with amplitude A_2= 7.6 mmag. Using GATSPY as independent method [5], which implements Fast Lomb-Scargle algorithm, we also estimated the mode parameters and found that they are similar to those found by FAMIAS within 1σ error estimated by FAMIAS. Figures 3 and 4 show Lomb-Scargle periodogram computed by GATSPY for 2013 and 2014, respectively.

Discussion and conclusions

The variability periods found by our analysis of light curves for the star S5 lie well in the range for periods common δSct stars. We found evidence that this star is δSct star pulsating in fundamental mode and its first overtone. There is some evidence of amplitude variation with time which might indicate

modulation similar to those usually found in double mode pulsation of RR Lyrae stars with Blazhko effect.

Using values for log(P) and values for (J-H) and (H-K) colors taken from [6] we pointed out that S5 fall into the range of RRab Lyrae stars on the diagrams (J-H) vs. (H-K), and (J-H) vs. log(P) (see, for example, [7]).

Long duration gaps in our data prevent us to make conclusive decision about its type of variability. The difficulty with identification of this variable as RR Lyrae type laying in the fact that this type of stars pulsate in radial mode which should have quite large amplitude of brightness variability while our star does not. Also the value of [Fe/H] might help us to make identification robust but unfortunately the known value of [Fe/H] is not precisely determined for this star at this moment [16] to make it possible.

In case this star is double mode RR Lyrae type it would be very valuable target for future asteroseismic analysis since double mode RR Lyrae allow more precise determination of their mass and radius and also can be used to infer more precisely distance modulus (see, for example, [8-10]).

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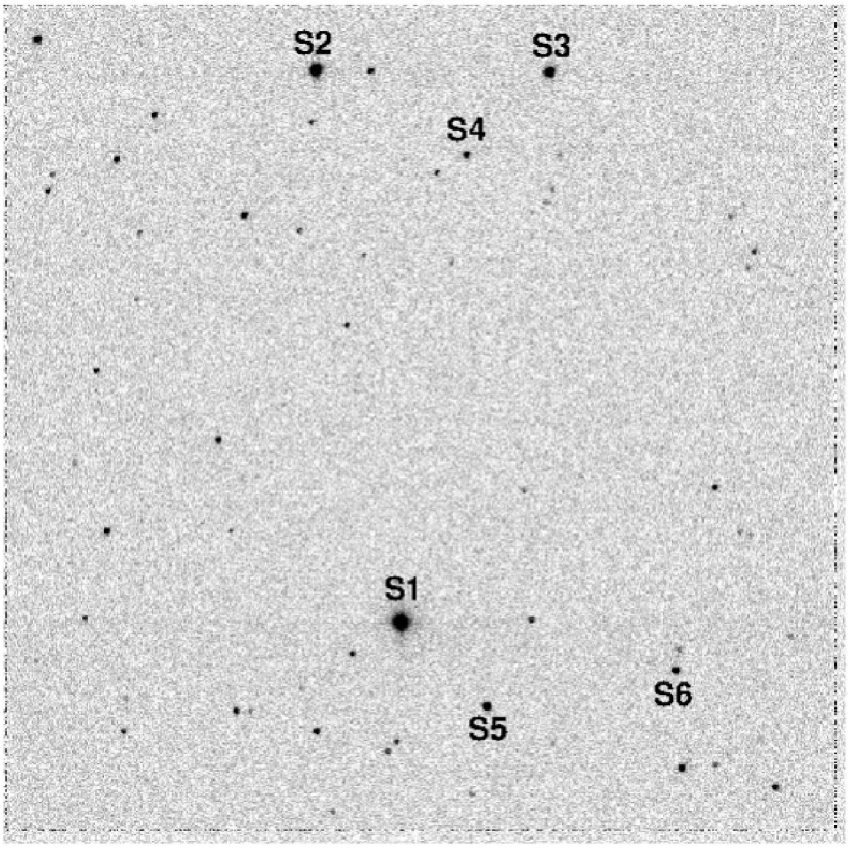

Figure 1 – Finding chart for variable and comparison stars in August and September 2013. North is up and East is to the left

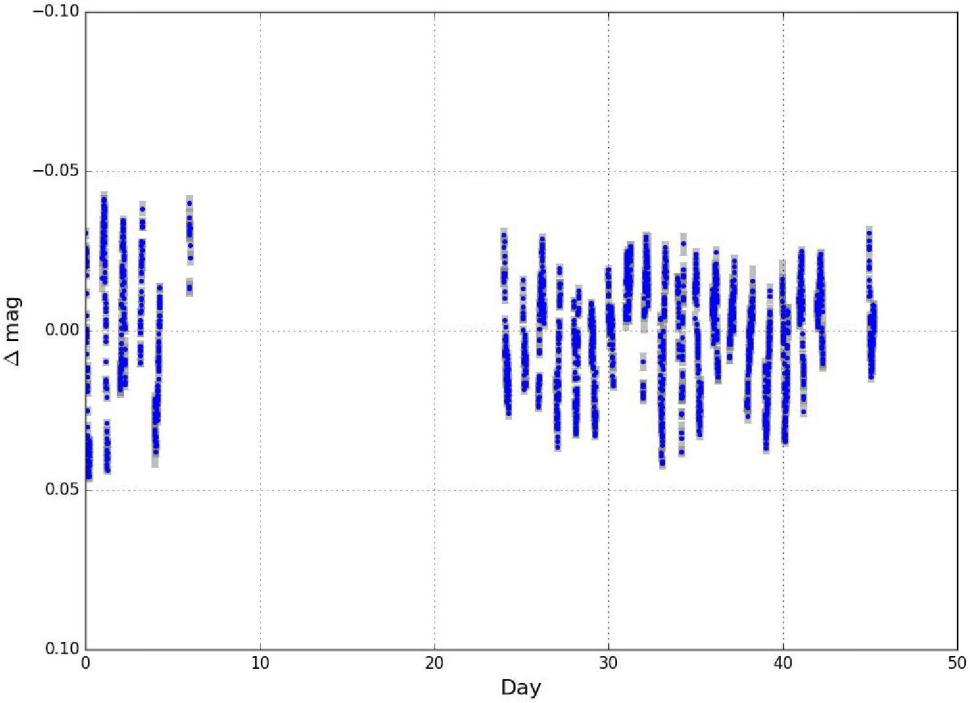

Figure 2 – Examples of the binned differential light curves of TYC3215-906-1 (star S5) in 2013 after subtracting the global median value

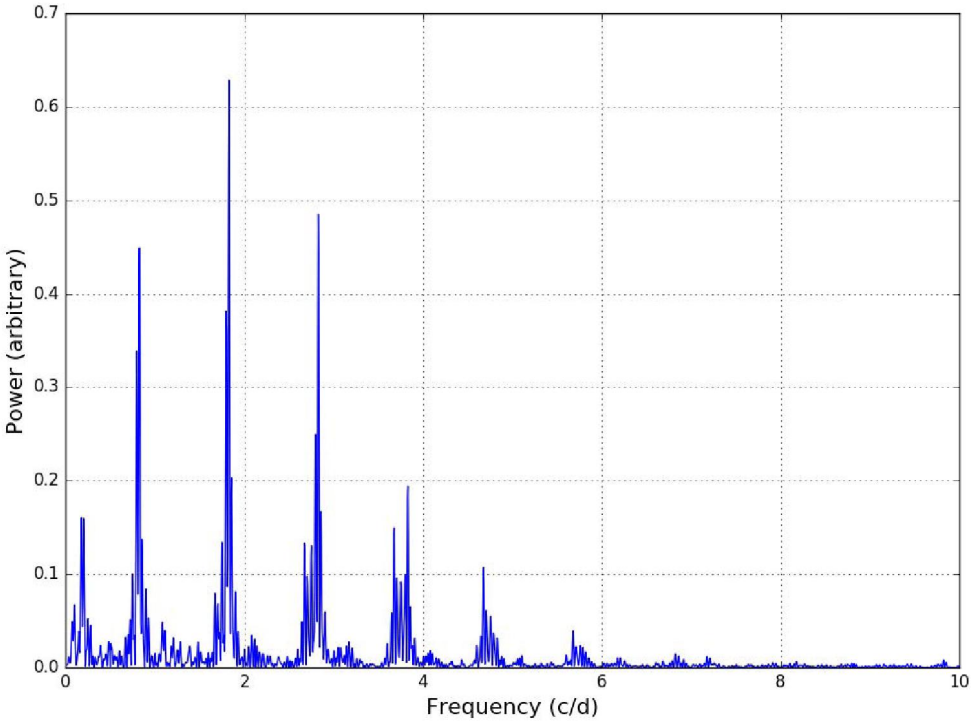

Figure 3 – Lomb-Scargle periodogram computed for light curve of TYC3215-906-1 obtained in 2013 on Maidanak Observatory