

A study of variable stars in the open cluster NGC 1582 and its surrounding field

Fang-Fang Song^{1,2}, Ali Esamdin¹, Lu Ma¹, Jin-Zhong Liu¹, Yu Zhang¹, Hu-Biao Niu¹ and Tao-Zhi Yang^{1,2}

¹ Xinjiang Astronomical Observatory, Chinese Academy of Sciences, Urumqi 830011, China; aliyi@xao.ac.cn

² University of Chinese Academy of Sciences, Beijing 100049, China; songfangf@xao.ac.cn

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Abstract This paper presents Charge-Coupled Device time-series photometric observations of the open cluster NGC 1582 and its surrounding field with Johnson *B*, *V* and *R* filters by using the Nanshan 1 m telescope administered by Xinjiang Astronomical Observatory. 19 variable stars and three variable candidates were detected in a $45' \times 48.75'$ field around the cluster. 12 of the variable stars are newly-discovered variable objects. The physical properties, classifications and memberships of these 22 objects are studied through their light curves, their positions on the color-magnitude diagram and with archival data from the Naval Observatory Merged Astrometric Dataset. Among these objects, five are eclipsing binary systems, six are pulsating variable stars including one known δ Scuti star and one newly-discovered RR Lyrae star. The distance to the RR Lyrae star is estimated to be 7.9 ± 0.3 kpc, indicating that the star is located far behind the cluster. Four variable stars are probable members of the cluster, and 13 of the 22 objects are confirmed to be field stars.

Key words: NGC 1582 — open cluster — variable stars — multi-color observation — magnitude

1 INTRODUCTION

Open clusters are the main components of the stellar population in our Galaxy and play a crucial role in astrophysical studies (Dias et al. 2002; Kharchenko et al. 2005; Piskunov et al. 2006; Kharchenko et al. 2013). The cluster variables show the same age, chemical composition, reddening and distance owing to their common origin (Friel 1995; Piskunov et al. 2006; Hasan et al. 2008). Searching for variable stars in open clusters can provide a window to explore stellar interiors, verify stellar evolution theory, and also offer very important clues for further understanding of the structure and evolution of the Milky Way (Dias et al. 2002; Piskunov et al. 2006).

NGC 1582 ($\alpha = 04^{\text{h}}32^{\text{m}}15.4^{\text{s}}$, $\delta = 43^{\circ}50'43.0''$; C 0428+437) is a large, sparse open cluster in Perseus (Baume et al. 2003). According to the Trumpler system, it can be classified as type IV2p (Trumpler 1930). The diameter of NGC 1582 is roughly in the range $15'$ (Dias et al. 2002) to $37'$ (Lynga & Palous 1987). It has rarely been studied because a small group of bright stars in the cluster are mixed with the rich Galactic disk field star population (Carraro 2002). The basic parameters of NGC 1582 are listed in Table 1.

The first announcement of variables in NGC 1582 was contributed by Richter (1970), who discovered two variable stars named NSV 1620 and NSV 1633. Both of these stars were described with very approximate coordinates,

and no existing light curves can be found in the literature. Richter classified NSV 1620 as a star of unknown type, and he believed that NSV 1633 could be an eclipsing variable. All the basic parameters of the stars can be found in the General Catalogue of Variable Stars (GCVS¹) (Samus et al. 2009). The first modern study of NGC 1582 was published by Baume et al. (2003). From the $UBV(I)c$ photometry and the high-resolution spectroscopy of bright stars in this cluster, Baume et al. (2003) estimated the reddening of $E(B - V) = 0.35 \pm 0.03$ mag, an approximate distance from the Sun of 1100 ± 100 pc and an age of 300 ± 100 Myr (Baume et al. 2003).

Recently, R. Furgoni reported a δ Scuti star in NGC 1582 named VSX J043245.8+434930 with a period of 0.09778 day in 2011 (Furgoni 2011). This star's parameters including its light curve can be found in the VSX database². Then, Charge-Coupled Device (CCD) observations of NGC 1582 were conducted by Yang et al. (2013). They presented two days of CCD time-series photometry in *V* and *R* bands, and announced the discovery of six variables in the region of the cluster (Yang et al. 2013). The basic parameters and the light curves of those variables are presented in table 3 and figure 8 of Yang et al. (2013), however, their variable types were not discussed.

¹ the General Catalogue of Variable Stars, <http://www.sai.msu.su/gcvs/>

² The International Variable Star Index, <http://www.aavso.org/vsx/>

In order to study variable stars in the open cluster NGC 1582 and its surrounding field, we obtained CCD time-series photometry in Johnson B , V and R bands using the Nanshan 1 m telescope administered by Xinjiang Astronomical Observatory (XAO).

The paper is organized as follows. The observations are described in Section 2. The data reduction and calibration are given in Section 3. The analysis and results are presented in Section 4. We give our conclusions in Section 5.

2 OBSERVATIONS

NGC 1582 was observed through the B , V and R filters of the standard Johnson-Cousin-Bessel multi-color filter system with the Nanshan 1 m telescope administered by XAO. This telescope sits on an alt-azimuth mount, and it has a primary focus design. Although the CCD camera (E2V CCD203-82 (blue) chip) has 4096×4096 pixels, only about a quarter of the CCD chip with 2400×2600 or 2400×2900 pixels was used, corresponding to a field of view of $45' \times 48.75'$ or $45' \times 54.375'$, respectively. The observed field of NGC 1582 is shown in Figure 1.

Observations were carried out for 14 nights (61.9 total monitoring hours) from December 2014 to January 2015. The exposure times of the B , V and R filters were 30 s, 15 s and 12 s, respectively. Totally, we collected 1792 CCD frames of NGC 1582, including 599 B -band, 594 V -band and 599 R -band images. The average seeing was 2.5 arcseconds during the observations, and the airmass ranged from 1.1 to 1.6. The journal of our observations is listed in Table 2.

3 DATA REDUCTION AND CALIBRATION

The CCD time-series frames were pre-processed by IRAF³ routines for subtracting bias, overscan and applying the flat-field correction. The dark correction was not considered since the CCD camera was operated at about -120°C with liquid nitrogen cooling and thus the thermionic noise was less than $1 \text{ e pix}^{-1} \text{ h}^{-1}$ at this temperature. The pixel coordinates were converted to equatorial coordinates by matching with the third US Naval Observatory CCD Astrograph Catalog (UCAC3).

The Nanshan 1 m telescope has a wide field of $1.3^\circ \times 1.3^\circ$. The focal plane of the telescope is not flat, leading to the fact that star images of the full field of view would be deformed slightly. This is more obvious at the edge of the pictures. The photometric software SExtractor (Bertin & Arnouts 1996) was therefore employed to perform the aperture photometry. SExtractor can provide the best apertures based on the shapes of star images automatically to ensure accuracy of photometry over the whole field. Detailed information on SExtractor can be consulted from <http://www.astromatic.net/> or Bertin & Arnouts (1996). Figure 2 shows the photometric errors and their trends versus B , V and R magnitudes from our observations.

³ Image Reduction and Analysis Facility, <http://iraf.noao.edu/>

Then a data processing system used by the XAO time-domain survey was applied to acquire light curves of all stars in the observed field. The data processing system is based on Tamuz et al. (2005), Cameron et al. (2006) and Ofir et al. (2010). The roughly de-correlated differential magnitude of one star is given by

$$x_{ij} = m_{ij} - \hat{m}_j - \hat{z}_i, \quad (1)$$

where m_{ij} is a two-dimensional array of instrumental magnitudes, i denotes a single CCD frame within the entire season's data and j labels an individual star. \hat{m}_j is the mean instrumental magnitude for each star and \hat{z}_i is the zero-point correction for each frame (Cameron et al. 2006).

In order to search for variables in the observed field, we visually examined all three-band light curves of our collection obtained by the above process. The light curves which show significant simultaneous variations and relatively large Root Mean Square (RMS) values in all filters are considered to be variable stars. Then, we checked all images again to ensure that the possible variables were neither located at the frame's edge nor contaminated by bright stars. The RMS vs magnitude diagram of all stars in the R band is shown in Figure 3.

110 non-variable stars with photometry precisions better than 0.03 mag in the R -band were selected to do the magnitude calibration. This process can produce comparison stars through utilizing brightness of these stars with random errors in the time series. We excluded stars near the edges of the CCD or which have been contaminated by other stars or bad pixels. The instrumental magnitudes b , v and r were then converted to the standard system by linear least-squares fits, whereas the standard magnitudes B , V and R were obtained through a cross match with data from the Naval Observatory Merged Astrometric Dataset version 1 (NOMAD1) (Zacharias et al. 2005). The calibration formulas for NGC 1582 are:

$$V - v = 0.19(\pm 0.08)(v - b) + 0.42(\pm 0.02), \quad (2)$$

$$B - b = 0.47(\pm 0.11)(v - b) + 1.16(\pm 0.03), \quad (3)$$

$$R - r = -0.18(\pm 0.11)(v - r) + 0.64(\pm 0.04). \quad (4)$$

4 RESULTS AND DISCUSSION

4.1 Light Curves and Observed Variable Stars

A total of 19 variable stars, labeled V1, V2, \dots , V19 in this paper, and three candidates C1, C2, and C3, have been detected through the process described in Section 3. Out of these, 12 are new detections. The locations of these 22 stars in the field of the cluster is shown in Figure 1.

Figure 3 displays the RMS of detected stars in the field of the cluster and the 22 variables and candidates are indicated with red open circles (19 variables) and green open boxes (three candidates).

V1 is listed as a variable star in the GCVS named NSV 1620, and V2 is listed in the VSX database named VSX J043245.8+434930. After comparing with the catalog of

Table 1 The Basic Parameters of NGC 1582

Name	RA (2000)	Dec (2000)	l (deg)	b (deg)	Diameter (arcmin)	Distance (pc)	Age (Myr)	Subclass
NGC 1582	04:32:15.4	+43:50:43	159.30	-2.89	15 ~ 37	1100 ± 100	300 ± 100	IV2p

Table 2 Journal of Observations for the Open Cluster NGC 1582 Using Nanshan 1 m Telescope

Date	Start (HJD 2456900+)	Length (h)	Frames (B, V, R)	Exposure (s) (B, V, R)	Seeing (arcsec)	Airmass	CCD-chip
2014Dec02	94.071	0.7	10, 9, 9	40, 25, 20	2.6	1.3683	2400 × 2600
2014Dec03	95.036	0.4	7, 7, 8	30, 15, 12	3.1	1.6349	2400 × 2600
2014Dec06	98.049	2.6	43, 44, 44	30, 15, 12	2.3	1.2608	2400 × 2600
2014Dec09	101.030	0.5	6, 6, 6	30, 15, 12	3.5	1.5190	2400 × 2600
2014Dec11	103.038	1.0	15, 16, 16	30, 15, 12	2.8	1.3807	2400 × 2600
2015Jan01	124.036	9.3	60, 59, 59	30, 15, 12	2.5	1.2845	2400 × 2600
2015Jan02	125.031	1.7	24, 23, 23	30, 15, 12	2.5	1.1225	2400 × 2600
2015Jan04	127.036	8.8	88, 88, 83	30, 15, 12	2.5	1.2560	2400 × 2900
2015Jan05	128.036	6.8	66, 66, 66	30, 15, 12	2.6	1.1080	2400 × 2900
2015Jan06	129.029	8.8	85, 85, 84	30, 15, 12	2.5	1.2533	2400 × 2900
2015Jan07	130.299	2.7	36, 37, 35	30, 15, 12	2.8	1.6198	2400 × 2900
2015Jan08	131.031	9.2	76, 76, 75	30, 15, 12	2.5	1.3543	2400 × 2900
2015Jan09	132.031	9.2	83, 82, 83	30, 15, 12	2.8	1.3634	2400 × 2900
2015Jan10	133.292	0.2	4, 3, 4	30, 15, 12	3.5	1.2774	2400 × 2900

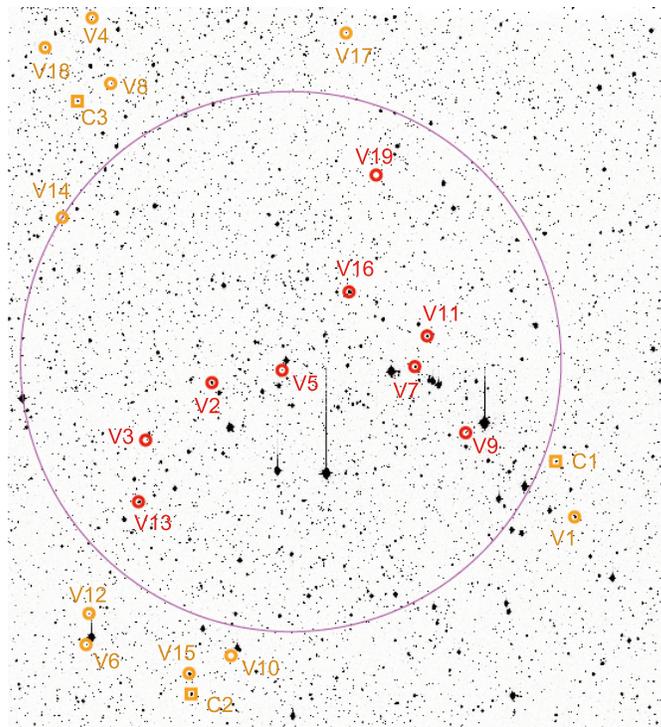


Fig. 1 Observed image of the NGC 1582 region ($45' \times 48.75'$ in R filter). The left is east and the top is north. The center of the magenta circle is $\alpha = 04^{\text{h}}32^{\text{m}}15.4^{\text{s}}$, $\delta = 43^{\circ}50'43.0''$ (Dias et al. 2002), and its radius is $18.5'$ (Lynga & Palous 1987). The 19 variable stars and three variable candidates detected by this work are marked in the image. Nine variables inside the magenta circle are marked in red and the others are in orange. The red ones are more likely to be members of the cluster than the orange ones.

Yang et al. (2013), five variables, labeled V3, V4, V5, V6 and V7 in this paper, are confirmed in our observations. These were originally discovered by Yang et al. (2013) and labeled as V1, V2, V4, V5 and V6 respectively in their paper. The light curves of V3 from Yang et al. (2013) (V3y

for distinction thereafter) and NSV 1633 obtained in this work are shown in Figure 4. The upper panels show the light curves of V3y and the lower panels show those of NSV 1633. These light curves do not exhibit variations above 0.07 and 0.05 mag levels respectively, therefore we

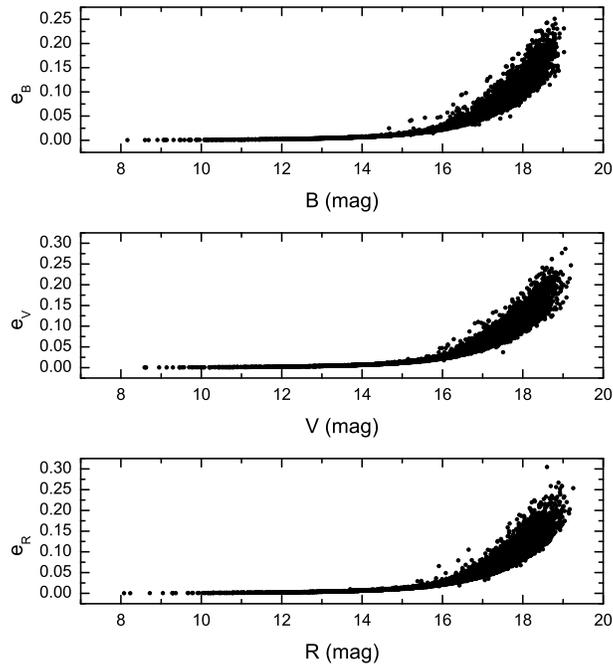


Fig. 2 Photometric errors of B , V and R bands from the observations.

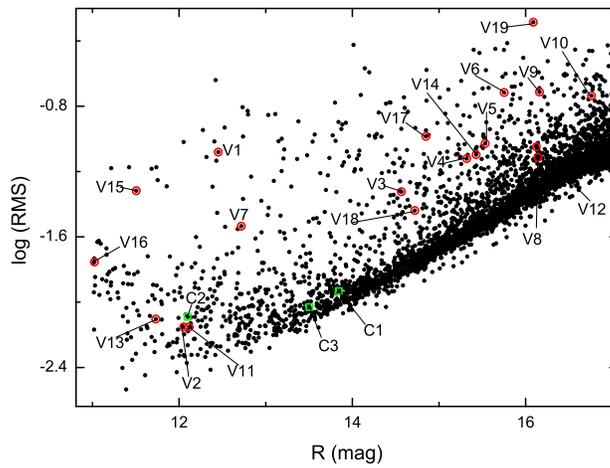


Fig. 3 The RMS - magnitude diagram of all light curves obtained in the R band. The red open circles indicate the 19 variable stars detected in this work, while the green boxes indicate the three variable candidates.

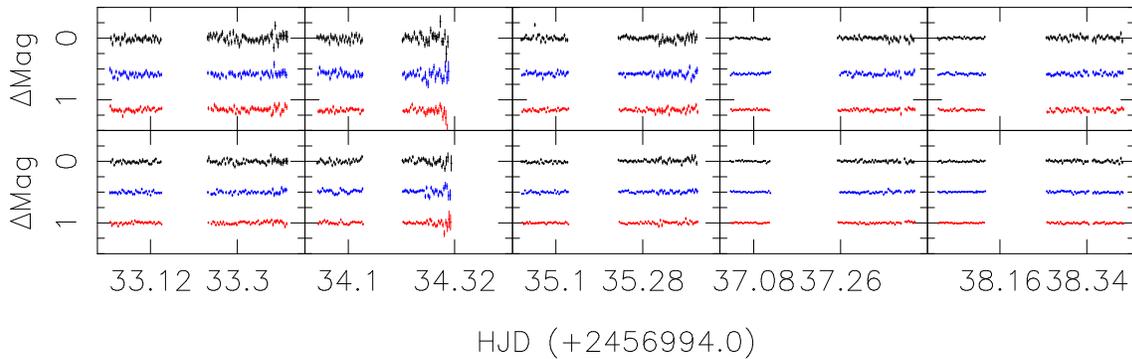


Fig. 4 Light curves of V3y (*upper panels*) and NSV 1633 (*lower panels*) after differential photometry with comparison stars in NGC 1582 in the B (*black curves*), V (*blue curves*) and R (*red curves*) filters observed by the Nanshan 1 m telescope during the five best observation nights.

Table 3 Parameters of the Eclipsing Binary Systems in the Observed Field

ID	RA (2000)	Dec (2000)	Magnitude NOMAD1 (<i>B</i> , <i>V</i> , <i>R</i>)	Amp (mag)	<i>P</i> (d)	Type	CM ¹	Ref ²
V5	04:32:18.871	+43:50:09.10	16.927, 16.162, 16.086	0.62	0.3979	EW	pm	V4*
V6	04:33:37.291	+43:31:55.81	17.203, 16.410, 16.319	0.82	0.3067	EW	nm	V5*
V8	04:33:19.440	+44:10:16.39	17.605, 16.797, 16.677	1.00	1.2368	EA	nm	
V9	04:31:10.344	+43:45:18.47	17.830, 16.961, 16.848	0.82	0.3067	EW	pm	
V10	04:32:42.833	+43:30:46.04	18.537, 17.611, 17.352	0.92	0.2624	EA	nm	

Notes: ¹ Cluster membership: ‘pm’ – probable member, ‘nm’ – non-member. ² Names given in the discovering paper of Yang et al. (2013).

Table 4 Parameters of the Pulsating Variable Stars in the Observed Field

ID	RA (2000)	Dec (2000)	Magnitude NOMAD1 (<i>B</i> , <i>V</i> , <i>R</i>)	Amp (mag)	<i>P</i> (d)	Type	CM ¹	Ref ²
V2	04:32:45.898	+43:49:30.72	13.156, 12.570, 12.671	0.04	0.0883	DSCT		VSX J043245.8 + 434930 [‡]
V3	04:33:11.292	+43:45:45.79	15.911, 15.158, 15.113	0.30	0.1968		pm	V1*
V11	04:31:23.242	+43:52:03.29	12.979, 12.525, 12.758	0.02	0.0312		pm	
V12	04:33:35.726	+43:34:03.36	17.719, 16.818, 16.723	0.56	0.1833		nm	
V13	04:33:15.329	+43:41:33.86	12.856, 12.253, 12.343	0.04	0.0838			
V14	04:33:39.936	+44:01:13.80	17.074, 16.160, 15.979	0.68	0.5858	RR Lyrae	nm	

Notes: ¹ Cluster membership: ‘pm’ – probable member, ‘nm’ – non-member. ² Name given in the discovering paper of Yang et al. (2013) (marked with *) and name given by VSX database (marked with ‡).

do not confirm their variable nature. Thus, the 12 variables V8, . . . , V19 are all new discoveries, as are the detections of the three candidates C1, C2 and C3.

The light curves of the 22 objects are shown in Figure 5. The probable types of variable stars can be specified roughly considering the features of their light curves (Samus et al. 2009; Sterken & Jaschek 2005). As shown in Table 3, we identify five eclipsing binary systems, including two Algol (Beta Persei)-type eclipsing systems (marked as “EA”) and three W Ursae Majoris-type eclipsing systems (marked as “EW”). The periods of the eclipsing systems are extracted by the PDM program of IRAF-ASTUTIL, which is based on the phase dispersion minimization algorithm (Stellingwerf 1978). The folded light curves of the five eclipsing binary systems are presented in Figure 6, and their parameters are given in Table 3.

Six variable stars, which are listed in Table 4, show typical characteristics of pulsation. In order to estimate the periods of these six pulsating variables, the phase-match technique and frequency analysis are used. The frequency analysis was performed by PERIOD04 (Lenz & Breger 2005), and the light curves are fitted by

$$m = m_0 - \sum A_i - \sin(2\pi(f_i t + \phi_i)). \quad (5)$$

The folded light curves of these pulsating variable stars are shown in Figure 7. V2 is marked “DSCT” in Table 4 because it is identified as a δ Scuti star in the VSX database. Considering the shape of their light curves and the lengths of the detected periods together with the amplitudes, V3, V12 and V13 probably belong to the δ Scuti class, while V3 and V12 are possible High Amplitude δ Scuti (HADS) stars. V11 is possibly a δ Scuti star or a GW Vir star. The light curves of V14 agree well with the RR Lyrae RRab, and V14 is marked as “RR Lyrae” in Table 4.

By adopting $E(B - V) = 0.35$ mag (Baume et al. 2003) and the absolute magnitude of RRab $M_V = 0.575 \pm 0.082$ mag (Arellano Ferro et al. 2016), and thus $(m - M)_0 = 14.5 \pm 0.09$, the distance to V14 is estimated to be 7.9 ± 0.3 kpc. The quoted uncertainty is estimated through uncertainties of measured magnitude, reddening and absolute magnitude. Since the distance of the cluster is 1.1 ± 0.1 kpc (Baume et al. 2003), we can confirm that V14 is a field RR Lyrae behind the cluster.

The variables presented in Table 5 are the stars whose types remain unconfirmed. Among these stars, V17 and V18 are likely Algol (Beta Persei)-type eclipsing systems (marked by “EA”), since each one shows one possible eclipse in their light curves. It might be possible that we have missed one or more eclipses while not observing. So, it is impossible for us to estimate a lower limit for the orbital period of the two variables and obtain their phased light curves. V16 is marked as “E” type since its light curves are similar to that of an eclipsing system. The periods of V1, V7 and V15 cannot be determined from the current work, because their periods are most likely longer than 2 days.

The left panel of Figure 8 displays the phased light curves of V4, demonstrating that the shape of light curves associated with V4 is not very similar to an eclipsing binary system, since the different depths of two minima are not visible. The light curves resemble the curve for an RRc, but the period is too short for an RR Lyrae star. Thus it could be a monoprotic HADS star.

The variation of light curves of V19 is quite like a pulsating star, but we could not find a reliable period for it. Obviously, more data and a longer time-series of observations are required for this star.

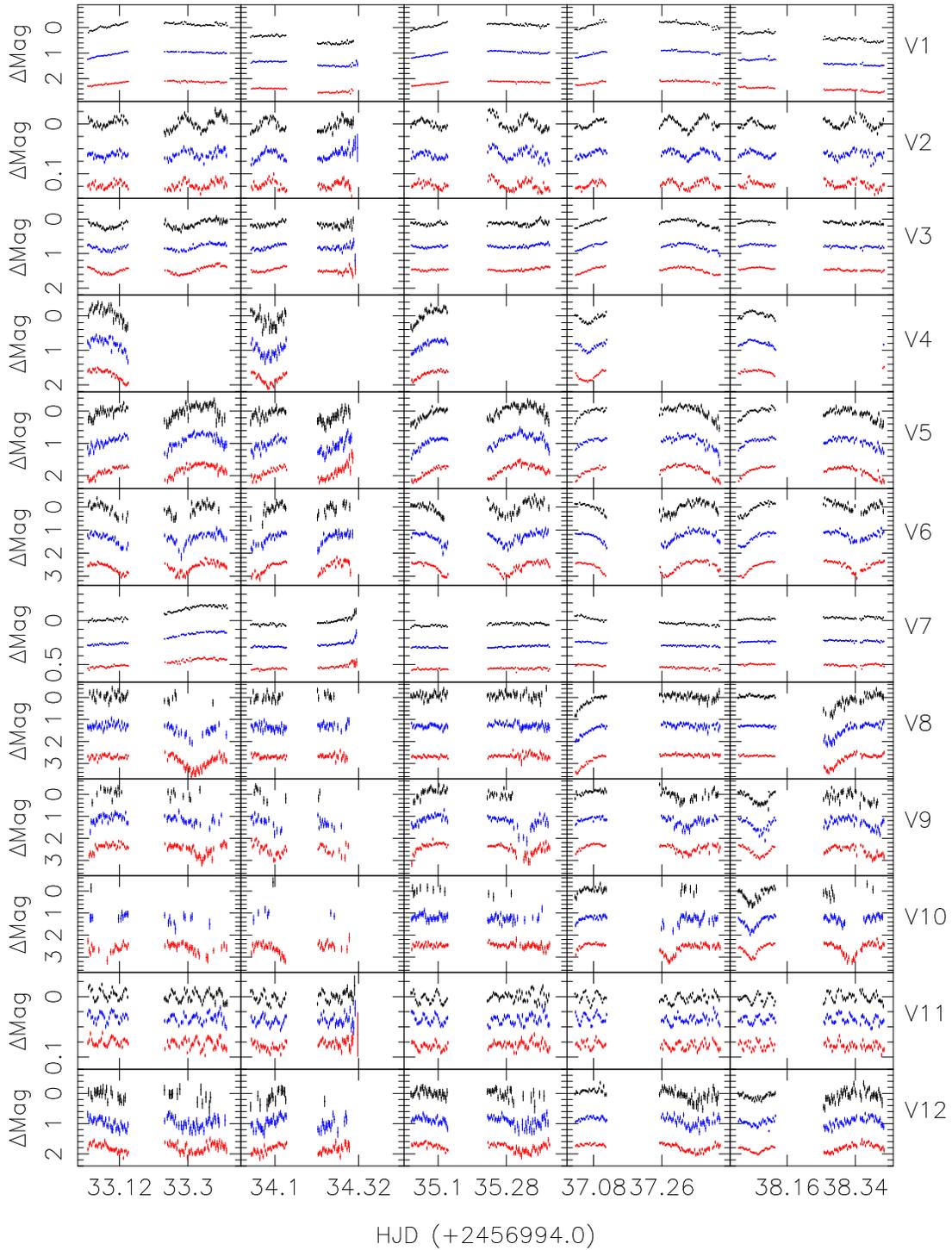
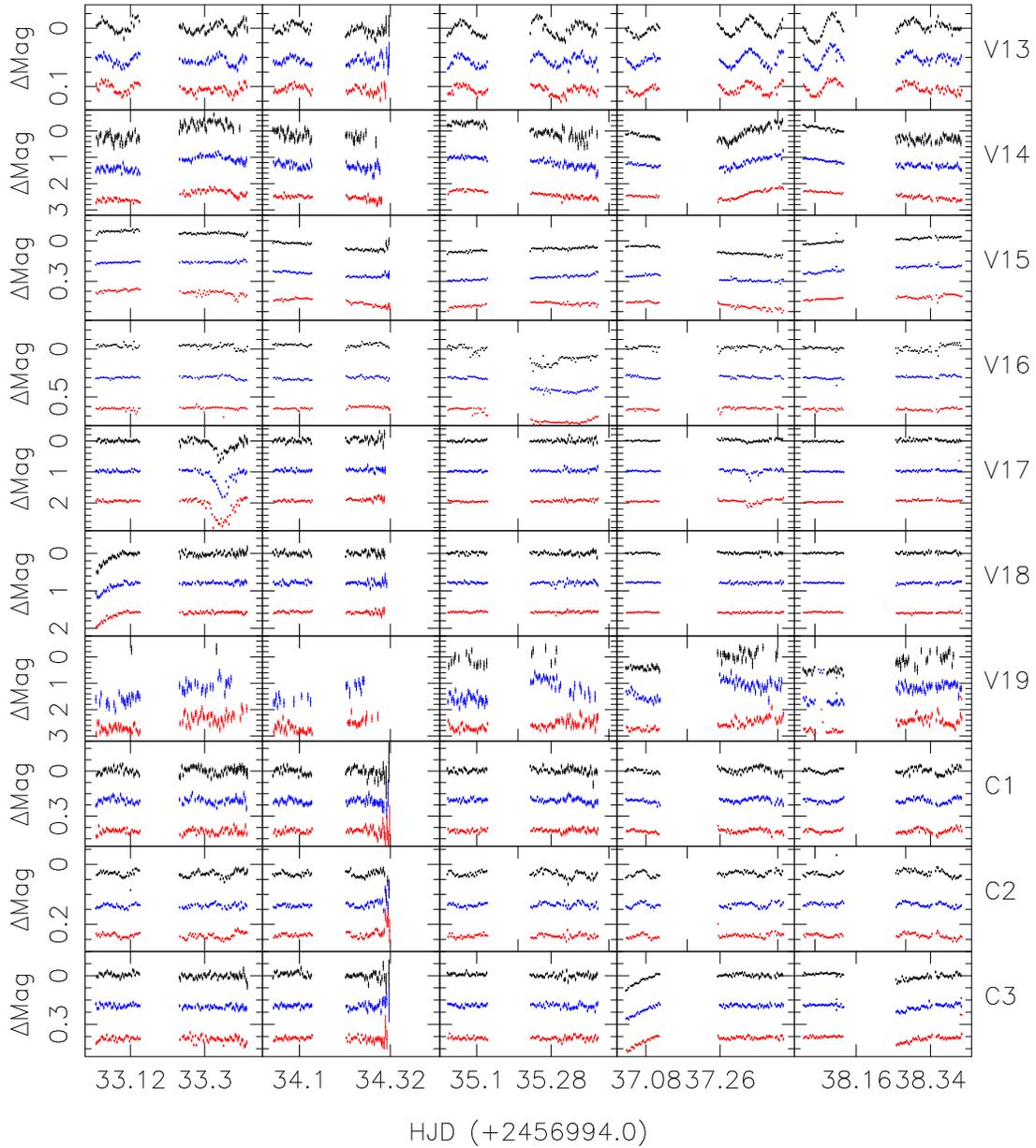


Fig. 5 Light curves of variable stars and variable candidates after differential photometry by using comparison stars in NGC 1582 in the *B* (black curves), *V* (blue curves) and *R* (red curves) filters. These were observed by the Nanshan 1 m telescope during the five best observation nights.

Three variable candidates detected in this work are listed in Table 6. As shown in Figure 5, variations of C1, C2 and C3 are very marginal. The light curves of C1 and C2 are a bit like those of pulsating stars, but their phased light curves are not obvious (see Fig. 8). C3 is likely a variable star, since it shows a 0.1 mag increase near HJD

2457031.11 in its light curves (see the fourth panel from the left in the bottom panels of Fig. 5). We have checked its images and position and found no evidence to indicate that it is affected by bad conditions. The signal-to-noise ratio of this variation is about 5.9, therefore C3 is classified as a variable candidate.

**Fig. 5** — *Continued.***Table 5** Parameters of the Unconfirmed Type of Variable Stars in the Observed Field

ID	RA (2000)	Dec (2000)	Magnitude NOMAD1 (<i>B</i> , <i>V</i> , <i>R</i>)	Amp (mag)	<i>P</i> (d)	Type	CM ¹	Ref ²
V1	04:30:30.689	+43:39:11.38	14.597, 13.506, 13.165	0.64	>2.00		nm	NSV 1620 [#]
V4	04:33:25.531	+44:14:49.13	16.756, 15.950, 15.872	0.60	0.1354		nm	V2 [*]
V7	04:31:28.481	+43:49:59.88	13.871, 13.257, 13.329	0.22	>2.17			V6 [*]
V15	04:32:58.877	+43:29:40.63	12.984, 12.203, 12.123	0.20	>2.00		nm	
V16	04:31:52.121	+43:55:18.80	11.698, 11.350, 11.687	0.24	>10.00	E		
V17	04:31:48.859	+44:13:02.24	16.178, 15.422, 15.398	1.16		EA	nm	
V18	04:33:43.932	+44:12:54.22	16.049, 15.317, 15.290	0.52		EA	nm	
V19	04:31:39.821	+44:03:13.64	17.782, 17.018, 17.019	0.72				

Notes: ¹ Cluster membership: 'nm' - non-member. ² Names given in the discovering paper of Yang et al. (2013) (marked with ^{*}) and name given by GCVS (marked with [#]).

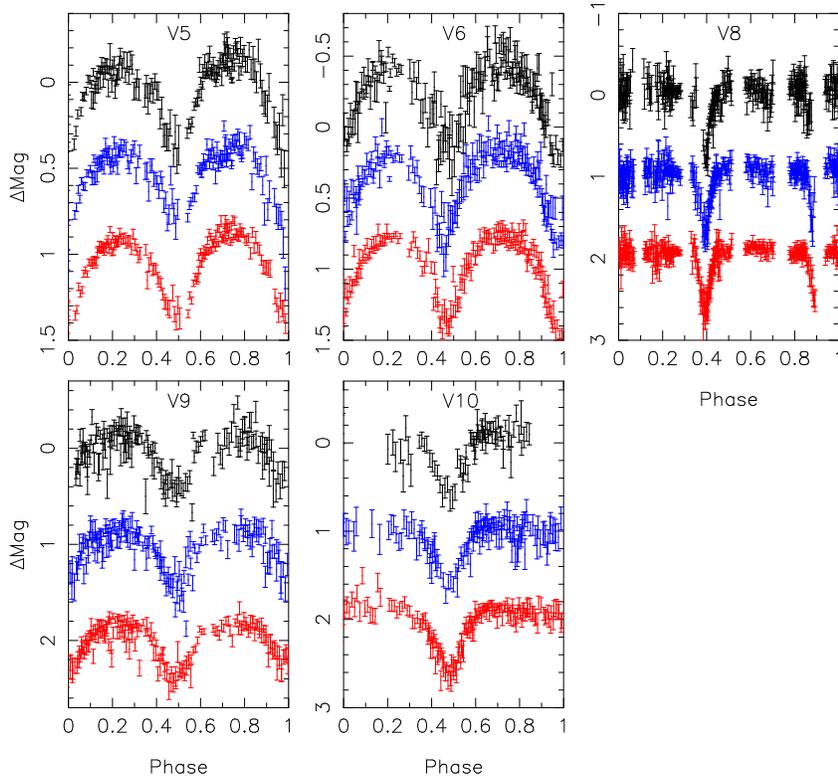


Fig. 6 Phased light curves of five eclipsing binary systems in the B (black curves), V (blue curves) and R (red curves) bands.

Table 6 Parameters of the Variable Candidates in the observed Field

ID	RA (2000)	Dec (2000)	Magnitude NOMAD1 (B , V , R)	Amp (mag)	P	CM ¹
C1	04:30:36.780	+43:43:03.36	14.989, 14.373, 14.450	0.08	0.0886	nm
C2	04:32:58.457	+43:28:15.92	13.212, 12.620, 12.716	0.04	0.0880	nm
C3	04:33:32.465	+44:09:09.29	14.551, 13.983, 14.118	0.14	5.00	nm

Notes: ¹ Cluster membership: ‘nm’ – non-member.

In this work, the types of variable stars are simply identified according to the appearance of their light curves. Further multi-color photometry and spectroscopic observations are needed to confirm the exact nature of these stars.

4.2 Color-Magnitude Diagrams

We show the $B - V$ versus V color-magnitude diagram (CMD) for NGC 1582 in Figure 9. The variable stars and variable candidates with reliable photometry in all three bands are marked as solid triangles (red or orange) in this figure. The thick solid lines are the Padova theoretical isochrones (Bressan et al. 2012) with the cluster parameters ($t = 300$ Myr, $V - M_V = 11.4$, $E(B - V) = 0.35$) from Baume et al. (2003). Since the metallicity of NGC 1582 is unknown, we plotted the isochrones with the given metallicities of 0.004 (green line), 0.008 (blue line) and 0.019 (red line).

To discuss whether the variable stars and variable candidates belong to the cluster, we first marked the cluster’s area with a magenta circle with radius $18.5'$ (this value is

suggested by Lynga & Palous 1987) in Figure 1 centered on the cluster center given by Dias et al. 2002. The objects outside the circle are considered to be non-members (labeled as ‘nm’ in Tables 3, 4, 5 and 6). V14, an RR Lyrae star, is located right on the edge of the circle. However, it is a field star far behind the cluster (see Sect. 4.1). In Figure 9, the variable stars inside the magenta circle of Figure 1 (V2, V3, V5, V7, V9, V11, V13, V16 and V19) are marked with red solid triangles, while those outside the circle, including V14, are marked with orange.

The CMD of NGC 1582 (Fig. 9) can then be used to discuss the membership of the variable stars inside the magenta circle of Figure 1. Stars in the same open cluster have the same age, initial chemical composition, and distance to the Earth (Piskunov et al. 2006; Wang et al. 2015). Stars located in the central dense region of the main sequence within a width of 3σ may therefore be considered as member stars (Yang et al. 2013).

Most of the stars in Figure 9 are field stars, so the main sequence of NGC 1582 is hard to determine in Figure 9 because the metallicity of the cluster is still unknown. As

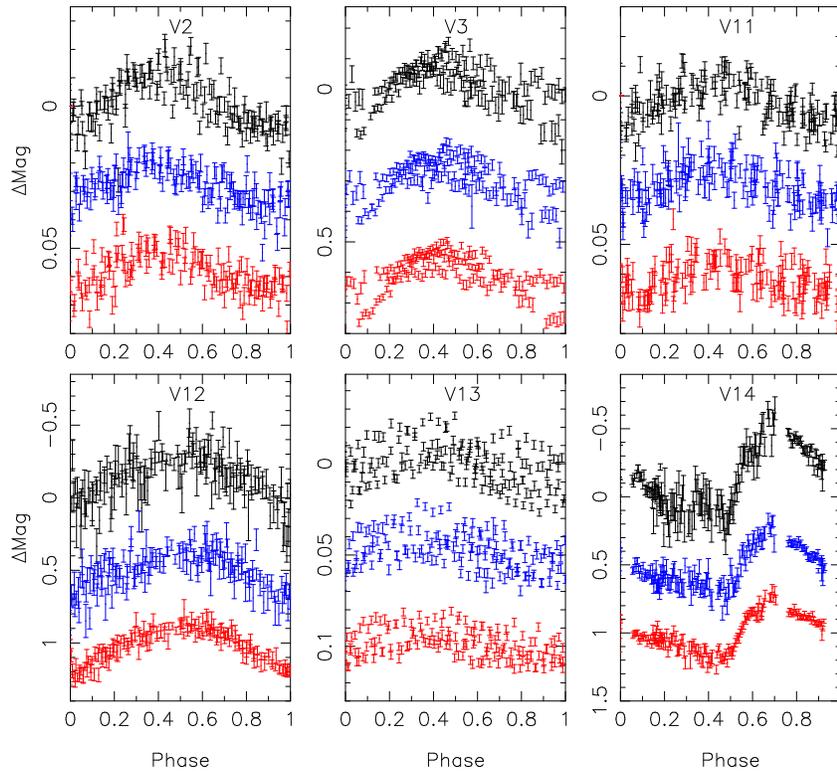


Fig. 7 Phased light curves of the six pulsating variable stars in the *B* (black curves), *V* (blue curves) and *R* (red curves) bands.

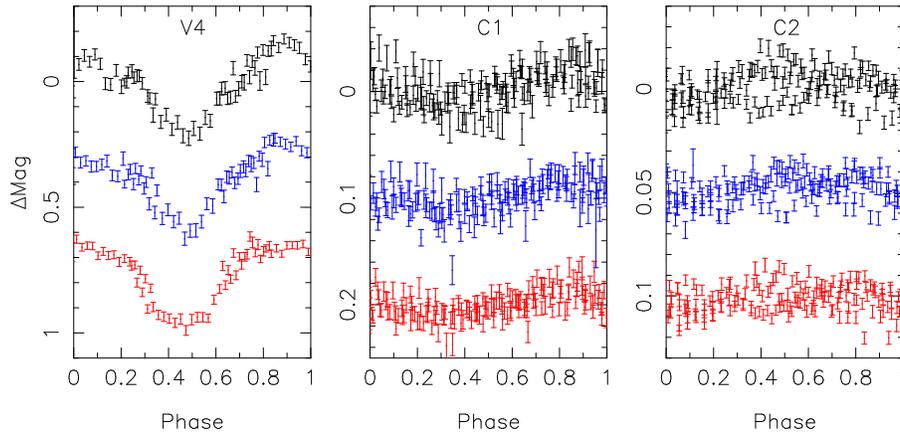


Fig. 8 Phased light curves for V4, C1 and C2 in the *B* (black curves), *V* (blue curves) and *R* (red curves) bands.

shown in Figure 9, V3, V5, V9 and V11 fit pretty well within the region enclosed by the three Padova isochrones, which may indicate that they are probable cluster members of NGC 1582. We list them as probable members of the cluster and label them as ‘pm’ in Table 3 and Table 4. Although the remaining stars, V2, V7, V13, V16 and V19, are close to the Padova isochrones with (Z) of 0.04 and 0.19, their membership is hard to determine. Yang et al. (2013) argue that V3, V5 and V7 (corresponding to V1, V4 and V6 in their paper respectively) are not members of the cluster. However, our observations cannot confirm their results. More detailed studies need to be taken in the future.

5 CONCLUSIONS

CCD time-series photometry in the *B*, *V* and *R* bands was collected with the Nanshan 1 m telescope to study variable stars in the open cluster NGC 1582 and its surrounding field. We have detected 22 variable stars in the field of the cluster, out of which 12 are new discoveries and three are classified as variable candidates.

Possible types of variable stars are specified preliminarily using the appearance of their light curves. According to features on the light curves of the 19 objects, five are eclipsing binary systems and six are pulsating variable stars including one certain δ Scuti star listed in the VSX database and one newly-discovered RR Lyrae star. The

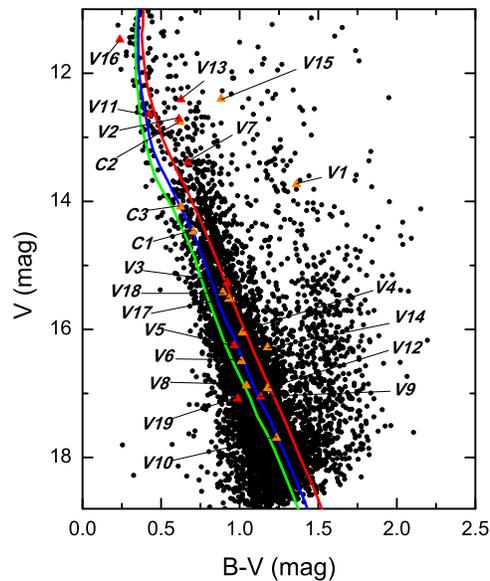


Fig. 9 CMD of NGC 1582. The solid triangles indicate the 19 variable stars and three variable candidates, which correspond to stars inside the magenta circle of Figure 1 shown with red and those outside with orange. The solid lines represent the Padova theoretical isochrones with cluster parameters ($t = 300$ Myr, $V - M_V = 11.4$, $E(B - V) = 0.35$; the metallicity Z values are 0.004 (green line), 0.008 (blue line) and 0.019 (red line)).

types of the others remain unconfirmed, and more time-series photometric and spectroscopic observations are necessary.

We conclude that the RR Lyrae star (V14), with a distance of about 8 kpc, is a field star behind the cluster. 12 objects are distributed over $18.5'$ away from the cluster center. They are not considered to be members of the cluster. Based on their locations in the CMD, four variable stars are probable members of the cluster. The membership of the remaining five variables cannot be determined in this work.

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