COMMISSIONS 27 AND 42 OF THE IAU
INFORMATION BULLETIN ON VARIABLE STARS

Number 4700

Konkoly Observatory
Budapest
21 April 1999

HU ISSN 0374 – 0676

NEW VARIABLE STARS IN NGC 7762

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In order to check variability of stars in open clusters we observed NGC 7762 in the framework of STACC (Small Telescope Arrays with CCD Cameras) (Frandsen & Arentoft, 1998). The main goal of this collaboration is to observe stars exhibiting complex pulsational spectrum. Observing open clusters is a reasonable solution, because 4-6 main-sequence pulsating variables can be studied on one CCD-frame. Provided that the main characteristics (age, distance, chemical composition, etc.) of the cluster-members are very similar, these stars can be used for comparative asteroseismological investigations: to help the identification of excited modes and to compare seismological information with theoretical models.

The first step toward this goal is to find adequate open clusters and variables. Frandsen & Arentoft compiled a list of potential target clusters considering the age and distance (i.e. apparent size) for small telescopes and CCD-cameras (Frandsen & Arentoft, 1996).

We have chosen NGC 7762, because there has been no previous systematic search. Frandsen & Arentoft found the following parameters for this cluster in the literature: 1.02 kpc distance, 800 Myr age and $0\overset{\mathrm{m}}{.}98$ reddening. Later Patat & Carraro found that NGC 7762 is much older, namely 1.8 Gyr (Patat & Carraro 1995).

Time series observations of NGC 7762 in V band were carried out on three consecutive nights in September, 1997 with the 1-meter RCC telescope at Konkoly Observatory (Piszkéstető, Hungary). Table 1 gives the summary of observations.

Table 1: Log of observations

Date	HJD	t_{exp} (s)	filter	N_{frames}	t_{eff} (h)	seeing	$V - v_{\mathrm{intsr}} = a$
1997 Sep 15/16	2450707	180	V	55	3	$2\overset{''}{.}3$	$13\overset{\mathrm{m}}{.}08 \pm 0\overset{\mathrm{m}}{.}02$
1997 Sep 16/17	2450708	180–190	V	50	3	$2\overset{''}{.}1$	$12\overset{\mathrm{m}}{.}61 \pm 0\overset{\mathrm{m}}{.}04$
1997 Sep 17/18	2450709	150–180	V	103	5	$1\overset{''}{.}5$	$12\overset{\mathrm{m}}{.}93 \pm 0\overset{\mathrm{m}}{.}01$

A Wright Instrument's camera with EEV CCD05-20 UV-coated chip (800×1200 pixels, 22.5 $\mu\mathrm{m}^2$ each) was used in the Cassegrain-focus. Its full well capacity was 10^5 e^- and the readout noise was 10 electrons. There were neither bad nor hot pixels on the chip. The image scale was $0\overset{''}{.}39$ per pixel, resulting in a $4' \times 6'$ field of view. Effective observing times are shown in Table 1, and we note in passing that in general observing conditions were poor.

The relatively small field of view did not allow us to cover the whole cluster, therefore one of the most populated subfields was selected. This area contains fainter stars; the brightest members of the cluster are out of our interest, because these objects are thought to be red giants.

The frames were corrected for nonlinearity before any other reduction with the following transformation: $N_{\rm corr} = N/(1 + 3 \cdot 10^{-6} N)$, where N is the original pixel value, and $N_{\rm corr}$ stands for the nonlinearity corrected pixel value. The basic steps of reduction of the CCD frames (cosmic ray elimination, bias subtraction and flat-fielding) were performed by IRAF packages. MOMF 3.0 (Multi Object Multi Frame) software package (Kjeldsen & Frandsen, 1992) adapted to our software environment was used to determine instrumental magnitudes.

The instrumental magnitudes were transformed to Johnson's V system based on the BV CCD-photometry of Patat & Carraro (1995). The covered range of $B - V$ color indices was small, so the color terms in the transformation were omitted. The applied formula was $V - v_{\rm instr} = a$, where the corresponding a values can be found in Table 1.

Table 2 shows the internal scatters of constant stars, indicating the quality of each night. It clearly shows that the second night was the worst, and the last night offered the best conditions.

MOMF 3.0 determines a d parameter (for details see Kjeldsen & Frandsen 1992), which quantity was found to be very useful to select potential variable stars from a large sample. We used this parameter determined on the third night to identify possible variable stars after establishing the empirical $d > 1.4$ criteria for variability. Table 2 also contains typical d values for constant stars.

Table 2: Internal scatter ($\sigma_{\rm int}$) and d parameter of constant stars

HJD	$V = 11 - 13^{\rm m}$		$V = 13 - 15^{\rm m}$		$V = 15 - 17^{\rm m}$	
	$\sigma_{\rm int}$	d	$\sigma_{\rm int}$	d	$\sigma_{\rm int}$	d
2450707	$0\overset{\rm m}{.}003$	1.12–1.23	$0\overset{\rm m}{.}005$	1.12–1.17	$0\overset{\rm m}{.}040$	1.11–1.28
2450708	$0\overset{\rm m}{.}004$	1.06–1.19	$0\overset{\rm m}{.}007$	1.01–1.24	$0\overset{\rm m}{.}070$	0.98–1.28
2450709	$0\overset{\rm m}{.}002$	1.00–1.12	$0\overset{\rm m}{.}005$	0.95–1.11	$0\overset{\rm m}{.}030$	0.96–1.24

After checking the light-curve and d value of each star on the frames, we found that stars numbered as #4, #33 and #47 (d = 1.93, 1.44, 1.68 on 17/18 September, HJD = 2450709) show significant variations (see Figures 1, 3 and 4). We used the identification numbers of Patat & Carraro (1995). Table 3 contains coordinates and GSC identification numbers. These stars are not affected by close visible companions, and are not situated at the edge of the frames (two effects that may cause problems during photometry), therefore these changes can be regarded as intrinsic light variations.

Table 3: Identification of the variable star candidates

P. & C. ID	GSC number	R.A. (J2000)	Dec. (J2000)
#4	GSC 4479_941	$23^{\rm h}50^{\rm m}05\overset{\rm s}{.}19$	$+68°02'04\overset{''}{.}4$
#33	—	$23^{\rm h}50^{\rm m}19\overset{\rm s}{.}17$	$+68°02'08\overset{''}{.}6$
#47	GSC 4479_1434	$23^{\rm h}49^{\rm m}42\overset{\rm s}{.}23$	$+68°03'44\overset{''}{.}4$

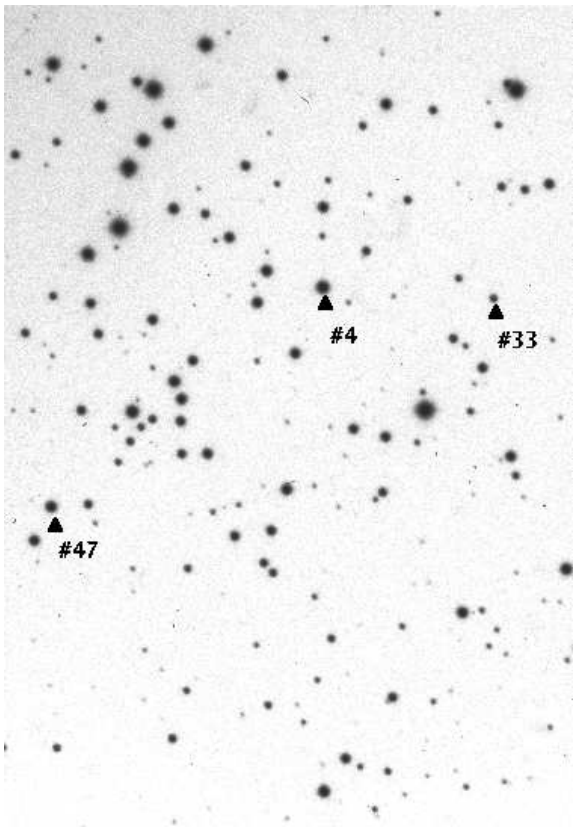

Figure 1. 10 combined CCD V-frames of the studied field of NGC 7762. The detected variable stars are also indicated. North is to the bottom, west is to the left. The field of view is $4' \times 6'$. Identification numbers are from Patat & Carraro (1995)

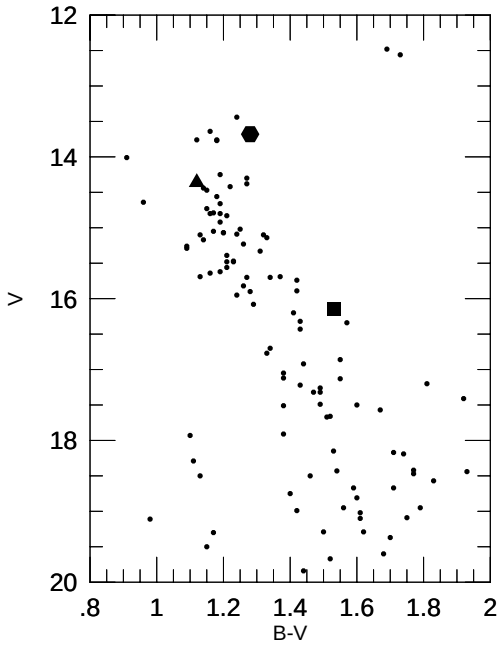

Figure 2. Color–magnitude diagram of NGC 7762. Filled hexagon: star #4, filled triangle: star #47, filled square: star #33

Star #4 brightened by $0\overset{\mathrm{m}}{.}04$ in V on the first and third nights. On the second night the sky conditions were quite bad as mentioned above, therefore the scatter is much higher, so we left out this dataset of star #4 from further investigations. The total amplitude can be $0\overset{\mathrm{m}}{.}01$–$0\overset{\mathrm{m}}{.}02$ and a preliminary period-estimation yields approximately 1 or 2 days, considering that the star was almost in the same phase on the two nights (Fig. 3). Its color index is $(B-V) = 1.28$ according to Patat & Carraro (1995), and after correcting for the interstellar reddening of the cluster we get $(B-V)_0 = 0.30$. This value along with the luminosity (apparent magnitude) shows that star #4 is an early F-type main-sequence star (Figure 2). According to the amplitude, the possible period and the position on the HR diagram this star can be a γ Doradus type variable (Krisciunas & Crowe 1997).

Star #33 showed a symmetric minimum of $0\overset{\mathrm{m}}{.}1$ on the third night (Fig. 3). Light curves obtained on previous nights neither confirm nor preclude variation. It can be stated that no obvious fading or brightening occurred during the first two nights of observations. The color-magnitude diagram of Patat & Carraro (1995) reveals that this star is slightly above the main sequence ($V = 16\overset{\mathrm{m}}{.}15$, $(B-V) = 1.53$, $(B-V)_0 = 0.55$). The shape of the light variation and the position of this star on the $V-(B-V)$ plane (see Figure 2) indicates an eclipsing binary nature.

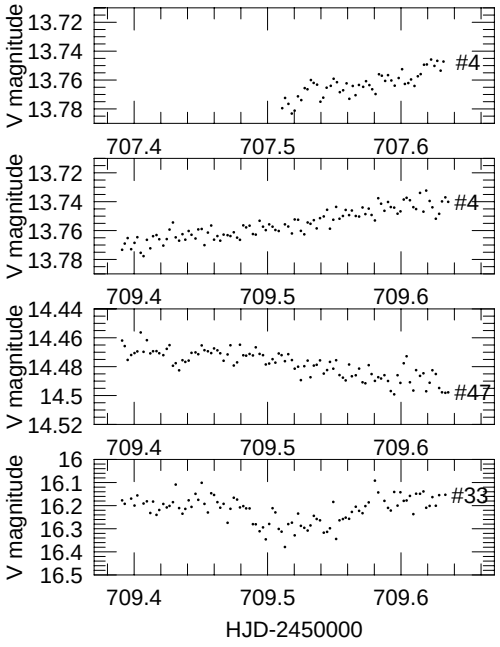

Figure 3. V light curves of the three variable stars...

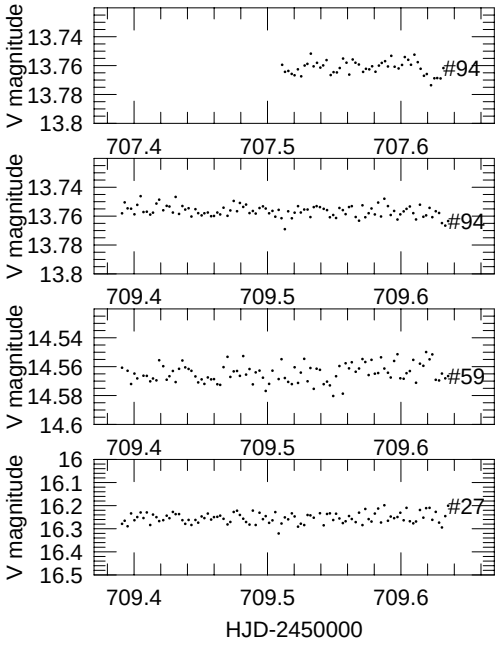

Figure 4. ... and corresponding V light curves of constant stars of the same brightness. Identification numbers are from Patat & Carraro (1995)

Star #47 faded by $0\overset{m}{.}03$ on the last night. Unfortunately light curves obtained on previous nights are of poor quality, and unable to confirm this small variation. Its color index is $(B-V)_0 = 0.14$. Star #47 is also a variable star candidate with a light variation resembling that of #4.

More multicolor photometry is needed for these stars to classify them without doubt and to determine their properties.

The fact that we did not find δ Scuti variables to the amplitude-limit presented in Table 2 in this region of the cluster

- confirms that NGC 7762 is older than 800 Myr,
- shows that this cluster is not an ideal target for further STACC-investigations.

I would like to thank my former supervisor, J. Nuspl, for introducing me to CCD photometry and his support during my work. I also thank Sz. Csizmadia for his assistance during observations.

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