A Photometric Study of the Pulsating Variable Star TYC 0075 01143 1

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We present the results of our new observations of TYC 0075 01143 1, a recently discovered double-mode δ Scuti variable. We improved the frequencies f_0 and f_1 and pulsation amplitudes, detected the interaction frequencies $f_1 + f_0$, $f_1 - f_0$, and a possible nonradial frequency f_N.

1 Introduction

In this paper, we present the results of our study of a multiple-periodicity δ Scuti variable star TYC 0075 01143 1. Its coordinates in the Tycho-2 catalog are $04^{\rm h}26^{\rm m}05\overset{\rm s}{.}90$, $+01°26'26\overset{''}{.}2$ (J2000.0).

Variability of TYC 0075 01143 1 = ASAS 042606+0126.4 was detected in the ASAS-3 project (Pojmanski 2002). In the ASAS catalog, the classification of the variable is EC/DSCT (a contact eclipsing binary or a δ Scuti variable); a period $P = 0\overset{\rm d}{.}07443$ is also given there. Kruslov (2011) confirmed that TYC 0075 01143 1 belonged to δ Scuti stars; he also detected the double-mode character of brightness variations and suggested the following light elements:

$$\text{Max} = \text{JD } 2453600.043 + 0\overset{\rm d}{.}0744301 \times E - \text{the fundamental mode } (f_0);$$

$$\text{Max} = \text{JD } 2453600.049 + 0\overset{\rm d}{.}0579031 \times E - \text{the first overtone mode } (f_1).$$

Preliminary results from our new CCD observations were published by Khruslov et al. (2012). In the present paper, we use a much longer series of observations that made it possible to detect new interaction frequencies and a possible nonradial frequency, f_N.

2 Observations

We acquired new CCD observations of TYC 0075 01143 1. Our observations were performed at the Tien Shan Astronomical Observatory of the V.G. Fesenkov Astrophysical Institute, at the altitude of 2750 m above the sea level, using a Ritchey–Chretien telescope designed by V.B. Sekirov. The telescope's mirror diameter is 360 mm, the focal length of the system being 1440 mm. The detector was an ST-402 SBIG CCD camera. The observations were made on 11 nights between December 17, 2011 and November 20, 2012 (JD 2455913–2456252); in total, we obtained 1718 brightness estimates. All frames had 60-second exposure times in Johnson's V band. For flat-fielding, we observed morning or evening twilight sky. The dark current was taken into account during the observations; the chip was cooled to $-20°$ C. Reductions made use of the MuniWin code.

The finding chart (Fig. 1) identifies the variable star, comparison star, and check star. The comparison star was GSC 00075–01862 and the check star, GSC 00075–01079. The magnitudes of these stars in the GSC2.3 catalog are respectively $V = 12.70$ and $V = 11.88$.

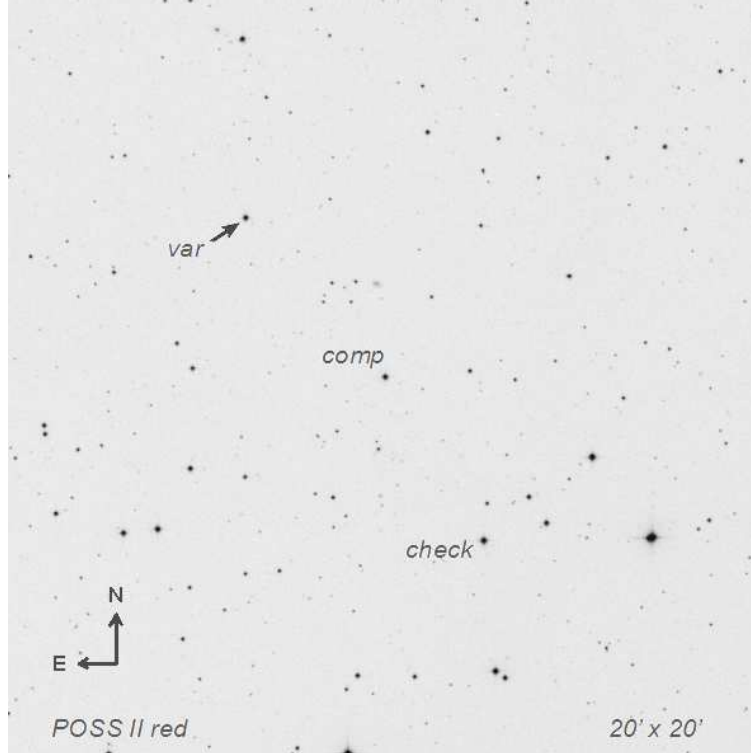Our observations are available online in the html version of this paper.

Figure 1.
The finding chart of TYC 0075 01143 1.

3   Results

We analyzed the time series using Deeming's method implemented in the WinEfk code written by V.P. Goranskij. Using our new observations of TYC 0075 01143 1, we improved the frequencies f_0 and f_1, detected oscillations corresponding to interaction between f_1 and f_0: $f_1 + f_0$ and $f_1 - f_0$; we also found a possible nonradial frequency f_N. The results are presented in the Table.

Table. Detected frequencies

Mode	Frequency, c/d	V-band semi-amplitude, mag	Period, days	Epoch, HJD
f_0	13.435398	0.126	0.07443025	2456100.0083
f_1	17.270241	0.074	0.05790307	2456100.0133
$f_1 + f_0$	30.70565	0.024	0.0325673	2456100.0084
$f_1 - f_0$	3.834915	0.016	0.260762	2456100.017
f_N	25.68687	0.016	0.0389304	2456100.0065

The light curves of TYC 0075 01143 1 are displayed in Fig. 2. The V-band range of TYC 0075 01143 1 is $12^{\mathrm{m}}00 - 12^{\mathrm{m}}55$. The period ratio $P_1/P_0 = 0.77795$ is typical of

high-amplitude double-mode δ Scuti stars radially pulsating in the fundamental and first overtone modes (Petersen & Christensen-Dalsgaard 1996).
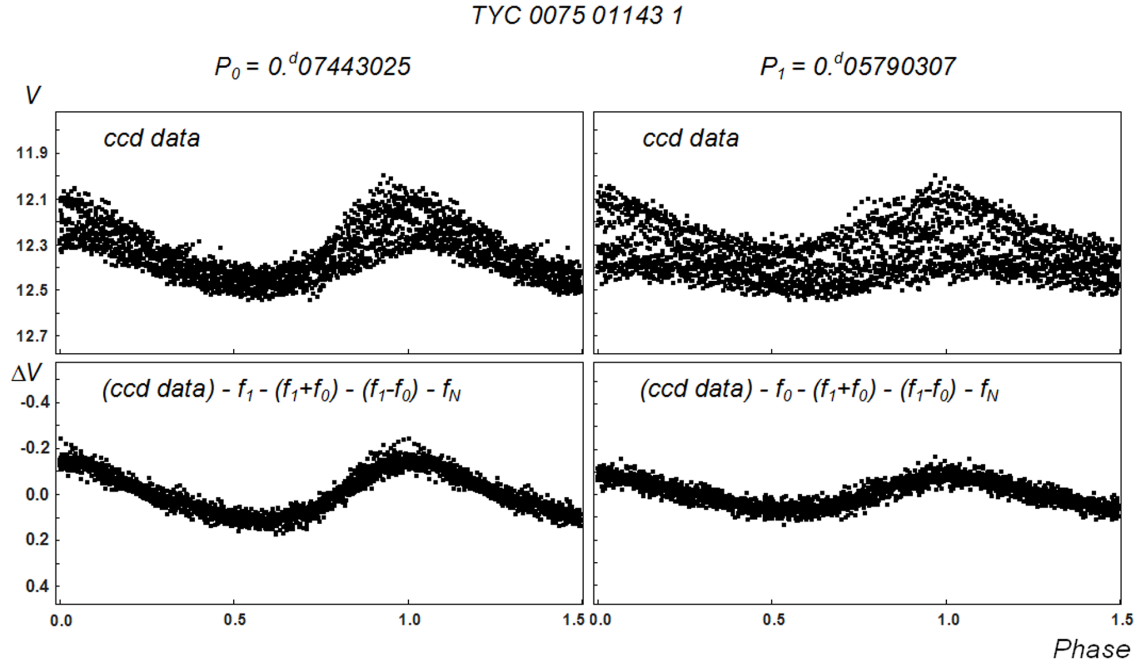

Figure 2.
The light curves of TYC 0075 01143 1. Upper panels: raw data; lower panels: the folded light curves with the other variation pre-whitened.

Along with the light curves, we present power spectra of TYC 0075 01143 1, for the raw data and after subtraction of the fundamental-mode oscillations (see Fig. 3). Figure 4 exhibits light-curve variations from one cycle to another during the same night, typical of high-amplitude double-mode δ Scuti variables.

The frequency f_N is identified rather reliably, its amplitude is close to that for the frequency $f_1 - f_0$. The structure of the power spectra (Fig. 5) leaves no doubt that f_N is a real frequency. However, we cannot completely rule out that the real frequency is a one-day alias of the tabulated f_N, namely $f_{Na} = 26.68996$ (the corresponding period being $0.^{d}0374673$).
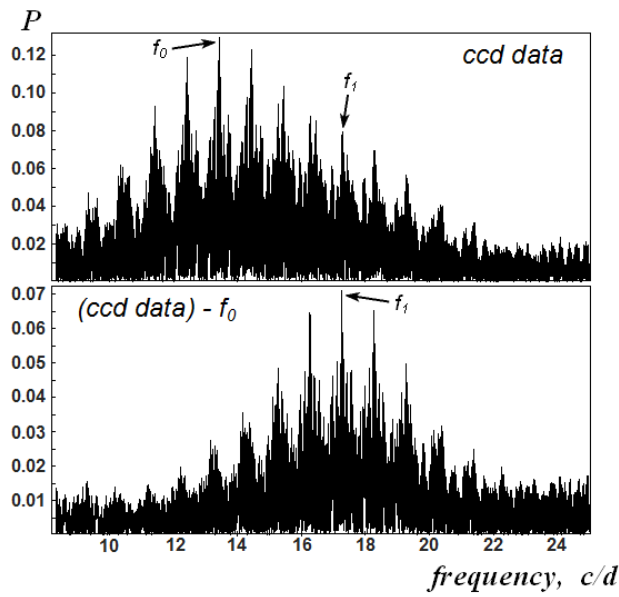
Figure 3.
Power spectra of TYC 0075 01143 1 for the frequencies f_0 and f_1.
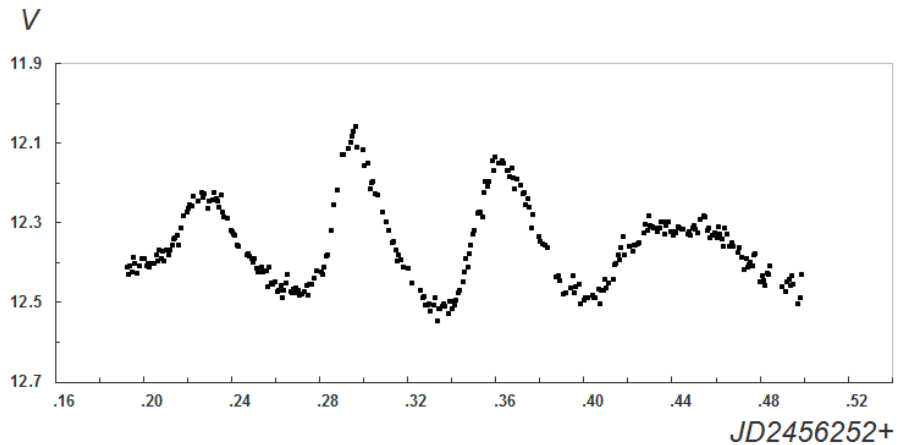

Figure 4.
Observations of TYC 0075 01143 1 acquired during a single night of November 20, 2012 (JD 2456252).

References:

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Petersen, J.O., Christensen-Dalsgaard, J. 1996, Astron. and Astrophys., **312**, 463

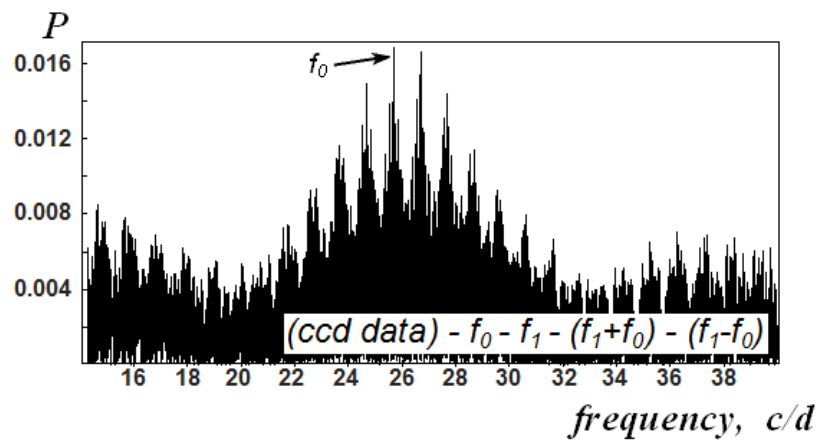Pojmanski, G., 2002, Acta Astronomica, **52**, 397

Figure 5.
The power spectrum for the frequency f_N. All the other detected frequencies were pre-whitened.