

Study for Variable Stars in King 18

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Abstract

The preliminary results of searching and study for variable stars using TESS photometry in the intermediate age open star cluster King 18 are presented. We have investigated the light curves and frequency spectra of different types of variable stars located in the open cluster area. The results obtained together with prospects of study of this open cluster are briefly discussed.

Keywords: open clusters and associations: individual King 18, stars: variables

1. Introduction

Open star clusters provide a good ground to study the evolution of stars, since all cluster member stars are formed from the common parent molecular cloud, which causes them to lie at approximately the same distance, they have the same age, and chemical composition but various masses. This allows constraints on the models of stellar evolution and estimate their age, distance and interstellar extinction in the direction of the cluster by comparing the colour-magnitude diagram (CMD) and colour-colour diagram (CCD) of star clusters with theoretical evolutionary models. To derive the cluster physical parameters, the knowledge of membership of the stars is essential. An analysis of kinematics of stars, especially of their proper motion (PM) data, is a quite reliable method for determining the cluster membership. In other words, exploring clusters in this way allows you to take a snapshot of evolution of whole populations of stars in the cluster. King 18 is an open star cluster discovered by (King, 1949). This cluster is of middle age located at a distance of about 2.4 kpc in the northern hemisphere [RA (J2000.0) = 22h 52m 06s, Dec (J2000.0) = +58°17'00"]. The number of most probable members of the cluster is about 67 stars that are located within the limiting radius of the cluster. The average proper motions (pmRA and pmDec) of the cluster are defined as $(-2.631 \pm 0.118$ and $-2.069 \pm 0.098)$ mas/year. This cluster is relatively poorly studied. The main parameters of the cluster were derived by (Tadross, 2008; Maciejewski, 2008; Glushkova et al., 2010). In 2003 we carried out the continuous monitoring (patrolling) a sample of seven unstudied open star clusters including King 18 to take the dense time-series and suspected some variables (Hojaev, 2005). This work can be considered as some kind of continuation of the search for variable stars in this cluster, initiated and started by us from ground-based observations at the Maidanak

Table 1: The list of suspected variables.

No	ID	RAdeg	DEdeg	Gmag	P (days)
1	371667757	343.04271	58.26999	$15.9740 \pm 6.37E-04$	3.56809
2	371667855	343.08025	58.28943	$16.3217 \pm 6.15E-04$	
3	371667765	343.07011	58.27206	$14.7277 \pm 2.73E-04$	2.27454
4	371667704	343.04007	58.26038	$12.3338 \pm 2.57E-03$	
5	2046865963	343.06637	58.28378	$14.9265 \pm 2.61E-03$	2.27216
6	371667801	343.07869	58.27966	$15.3368 \pm 3.96E-04$	2.27701
7	371667825	343.06692	58.28406	$12.5487 \pm 9.93E-03$	2.27217
8	371667869	343.13206	58.29222	$13.8927 \pm 6.10E-04$	0.87566
9	371667856	343.05829	58.28943	$12.2359 \pm 2.88E-04$	2.27142
10	371667778	343.08004	58.27411	$16.5549 \pm 7.79E-04$	

observatory twenty years ago, but now continued using observations from space-born or space-based observatories.

2. Observational data and analysis

The light curves from the Transiting Exoplanet Survey Satellite (TESS) (Ricker et al., 2015) space mission database were used to search for variable stars in the region of the cluster. Mikulski Archive for Space Telescopes (MAST) (Swade et al., 2019) was used to download the data. A total of 415 HLSP time series were downloaded and subsequently analyzed to find variable stars. Based on the results of the analysis, 42 suspected variable stars were identified, of which ten stars were finally selected, the light curves of which allow us to assert that they are variable stars. The capabilities of the Lightkurve (Lightkurve Collaboration et al., 2018) software were used for data analysis.

3. Results and discussions

3.1. New variable stars

The search for variable stars in the cluster region was carried out using HLSP data from the PATHOS pipeline (Nardiello, 2020). We used data downloaded from the MAST portal. After the preliminary analysis of the data, a number of objects were selected whose light curves showed the changes of brightness. Using the Lightkurve package, this list of objects was redownloaded and the light curves with the short time intervals (27-days) were inspected. We used Lomb-Scargle (Lomb, 1976; Scargle, 1982) periodogram to detect the periodicity in changes of brightness. Based on the selection results, 10 candidate stars were selected in the King 18 region whose light curves showed the presence of a change in brightness. The list of suspected variables is given in Table 1. The sample light curves of probable variable stars located in the region of the open star cluster King 18 are shown in Fig. 1 with results of periodogram analysis for some of them. The phase light curves shown in the figure are convolved

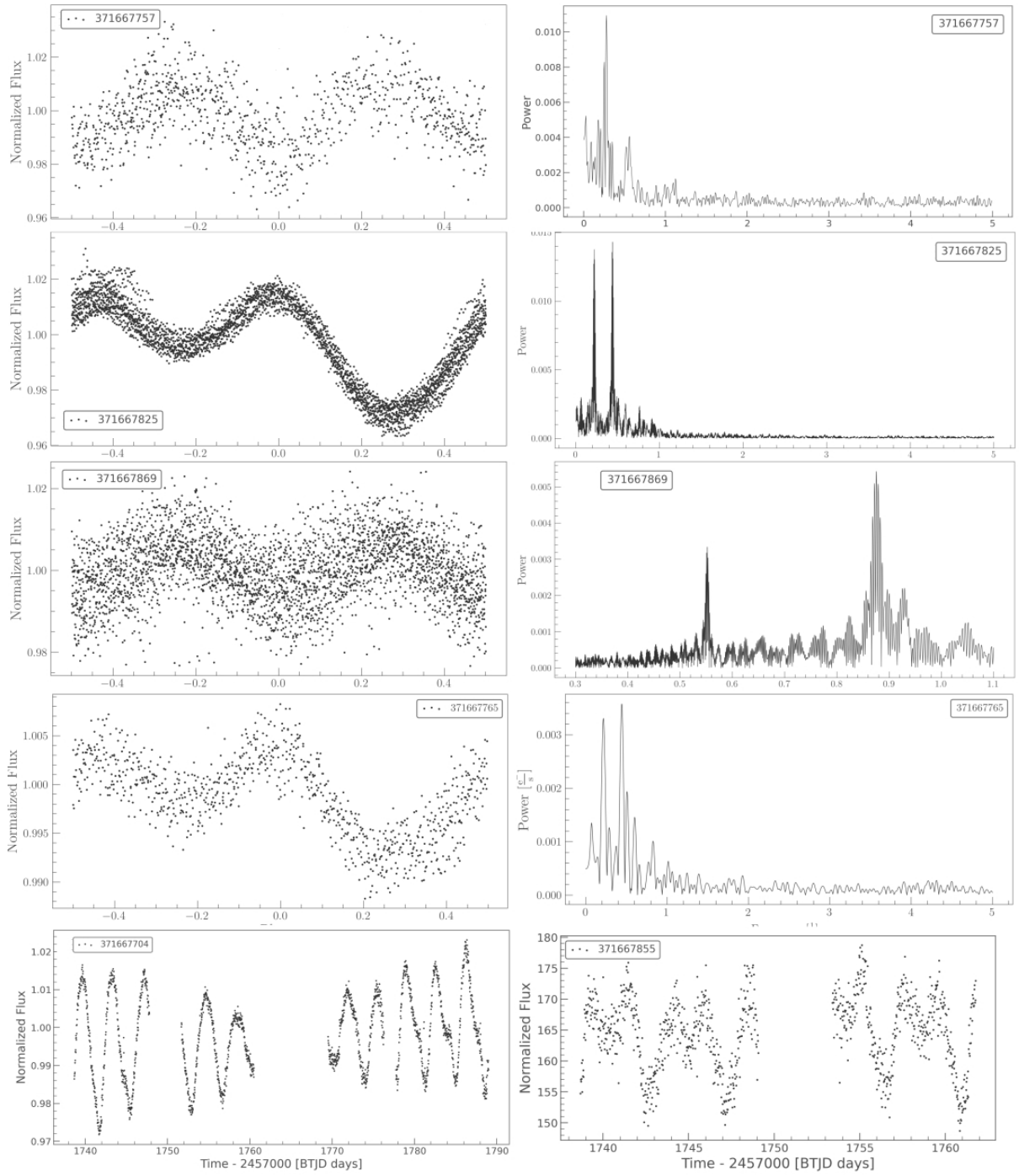


Figure 1: Sample light curves (left) and periodograms (right) of variable stars in the region of the King 18 cluster.

Table 2: Kinematic parameters of probable variable stars in the King 18 region. Column 'Pmemb' lists the membership probability published by Dias et al. (2021).

No	ID	Plx	pmRA	pmDE	Pmemb
1	371667757	0.361 ± 0.040	-2.945 ± 0.072	-2.015 ± 0.065	0.4
2	371667855	0.314 ± 0.050	-2.768 ± 0.090	-2.089 ± 0.083	0.6
3	371667765	0.277 ± 0.024	-2.656 ± 0.043	-2.095 ± 0.040	1.0
4	371667704	4.987 ± 0.026	18.209 ± 0.049	5.370 ± 0.043	
5	2046865963	0.261 ± 0.052	-2.535 ± 0.089	-2.144 ± 0.094	0.9
6	371667801	0.305 ± 0.292	-2.543 ± 0.054	-2.12 ± 0.049	1.0
7	371667825	0.514 ± 0.127	-3.055 ± 0.144	-1.984 ± 0.132	
8	371667869	0.262 ± 0.019	-2.830 ± 0.040	-2.031 ± 0.033	0.4
9	371667856	0.314 ± 0.030	-2.478 ± 0.062	-2.114 ± 0.047	0.8
10	371667778	0.282 ± 0.058	-2.508 ± 0.113	-1.985 ± 0.092	0.7

with $2 * P$, where the P corresponds to the period of brightness variations or to the frequency with maximum power in the power spectrum. The nature of the light curves of most of these variable stars suggests that they are pulsating type variables. For a more detailed study of these variables, longer time series are needed (the TESS data contain the applicable but not long-term time series for some stars obtained in several sectors only), it would be advisable to conduct ground-based observations of these suspected variable stars.

3.2. Proper motions and membership

To determine the membership of new variable stars to the King 18 cluster, we used the data on the membership probability of stars in this cluster published by Dias et al. (2021). The kinematic parameters of new variable stars in the King 18 region are presented in Table 2. It turned out that 8 of them are probable members of the cluster, and two stars are most likely field stars. The proper motion diagram of probable members of the cluster (black dots) and new variable stars (blue crosses) is shown in the left panel of Fig. 2. The spatial distribution of these stars is shown in the right panel of Fig. 3.

3.3. The color-magnitude diagram

The color-magnitude diagram (CMD) for the King 18 cluster is shown in Fig. 3. On the CMD the new variable stars are marked as blue crosses. The green circles indicate those new variable stars that belong to the cluster according to Dias et al. (2021). Black dots (Prob>0.6) and gray dots (Prob>0) represent the stars which were designated by Dias et al. (2021) as probable members of the cluster. It is easy to note that the new variable stars that we discovered belong to the Main Sequence and are fairly evolved stars. In conclusion, we should note that in this paper some preliminary results of the search for variable stars in open star cluster King 18 using the TESS archival data are presented. The study of this cluster will be continued.

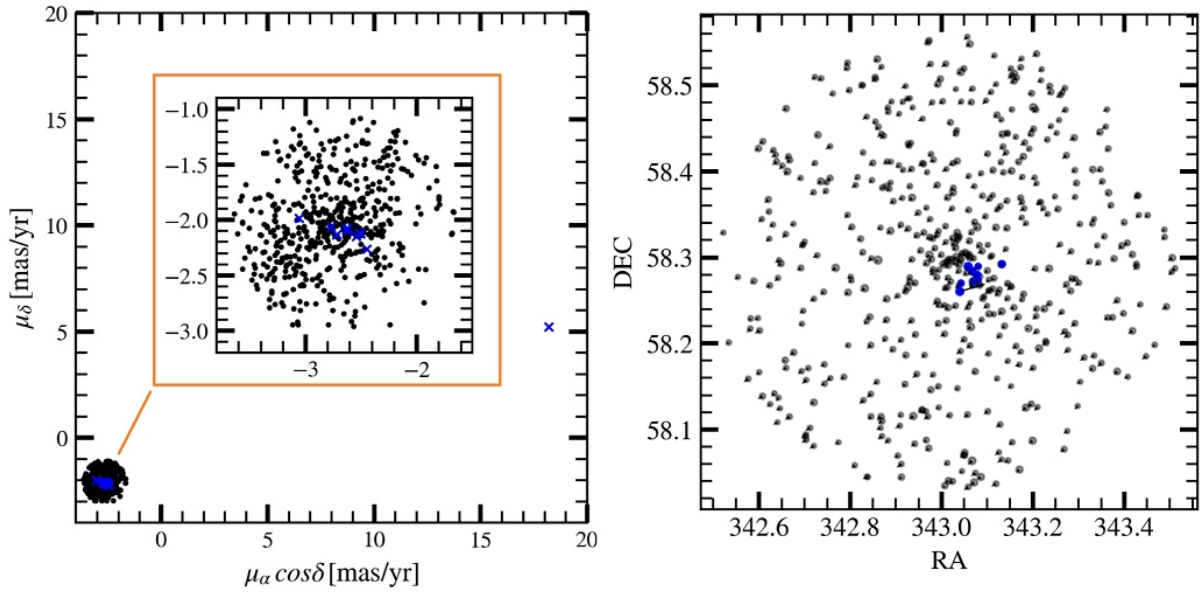


Figure 2: (left) PMD for new variable stars located in the region of the King 18 cluster. (right) 2-D distribution of new variable stars located in the region of the King 18 cluster.

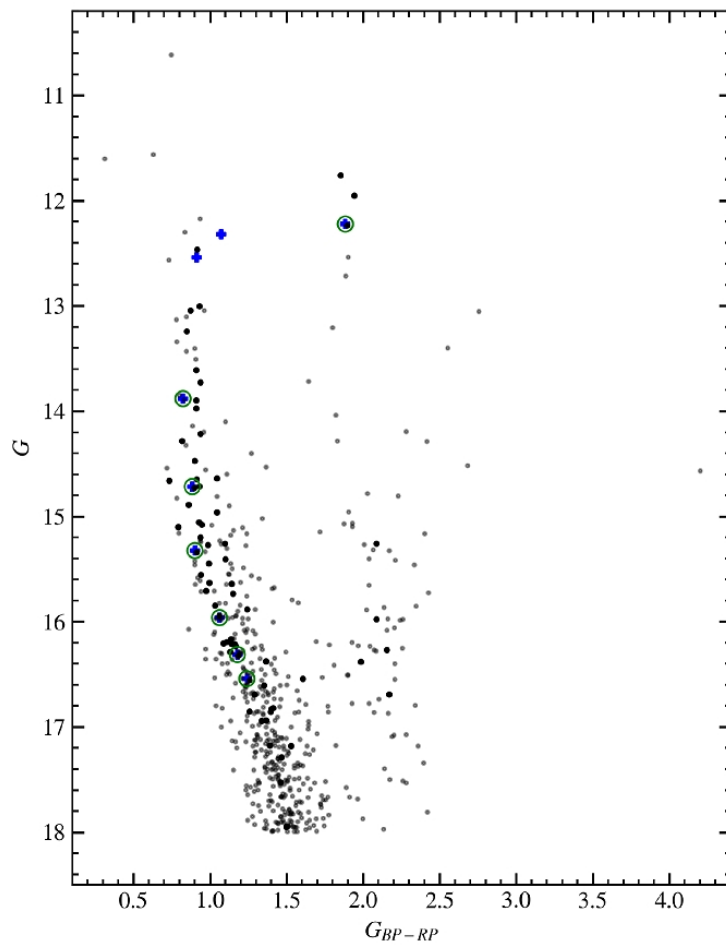


Figure 3: CMD of the King 18 cluster with new variable stars located in the region.

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Further Information

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Author contributions

ASH (concept/ideas, data analysis, paper writing); RK (data processing, paper writing)

Conflicts of interest

The authors declare no conflict of interest.

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