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PHOTOMETRY OF GS UMa: A SUSPECTED δ SCUTI VARIABLE

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Abstract

We present the time series analysis of GS UMa. GS UMa is a suspected δ Scuti variable with a primary frequency of 6.0987 d^{-1}.

δ Scuti stars are one of the most known pulsating variables which oscillate in radial and non-radial pressure, gravity and mixed modes mostly in a frequency ranges of 5−50 d^{-1} (Breger, 2000). Thanks to the space missions (*Kepler*, CoRoT, MOST), many new δ Scuti variables have been discovered. These discoveries have uncovered new problems about δ Scuti stars. One of the problems concerns the borders of the δ Scuti instability strip. Uytterhoeven et al. (2011) showed that there are many δ Scuti variables located outside their own instability strip. According to the theory, it is not expected to detect such variables beyond the borders.

GS UMa ($V=8\overset{m}{.}66$, HIP 51361, $RA = 10^h29^m26\overset{s}{.}8$, $DEC = +39°46'08\overset{''}{.}5$) is a poorly classified δ Scuti variable. Its variability was first found by Duerbeck (1997) using the Hipparcos data. The star was defined as a suspect δ Scuti star by Kahraman Aliçavuş et al. (2017). They carried out a detailed spectroscopic analysis of the star and derived the atmospheric parameters (effective temperature $T_{\rm eff}$, surface gravity $\log g$, microturbulent velocity ξ), projected rotational velocity, and the chemical abundances of the variable. As a result of their analysis, they showed that the star is located outside the instability strip of δ Scuti stars. Therefore, in this study, we focus on the photometric observations of GS UMa to reveal its variability type.

Table 1: Information of the comparison (C1) and the check (C2) stars.

ID	Name	RA (J2000)	DEC (J2000)	V (mag)
C1	GSC 3002−00989	$10^h29^m15\overset{s}{.}5$	$+39^o\ 45'00\overset{''}{.}4$	9.89
C2	GSC 3002−00097	$10^h28^m58\overset{s}{.}1$	$+39^o\ 40'01\overset{''}{.}0$	9.30

Photometric observations of GS UMa were carried out at the Çanakkale Onsekiz Mart University Observatory with the Apogee ALTA U47 CCD mounted on the 30 cm Cassegrain-Schmidt telescope. The photometric data was obtained with Johnson B and

V filters on 4, 12, 19, 26, and 28 April 2018. About 25 hours of data was taken during the observation period. From the observations, the stars which do not exhibit any significant light variation, were selected to be comparison and check stars. Information of the comparison and check stars used are given in Table 1. The basic image reduction steps (bias, dark, and flat correction) were performed by using the C-Munipack[1] software.

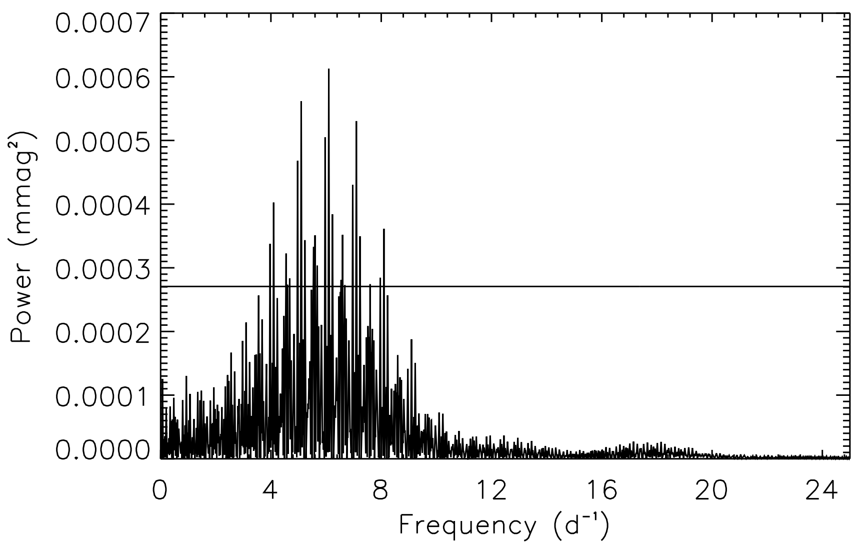

Figure 1. Power spectrum of GS UMa. Solid horizontal line represents the significance limit.

The observed light curves were analysed by using the Period04 program (Lenz & Breger 2005) to derive the pulsation period and amplitude of the star. As a result of this analysis, a significant pulsation frequency of 6.0987 d^{-1} with signal-to-noise (S/N) level higher than the significance limit ($\mathrm{S/N} \geq 4$, Breger et al. 1993) and with 46.35 mmag pulsation amplitude in V filter was obtained. Furthermore, we detected a frequency value lower than 5 d^{-1}. However, its S/N level is lower than the significance limit. The existence of this frequency should be checked with new long-term observations. Additionally, we used the SuperWASP data[2] for the frequency analysis. In this analysis, we determined three significant frequencies. The obtained frequencies can be found in Table 2. The power spectrum and the comparison of the observed light curves with the calculated ones are shown in Fig. 1 and Fig. 2, respectively.

We calculated the pulsation constant (Q) value of the star by utilizing the below equation given by Petersen & Jørgensen (1972).

$$\log Q = -6.456 + 0.5 \log g + 0.1 M_{\mathrm{Bol}} + \log T_{\mathrm{eff}} + \log P$$

The T_{eff} and $\log g$ values were taken from Kahraman Aliçavuş et al. (2017). M_{Bol} was calculated using the bolometric correction value which was taken from Cox et al. (2000) and the *Gaia* parallax (Gaia Collaboration et al. 2016). As a result of this calculation, we determined the Q value to be $0\overset{\mathrm{d}}{.}069 \pm 0.012$. This value is out of range of Q for δ

[1] `http://c-munipack.sourceforge.net/`
[2] `https://wasp.cerit-sc.cz/form`

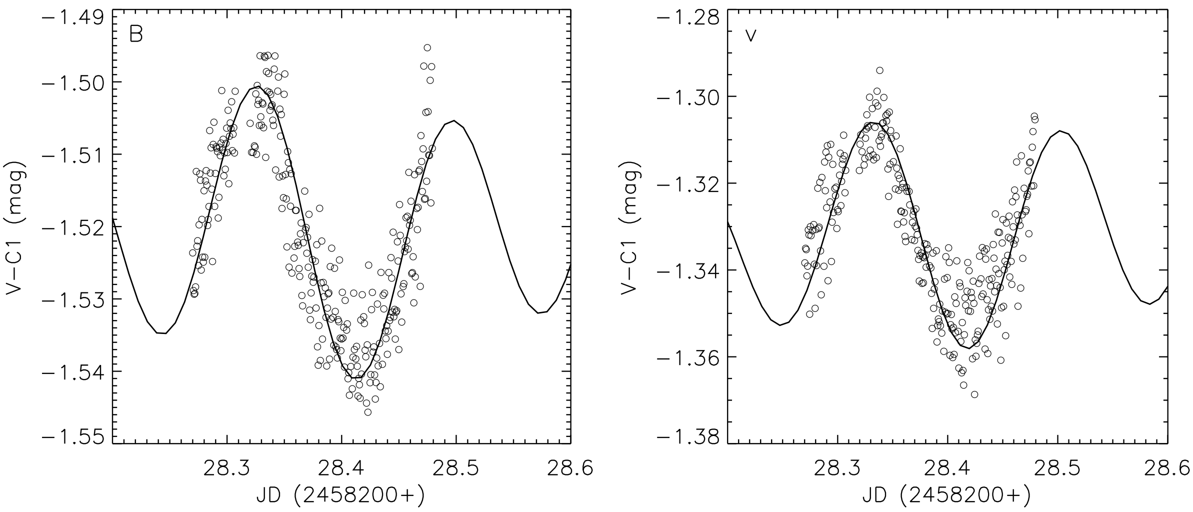

Figure 2. Comparison of the observed B (left panel) and V (right panel) light curves of GS UMa with the calculated light curves (solid lines).

Table 2: Frequencies detected in GS UMa.

Filter	Parameter	Frequency (d^{-1})	Amplitude (mmag)	S/N
B	f_1	6.0987±0.0014	38.76±1.62	24
V	f_1	6.0987±0.0013	46.35±0.99	18
SuperWASP	f_1	6.0972±0.0000	41.99±0.34	34
SuperWASP	$f_2 = 2f_1$	12.1944±0.0000	11.29±0.37	11
SuperWASP	f_3	5.0120±0.0056	6.68±0.61	5

Scuti stars according to the study of Antonello & Pastori (1981). However, it should be noticed that a limited number of stars were used in this study.

GS UMa is located beyond to the red border of δ Scuti and γ Doradus instability strip (Kahraman Aliçavuş et al., 2017). According to our frequency analysis results, the star shows δ Scuti-type pulsation. However, we also detected a frequency lower than 5 d^{-1}. This frequency is in the range of γ Doradus stars' pulsation frequency interval. In addition, it is shown that a large majority of δ Scuti stars ($\sim 98\%$) in the *Kepler* field show low frequencies (Balona, 2018). A most recent explanation of these low frequencies was explained by interaction between oscillation and convection (Xiong et al., 2016). Therefore, GS UMa simply might be a δ Scuti star exhibiting low frequency pulsation. However, to reveal this feature the star needs more high quality observations.

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