

Photometry of Fifteen New Variable Sources Discovered by IMSNG

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Abstract We report the discovery of fifteen new variable objects from data taken in the course of a survey that monitors nearby galaxies to uncover the onset of supernovae. A light curve was generated for each variable star candidate and was evaluated for variability in brightness and periodicity. Three objects were determined as periodic variables through period analysis using *vstar*. Nearly periodic, short-duration dips are found for three objects, and these objects are likely to be eclipsing binaries. Variability of the remaining sources are rather random, and we were not able to conclude whether they are irregular variables or not from a lack of data.

1. Introduction

Intensive Monitoring Survey of Nearby Galaxies (IMSNG) is a daily monitoring program of 60 nearby galaxies to catch the early light curve of supernovae operated by the Center for the Exploration of the Origin of the Universe (CEOU), Seoul National University (Im *et al.* 2015a). While IMSNG's principle purpose has been observing supernovae, the high cadence of the survey has provided opportunities for the discovery of variable stars. In this paper, we present the photometry and period analysis of fifteen previously unknown variable stars using IMSNG data.

Observation information and data calibration techniques are discussed in section 2. A light curve was generated for each variable star candidate to be evaluated for variability in brightness and periodicity; the photometry and period analysis of the variable star candidates are presented and analyzed in section 3. We conclude in section 4.

2. Observation and data calibration

For this paper, we used *r*-band images taken with the Lee Sang Gak Telescope (LSGT hereafter; Im *et al.* 2015b for LSGT paper), a 0.43-m telescope at the Siding Springs Observatory, Australia. The images were taken with SNUCAM-II camera which provides a field of view of $15.7' \times 15.7'$ and a pixel scale of $0.92''$ (Choi and Im 2017). Under normal circumstances, each field containing a target galaxy at the center was imaged once a day during the observation period. A total of three frames were taken at a given epoch and were later combined into a single, deeper image. Reduction of LSGT data was done by dark subtraction and flat-fielding.

In order to identify transients easily, we created a reference image to subtract from the LSGT data. For each field, eight to fifteen nights of LSGT data taken between the first two months

of observation were selected and combined into a master reference. Images with high zero-point and low full-width-half-maximum (FWHM) values were chosen. The reference image went through a process of convolution with a Gaussian profile and flux-scaling to match the seeing and the zero-point of each image.

The subtraction yields an image in which sources with constant brightness are erased out of the image. In comparison to the reference image, sources that had increased in brightness appear as white dots and ones that had decreased in brightness appear as black dots on the image. Sources that switched between white and black dots on the subtracted image were selected as variable star candidates. Subtracted images of variable star candidate USNO-B1.0 0685-0078225 are presented in Figure 1. The variable star candidates were cross-identified using NED (NASA/IPAC Extragalactic database) and IRSA (NASA/IPAC Infrared Science Archive). All the objects discussed in this paper are not identified as variables in the VSX (The International Variable Star Index).



Figure 1. Subtracted images of USNO-B1.0 0685-0078225. The right image is from Julian Date (JD) 2457685 and the left is from JD 2457696.

After this visual inspection, the standard deviation of the light curve is compared with that of the average photometric error of the object. When the light curve standard deviation is 2.56 times that of the average photometric error, we identify the object as variable. The factor of 2.56 nominally represents 99% confidence in the reality of the variability according to the C-test (Jang and Miller 1997; Romero *et al.* 1999; also see Kim *et al.* 2018).

Table 1. Variable sources identified from our data. Identifications, positional data, and classifications were taken from NED and IRSA.

Identification	R. A. (2000) h m s	Dec. (2000) ° ' "	Mag. ¹	Mag. error ²	Variability Mag. ³	Classification
STSSL2 J041928.18-545750.708	04 19 28.185	-54 57 50.73	16.407	0.019	0.717	IrS ⁴
GALEXMSC J042034.71-550055.708	04 20 34.72	-55 00 55.7	15.259	0.016	0.271	IrS, UvS5
USNO-B1.0 0685-0078225	06 16 40.50	-21 25 01.23	15.425	0.020	0.300	IrS
2MASS J10253022-3952044	10 25 30.225	-39 52 04.48	17.344	0.033	0.484	IrS
2MASS J10260936-3947373	10 26 09.369	-39 47 37.32	17.138	0.031	1.512	IrS
GALEXASC J102502.22-294913.8	10 25 02.22	-39 49 13.8	13.195	0.012	0.601	IrS, UvS
GALEXASC J102509.56-394736.7	10 25 09.57	-39 47 36.7	14.951	0.014	0.559	IrS, UvS
SDSS J123801.86+115436.5	12 38 01.865	+11 54 36.54	15.177	0.018	0.285	IrS ⁶
GALEXMSC J180742.51+174200.4	18 07 42.51	+17 42 00.4	16.319	0.030	0.510	UvS
GALEXASC J180759.71+173815.4	18 07 59.71	+17 38 15.4	16.684	0.034	0.321	IrS, UvS
2MASS J18080948+1736557	18 08 09.49	+17 36 55.77	16.82	0.037	0.410	IrS, UvS
2MASS J19422267-1019583	19 42 22.673	-10 19 58.33	16.542	0.034	0.433	IrS, UvS
GALEXASC J194247.24-102215.3	19 42 47.24	-10 22 15.4	14.981	0.028	0.338	IrS, UvS
SSTSL2 J194231.40-102150.5	19 42 31.409	-10 21 50.52	16.62	0.035	0.441	IrS
2MASS J18180055-5443534	18 18 00.559	-54 43 53.20	15.722	0.030	0.896	IrS

Notes: 1. median; 2. average; 3. max magnitude – min magnitude; 4. infrared source; 5. ultraviolet source; 6. star.

We selected three calibration stars, which also served as comparison stars for the variable star candidates, from the data release 8 (DR8) of the AAVSO Photometric All-Sky Survey (APASS; Henden *et al.* 2012) for the calculation of the photometric zero point for each epoch data. Stars with *r*-band magnitude error = 0, *r* < 14 mag, *r* > 17 mag, or a nearby light source were eliminated in the selection process. The stars with *r* < 14 mag are found to be saturated at center in the LSGT images, and the stars with *r* > 17 mag have large photometric errors in the APASS catalog. Values for *r*-band magnitude and *r*-band magnitude error were directly taken from APASS. The magnitudes of the objects were measured using a 3.0-inch diameter aperture with *SEXTRACTOR* (Bertin and Arnouts 1996) on images before the subtraction of the reference image. Period analysis on the variable star candidates was performed using *VSTAR*, developed by the AAVSO.

3. Results and discussion

Here, we describe the properties of each variable sources we identified. Table 1 describes the summary of the newly identified variable sources.

3.1. STSSL2 J041928.18-545750.7

This object was observed in the direction of NGC 1566. The cross-identifications of the object are listed in Table 2. It is classified as an infrared source in NED. Figure 2 is a light curve of the object, which was imaged over a nine-month span from Heliocentric Julian Date (HJD) 2457595 to 2457862. The brightness range over the observed period is ~0.7 magnitude. Figure 3 is a light curve of STSSL2 J041928.18-545750.7 and its comparison stars. The information about the comparison stars is listed in Table 3. While the comparison stars exhibit no variability in brightness, the variable star candidate shows strong variability. From our period analysis, the object appeared to have no signs of periodicity. However, it is likely that the result was influenced by a lack of data. With observations conducted only once a night, at its highest frequency, it is difficult for our data to reveal periods less than one day.

It cannot be concluded whether STSSL2 J041928.18-545750.7 is an irregular or periodic variable without further observations.

Table 2. Cross-identifications of STSSL2 J041928.18-545750.7. Positional data were taken from NED and IRSA.

Identification	R. A. (2000) h m s	Dec. (2000) ° ' "
STSSL2 J041928.18-545750.7	04 19 28.185	-54 57 50.73
2MASS J04192819-5457506	04 19 28.193	-54 57 50.69
USNO-B1.0 0350-0032627	04 19 28.15	-54 57 50.59

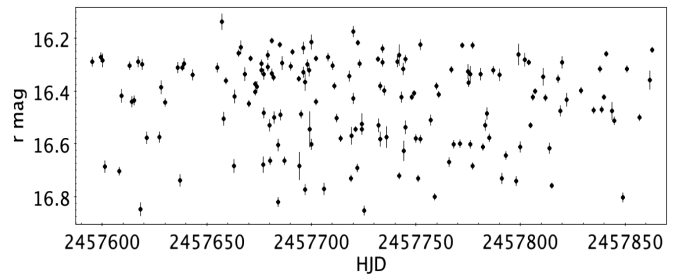


Figure 2. Light curve of STSSL2 J041928.18-545750.7.

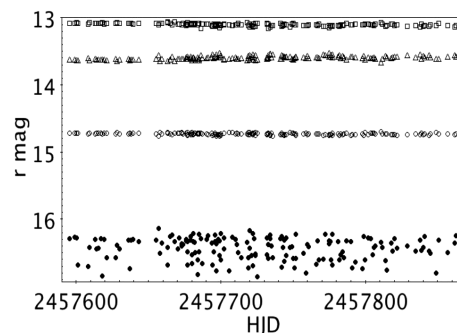


Figure 3. Light curve of STSSL2 J041928.18-545750.7 (solid circle) and its comparison stars (c1, open circle; c2, square; c3, triangle). The error bars are omitted.

Table 3. Comparison stars for variable star candidates in the field of NGC1566: STSSL2 J041928.18-545750.7 and GALEXMSC J042034.71-550055.7. Data were taken from APASS.

Name ¹	Record No. ²	R. A. (2000)			Dec. (2000)			r	r error
		h	m	s	°	'	"		
Comparison 1	36757548	04	20	23.51	-55	00	25.41	14.717	0.031
Comparison 2	36757545	04	20	22.18	-55	02	42.55	13.104	0.027
Comparison 3	36757550	04	19	48.85	-54	59	58.35	13.623	0.026

Notes: 1. in this paper; 2. in APASS.

3.2. GALEXMSC J042034.71-550055.7

This object shares the same field as STSSL2 J041928.18-545750.7. It is classified as an infrared and ultraviolet source in NED. The cross-identifications of the object are listed in Table 4. Figure 4 is a light curve of the object, which was imaged from HJD 2457595 to 2457862. The brightness range over the observed period is ~0.2 magnitude. Figure 5 is a light curve of GALEXMSC J042034.71-550055.7 and its comparison stars. The information about the comparison stars is listed in Table 3. The object shows a stronger sign of variability in brightness than its comparison stars. A period analysis revealed three possible periods of variability: 2.701 days and its aliases, 1.585 days and 0.729 days. Figure 6 is the power spectrum and Figure 7 is the phase plot phased to a period of 2.701 days.

Table 4. Cross-identifications of GALEXMSC J042034.71-550055.7. Positional data were taken from NED and IRSA.

Identification	R. A. (2000)			Dec. (2000)		
	h	m	s	°	'	"
GALEXMSC J042034.71-550055.7	04	20	34.72	-55	00	55.7
2MASS J04203483-5500557	04	20	34.836	-55	00	55.76
SSTSL2 J042043.84-550055.7	04	20	34.846	-55	00	55.73
USNO-B1.0 0349-0032686	04	20	34.81	-55	00	55.63

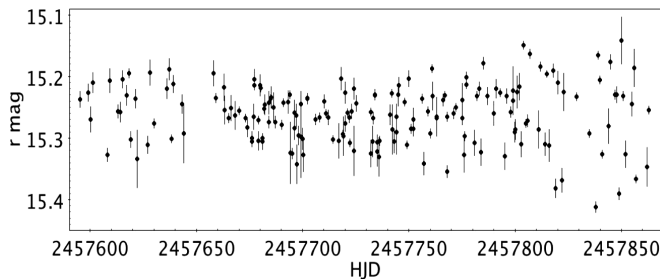


Figure 4. Light curve of GALEXMSC J042034.71-550055.7.

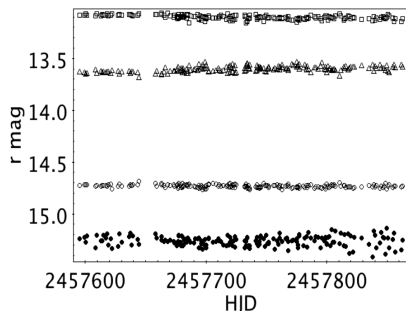


Figure 5. Light curve of GALEXMSC J042034.71-550055.7 (solid circle) and its comparison stars (c1, open circle; c2, square; c3, triangle). Error bars are omitted.

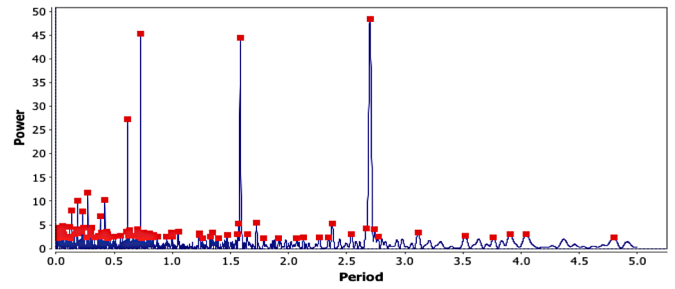


Figure 6. Power spectrum for GALEXMSC J042034.71-550055.7. Period is in days.

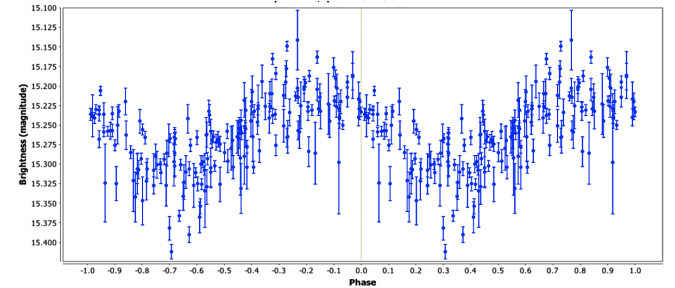


Figure 7. Phase plot of GALEXMSC J042034.71-550055.7 phased to a period of 2.701 days. Brightness (vertical axis) is in r magnitude.

3.3. USNO-B1.0 0685-0078225

This object was observed in the field of NGC 2207. It is classified as an infrared source in NED. The cross-identifications of the object are listed in Table 5. Figure 8 is a light curve of USNO-B1.0 0685-0078225 and its comparison stars, which were imaged from HJD 2457609 to 2457889. The information about the comparison stars is listed in Table 6. The brightness range over the observed period is ~0.25 magnitude. The object shows a strong evidence of variability in brightness and periodicity; a sinusoidal light curve of the variable star candidate could be observed. Period analysis on the object revealed a period of 86.337 days. Figure 9 is a phase diagram of USNO-B1 0685-0078225.

Table 5. Cross-identifications of USNO-B1.0 0685-0078225. Positional data were taken from NED and IRSA.

Identification	R. A. (2000)			Dec. (2000)		
	h	m	s	°	'	"
USNO-B1.0 0685-0078225	06	16	40.50	-21	25	01.23
2MASS J06164051-2125010	06	16	40.512	-21	25	01.08
SSTSL2 J061640.49-212501.0	06	16	40.494	-21	25	01.10

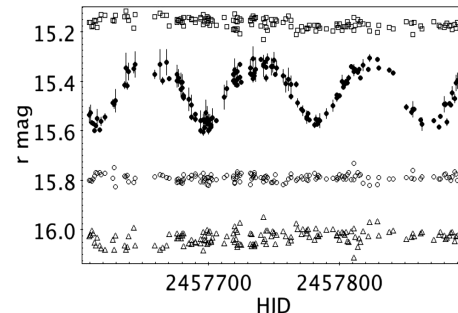


Figure 8. Light curve of USNO-B1.0 0685-0078225 (solid circle) and its comparison stars (c1, open circle; c2, square; c3, triangle).

Table 6. Comparison stars for USNO-B1.0 0685-0078225. Data were taken from APASS.

Name ¹	Record No. ²	R. A. (2000)			Dec. (2000)			r	r error
		h	m	s	°	'	"		
Comparison 1	18952833	06	16	44.32	-21	27	7.19	15.819	0.041
Comparison 2	18953603	06	16	45.82	-21	17	40.48	15.201	0.019
Comparison 3	18953333	06	16	21.51	-21	26	40.87	15.97	0.039

Notes: 1. in this paper.; 2. in APASS.

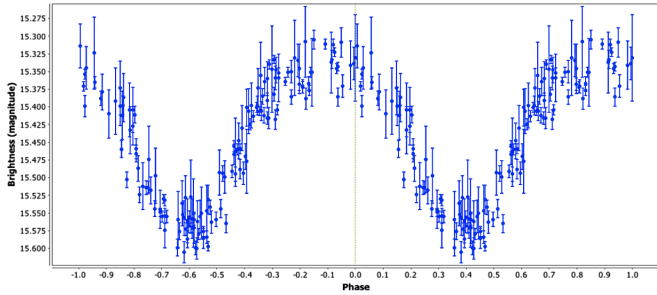


Figure 9. Phase plot of USNO-B1.0 0685-0078225 phased to a period of 86.337 days. Brightness (vertical axis) is in r magnitude.

3.4. 2MASS J10253022-3952044

This object was observed in the field of NGC 3244. It is classified as an infrared source in NED. The cross-identifications of the object are listed in Table 7. Figure 10 is a light curve of the object containing data points from HJD 2457690 to 2457942, which is about eight months. Figure 11 is a light curve of the object and its comparison stars. Table 8 includes information about the comparison stars. The brightness range over the observed period is ~0.5 magnitude. The variable star candidate exhibits an irregular variability in brightness and a period analysis was not able to identify a period. However, the object shows occasional dips in magnitude, and it is likely to be an eclipsing binary star system. Further observations should be conducted to reveal the complete behavior of the object.

Table 7. Cross-identifications of 2MASS J10253022-3952044. Positional data were taken from NED and IRSA.

Identification	R. A. (2000)			Dec. (2000)		
	h	m	s	°	'	"
2MASS J10253022-3952044	10	25	30.225	-39	52	04.48
USNO-B1.0 0501-0215795	10	25	30.24	-39	52	04.71

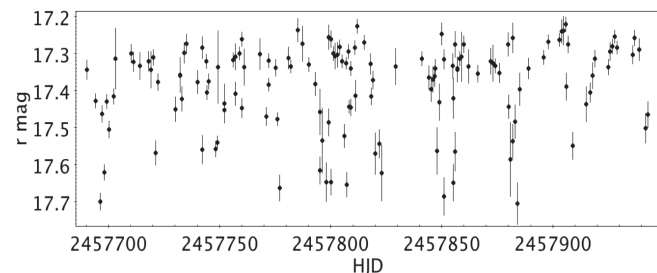


Figure 10. Light curve of 2MASS J10253022-3952044.

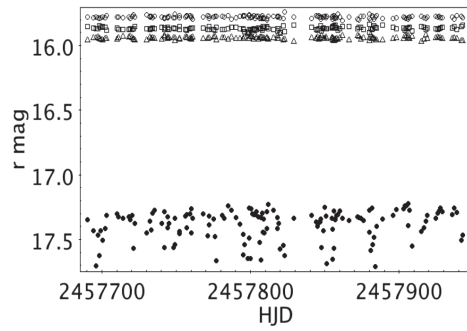


Figure 11. Light curve of 2MASS J10253022-3952044 (solid circle) and its comparison stars (c1, open circle; c2, square; c3, triangle). Error bars are omitted.

Table 8. Comparison stars for variable star candidates in the field of NGC 3244: 2MASS J10253022-3952044, 2MASS J10260936-3947373, GALEXASC J102502.22-294913.8, and GALEXASC J102509.56-394736.7. Data were taken from APASS.

Name ¹	Record No. ²	R. A. (2000)			Dec. (2000)			r	r error
		h	m	s	°	'	"		
Comparison 1	42498874	10	25	13.69	-39	44	11.05	15.754	0.06
Comparison 2	42498886	10	25	10.77	-39	42	10.31	15.918	0.022
Comparison 3	42498875	10	25	11.82	-39	42	37.4	15.92	0.034

Notes: 1. in this paper.; 2. in APASS.

3.5. 2MASS J10260936-3947373

This object was observed in the same field of 2MASS J10253022-3952044. It is classified as an infrared source in NED. The cross-identifications of the object are listed in Table 9. Figure 12 is a light curve of the object which was imaged from HJD 2457690 to 2457941. Figure 13 is a light curve of 2MASS J10260936-3947373 and its comparison stars. Table 8 includes information about the comparison stars. The brightness range over the observed period is ~1.0 magnitude. No periodicity of the object was identified in the period analysis, but just like 2MASS J10253022-3952044, the occasional, short-duration dips in brightness suggest that this object is probably an eclipsing binary. Further observations should be conducted of this object.

Table 9. Cross-identifications of 2MASS J10260936-3947373. Positional data were taken from NED and IRSA.

Identification	R. A. (2000)			Dec. (2000)		
	h	m	s	°	'	"
2MASS J10260936-3947373	10	26	09.369	-39	47	37.32
USNO-B1.0 0502-0215697	10	26	09.38	-39	47	37.60

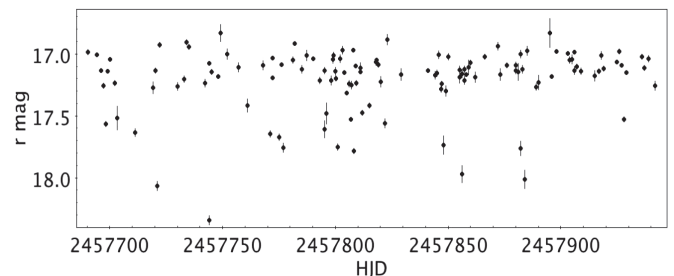


Figure 12. Light curve of 2MASS J10260936-3947373.

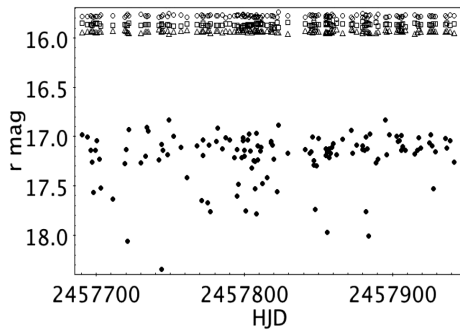


Figure 13. Light curve of 2MASS J10260936-3947373 (solid circle) and its comparison stars (c1, open circle; c2, square; c3, triangle). Error bars are omitted.

3.6. GALEXASC J102502.22-294913.8

This object was observed in the same field as the previous object. It is classified as an infrared and ultraviolet source in NED. The cross-identifications of the object are listed in Table 10. Figure 14 is a light curve of GALEXASC J102502.22-294913.8, which was imaged from HJD 2457690 to 2457942. Figure 15 is a light curve of the object and its comparison stars. Information about the comparison stars is listed in Table 8. The brightness range over the observed period is ~ 0.5 magnitude. The brightness of the object remains relatively constant except for when an unusual darkening occurs every ~ 70 days. This periodic dip in brightness suggests that this object is an eclipsing binary star system. However, when performing a period analysis using *VSTAR*, we failed to identify a periodicity. Further observations should be conducted of this object to confirm its pattern of variability in brightness.

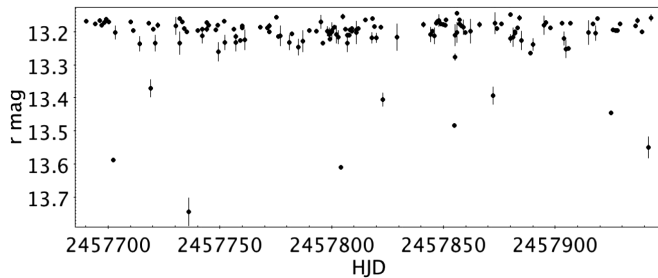


Figure 14. Light curve of GALEXASC J102502.22-294913.8.

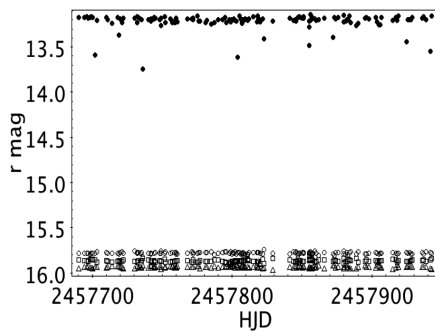


Figure 15. Light curve of GALEXASC J102502.22-294913.8 (solid circle) and its comparison stars (c1, open circle; c2, square; c3, triangle). Error bars are omitted.

Table 10. Cross-identifications of GALEXASC J102502.22-294913.8. Positional data were taken from NED and IRSA.

Identification	R. A. (2000)			Dec. (2000)		
	h	m	s	°	'	"
GALEXASC J102502.22-294913.8	10	25	02.22	-39	49	13.8
2MASS J10250224-3949140	10	25	02.241	-39	49	14.10
GALEXMSC J102502.26-394914.2	10	25	02.261	-39	49	14.23
USNO-B1.0 0501-0215578	10	25	02.24	-39	49	14.14

3.7. GALEXASC J102509.56-394736.7

This object was observed in the field of NGC 3244. It is classified as an infrared and ultraviolet source in NED. The cross-identifications of the object are listed in Table 11. Figure 16 is a light curve of the object containing data points from HJD 2457690 to 2457942. The brightness range over the observed period is ~ 0.5 magnitude. Figure 17 is a light curve of GALEXASC J102509.56-394736.7 and its comparison stars. Information about the comparison stars is listed in Table 8. The object shows a strong sign of variability in brightness in comparison to its comparison stars. The object exhibits an irregular pattern of variability in brightness, but as it is in the case of STSSL2 J041928.18-545750.7, further observations should be conducted of this target.

Table 11. Cross-identifications of GALEXASC J102509.56-394736.7. Positional data were taken from NED and IRSA.

Identification	R. A. (2000)			Dec. (2000)		
	h	m	s	°	'	"
GALEXASC J102509.56-394736.7	10	25	09.57	-39	47	36.7
2MASS J10250953-3947372	10	25	09.537	-39	49	47 37.22
GALEXMSC J102509.61-394737.2	10	25	09.	-39	49	47 37.3
USNO-B1.0 0502-0215192	10	25	09.61	-39	47	38.57

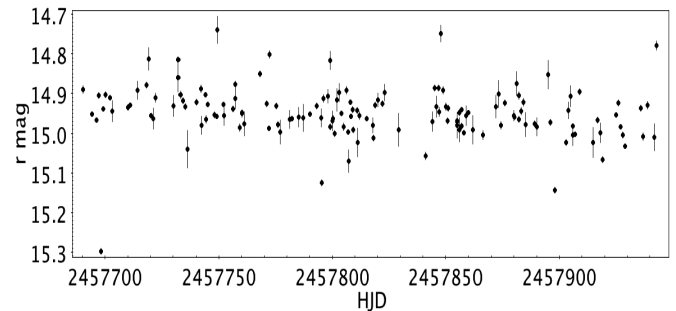


Figure 16. Light curve of GALEXASC J102509.56-394736.7.

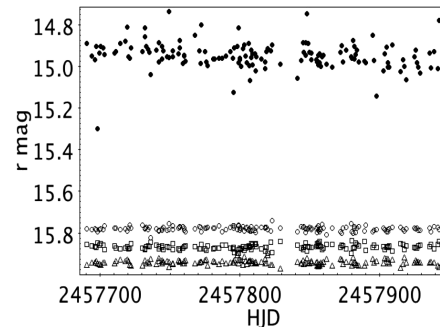


Figure 17. Light curve of GALEXASC J102509.56-394736.7 (solid circle) and its comparison stars (c1, open circle; c2, square; c3, triangle). Error bars are omitted.

3.8. SDSS J123801.86+115436.5

This star was observed in the direction of M58. It is also classified as an infrared source in NED. The cross-identifications of the object are listed in Table 12. Figure 18 is a light curve of SDSS J123801.86+115436.5 which was imaged from HJD 2457781 to 2457876. The brightness range over the observed period is ~ 0.15 magnitude. Figure 19 is a light curve of the object and its comparison stars. Table 13 lists information about the comparison stars. The brightness of the object increases around HJD 2457820. In comparison to its comparison stars, the variable star candidate shows a slightly stronger sign of variability in brightness. Because of the inconsistency and scarcity of this target's data, we were not able to conclude on the object's periodicity. Further observations should be conducted to clarify not only the periodicity of the object, but also its variability.

Table 12. Cross-identifications of SDSS J123801.86+115436.5. Positional data were taken from NED and IRSA.

Identification	R. A. (2000) h m s	Dec. (2000) ° ' "
SDSS J123801.86+115436.5	12 38 01.865	+11 54 36.54
2MASS J12380186+1154367	12 38 01.869	+11 54 26.72
SSTSL2 J123801.86+115436.8	12 38 01.867	+11 54 36.84
USNO-B1.0 1019-0238385	12 38 01.87	+11 54 36.59

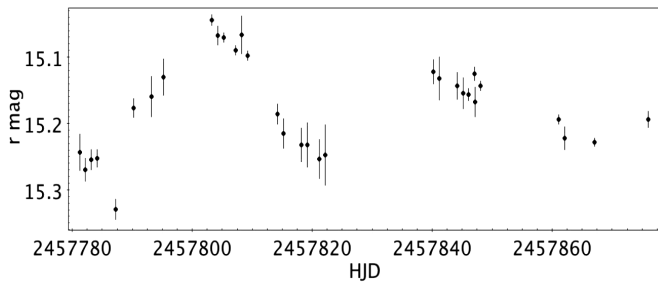


Figure 18. Light curve of SDSS J123801.86+115436.5.

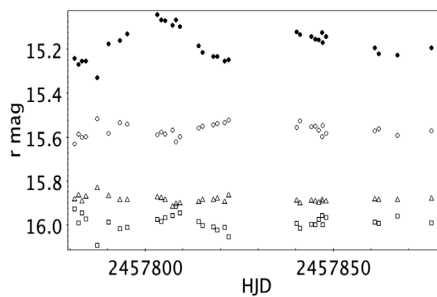


Figure 19. Light curve of SDSS J123801.86+115436.5 (solid circle) and its comparison stars (c1, open circle; c2, square; c3, triangle). Error bars are omitted.

Table 13. Comparison stars for SDSS J123801.86+115436.5. Data were taken from APASS.

Name ¹	Record No. ²	R. A. (2000) h m s	Dec. (2000) ° ' "	r	r error
Comparison 1	27580451	12 37 29.9	+11 53 3.63	15.583	0.12
Comparison 2	27580450	12 38 14.97	+11 50 30.73	15.967	0.086
Comparison 3	27580456	12 37 48.52	+11 54 48.86	15.893	0.048

Notes: 1. in this paper; 2. in APASS.

3.9. GALEXMSC J180742.51+174200.4

This object was observed in the field of NGC6555. It is classified as an ultraviolet source in IRSA. The cross-identifications of the object are listed in Table 14. Figure 20 is a light curve of GALEXMSC J180742.51+174200.4, which was imaged from HJD 2457864 to 2457960. IMSNG data of this field only covers a limited time span of 96 days. Figure 21 is a light curve of the variable star candidate and its comparison stars. Information about the comparison stars is listed in Table 15. The brightness range over the observed period is ~ 0.4 magnitude. The object shows strong signs of variability in brightness, but we were not able to identify any evidence of periodicity when running a period. As it is the case for SDSS J123801.86+115436.5, the object's variability behavior should not be concluded without further accumulation of observational data.

Table 14. Cross-identifications of GALEXMSC J180742.51+174200.4. Positional data were taken from IRSA.

Identification	R. A. (2000) h m s	Dec. (2000) ° ' "
GALEXMSC J180742.51+174200.4	18 07 42.51	+17 42 00.5
2MASS 18074251+1742003	18 07 42.51	+17 42 00.37
USNO-B1.0 1077-0384323	18 07 42.53	+17 42 00.41

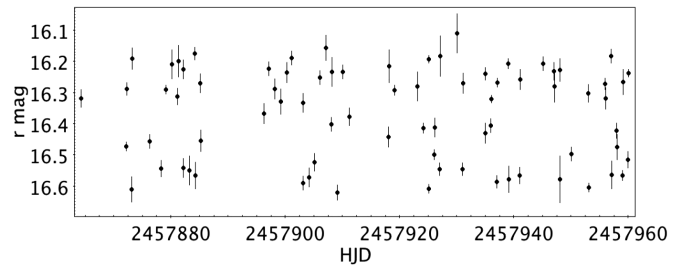


Figure 20. Light curve of GALEXMSC J180742.51+174200.4.

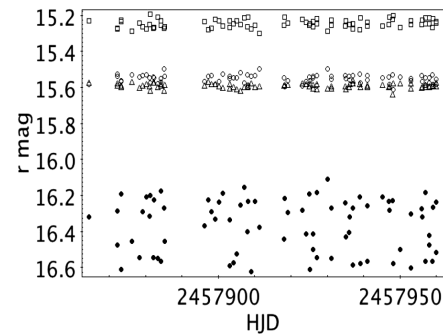


Figure 21. Light curve of GALEXMSC J180742.51+174200.4 (solid circle) and its comparison stars (c1, open circle; c2, square; c3, triangle). Error bars are omitted.

Table 15. Comparison stars for variable star candidates in the field of NGC6555: GALEXMSC J180742.51+174200.4, GALEXASC J180759.71+173815.4, and 2MASS J18080948+1736557. Data were taken from APASS.

Name ¹	Record No. ²	R. A. (2000) h m s	Dec. (2000) ° ' "	r	r error
Comparison 1	35377630	18 08 2.78	+17 41 37.74	15.511	0.02
Comparison 2	34985413	18 07 36.83	+17 35 32.33	15.275	0.048
Comparison 3	34985436	18 07 54.07	+17 37 12.55	15.609	0.163

Notes: 1. in this paper; 2. in APASS.

3.10. GALEXASC J180759.71+173815.4

This object was observed in the same field of GALEXASC J180742.51+174200.4. It is classified as an infrared and ultraviolet source in NED. The cross-identifications of the object are listed in Table 16. Figure 22 is a light curve of GALEXASC J180759.71+173815.4 which was imaged from HJD 2457864 to 2457960. The brightness range over the observed period is ~ 0.3 magnitude. Figure 23 is a light curve of the variable star candidate and its comparison stars. Information about the comparison stars is listed in Table 15. Compared to its comparison stars, the GALEXASC J180759.71+173815.4 shows a stronger sign of variability in brightness. The object's variability in brightness appears to be irregular, and a period analysis failed to indicate any signs of periodicity. Additional observations would be beneficial to reveal more specific details about the object's pattern of variability.

Table 16. Cross-identifications of GALEXASC J180759.71+173815.4. Positional data were taken from IRSA.

<i>Identification</i>	<i>R. A. (2000)</i> <i>h m s</i>	<i>Dec. (2000)</i> <i>° ' "</i>
GALEXASC J180759.71+173815.4	18 07 59.72	+17 38 15.4
2MASS 18075972+1738153	18 07 59.725	+17 38 15.39
USNO-B1.0 1076-0373592	18 07 59.71	+17 38 15.86

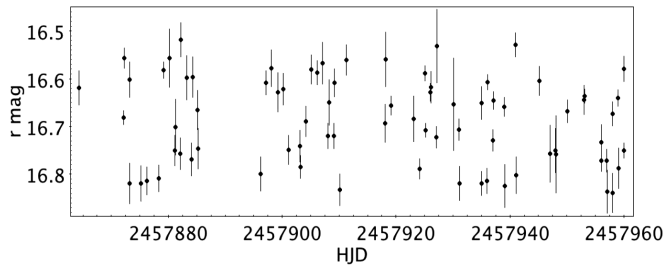


Figure 22. Light curve of GALEXASC J180759.71+173815.4.

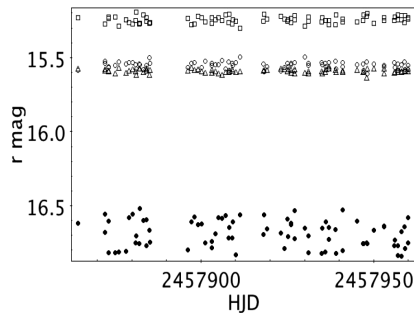


Figure 23. Light curve of GALEXASC J180759.71+173815.4 (solid circle) and its comparison stars (c1, open circle; c2, square; c3, triangle). Error bars are omitted.

3.11. 2MASS J18080948+1736557

This object was imaged in the field of NGC6555. The cross-identifications of the object are listed in Table 17. It is classified as an infrared and ultraviolet source in NED. Figure 24 is a light curve of 2MASS J18080948+1736557 which was imaged from HJD 2457864 to 2457960. Figure 25 is a light curve of the variable star candidate and its comparison stars. Information about the comparison stars is listed in Table 15. The brightness range over the observed period is ~ 0.4 magnitude. The light curve and period analysis of the object indicates that the object

is possibly an irregular variable, but further observations should be conducted as the data coverage of the target's variability behavior is limited.

Table 17. Cross-identifications of 2MASS J18080948+1736557. Positional data were taken from IRSA.

<i>Identification</i>	<i>R. A. (2000)</i> <i>h m s</i>	<i>Dec. (2000)</i> <i>° ' "</i>
2MASS J18080948+1736557	18 08 09.49	+17 36 55.77
GALEXASC J18089.49+173656.2	18 08 09.49	+17 36 56.2
GALEXASC J18089.48+173655.7	18 08 09.49	+17 36 55.8
USNO-B1.0 1076-0373717	18 08 09.49	+17 36 56.19

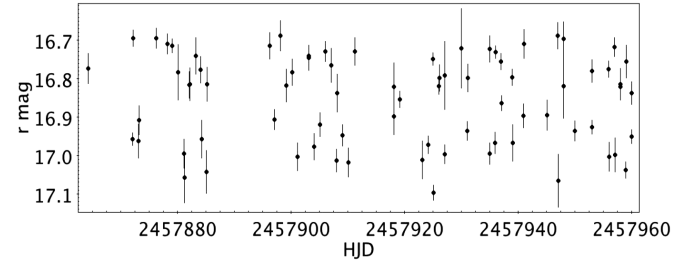


Figure 24. Light curve of 2MASS J18080948+1736557.

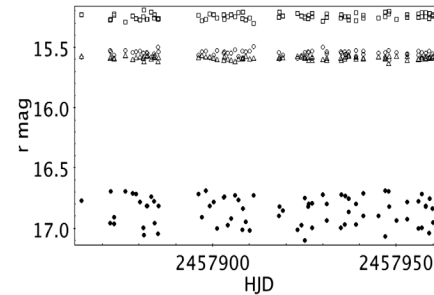


Figure 25. Light curve of 2MASS J18080948+1736557 (solid circle) and its comparison stars (c1, open circle; c2, square; c3, triangle). Error bars are omitted.

3.12. 2MASS J19422267-1019583

This object was imaged in the field of NGC 6814. It is classified as an infrared and ultraviolet source in NED. The cross-identifications of the object are listed in Table 18. Figure 26 is a light curve of 2MASS J19422267-1019583 which was imaged from HJD 2457872 to 2457960 for a total of 62 useful measurements. The brightness range over the observed period is ~ 0.4 magnitude. Figure 27 is a light curve of the variable star candidate and its comparison stars. Information about the comparison stars is listed in Table 19. The object shows a strong evidence of variability in brightness in comparison to its comparison stars. While the period analysis revealed no signs of periodicity, from a lack of data, we were not able to conclude whether the variable is irregular or periodic.

Table 18. Cross-identifications of 2MASS J19422267-1019583. Positional data were taken from NED and IRSA.

<i>Identification</i>	<i>R. A. (2000)</i> <i>h m s</i>	<i>Dec. (2000)</i> <i>° ' "</i>
2MASS J19422267-1019583	19 42 22.673	-10 19 58.33
GALEXASC J194222.66-101958.6	19 42 22.66	-10 19 58.6
GALEXASC J194222.70-101957.7	19 42 22.70	-10 19 57.8
USNO-B1.0 0796-0586608	19 42 22.70	-10 19 58.44

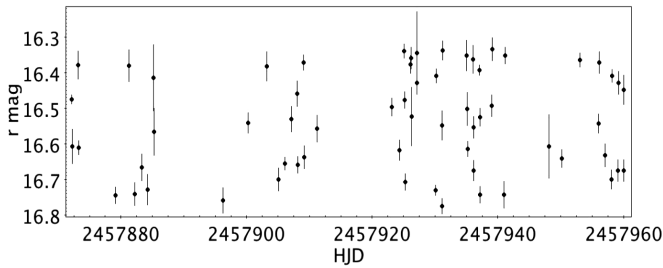


Figure 26. Light curve of 2MASS J19422267-1019583.

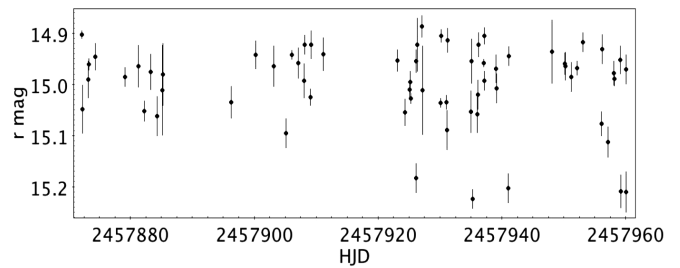


Figure 28. Light curve of GALEXASC J194247.24-102215.3. Error bars are omitted.

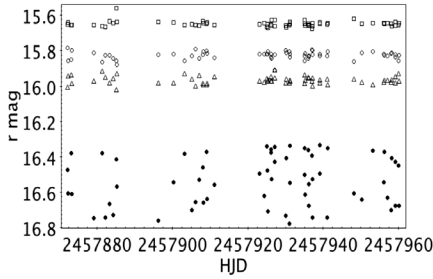


Figure 27. Light curve of 2MASS J19422267-1019583 (solid circle) and its comparison stars (c1, open circle; c2, square; c3, triangle). Error bars are omitted.

Table 19. Comparison stars for variable star candidates in the field of NGC6814: 2MASS J19422267-1019583, GALEXASC J194247.24-102215.3, and SSTSL2 J194231.40-102150.5. Data were taken from APASS.

Name ¹	Record No. ²	R. A. (2000) h m s	Dec. (2000) ° ' "	r	r error
Comparison 1	30624988	19 42 43.66	-10 22 13.09	15.768	0.059
Comparison 2	30625086	19 42 35.97	-10 17 23.69	15.642	0.01
Comparison 3	30625364	19 42 28.53	-10 12 29.19	16.037	0.043

Notes: 1. in this paper; 2. in APASS.

3.13. GALEXASC J194247.24-102215.3

This object was imaged in the direction of NGC 6814. It is classified as an infrared and ultraviolet source in NED. The cross-identifications of the object are listed in Table 20. Figure 28 is a light curve of GALEXASC J194247.24-102215.3, which was imaged from HJD 2457872 to 2457960. Figure 29 is a light curve of the variable star candidate and its comparison stars. Information about the comparison stars is listed in Table 19. The brightness range over the observed period is ~0.3 magnitude. For the same reasons as the previous object, 2MASS J19422267-1019583, we were not able to conclude on the periodicity of GALEXASC J194247.24-102215.3.

Table 20. Cross-identifications of GALEXASC J194247.24-102215.3. Positional data were taken from NED and IRSA.

Identification	R. A. (2000) h m s	Dec. (2000) ° ' "
GALEXASC J194247.24-102215.3	19 42 47.24	-10 22 15.4
2MASS J19424724-1022151	19 42 47.250	-10 22 15.19
USNO-B1.0 0796-0586941	19 42 47.22	-10 22 15.54

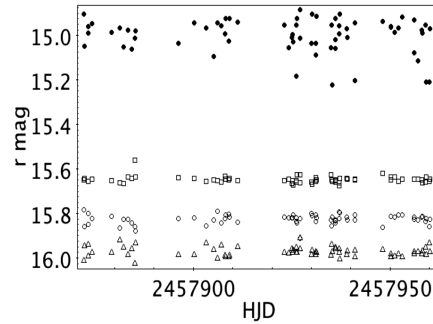


Figure 29. Light curve of GALEXASC J194247.24-102215.3 (solid circle) and its comparison stars (c1, open circle; c2, square; c3, triangle). Error bars are omitted.

3.14. SSTSL2 J194231.40-102150.5

This object is in the same field of view as the previous object. It is classified as an infrared source in NED. The cross-identifications of the object are listed in Table 21. Figure 30 is a light curve of SSTSL2 J194231.40-102150.5, which was imaged from HJD 2457872 to 2457960. The brightness range over the observed period is ~0.4 magnitude. Figure 31 is a light curve of the variable star candidate and its comparison stars. Information about the comparison stars is listed in Table 19. A period analysis revealed a possible period of 0.12497 days with no indication of aliases. The power spectrum is shown in Figures 32 and 33. Figure 34 is the phase plot of the object phased to a period of 0.12497 days.

Table 21. Cross-identifications of SSTSL2 J194231.40-102150.5. Positional data were taken from NED and IRSA.

Identification	R. A. (2000) h m s	Dec. (2000) ° ' "
SSTSL2 J194231.40-102150.5	19 42 31.409	-10 21 50.52
2MASS J19423139-1021503	19 42 31.394	-10 21 50.31
USNO-B1.0 0796-0586742	19 42 31.40	-10 21 50.49

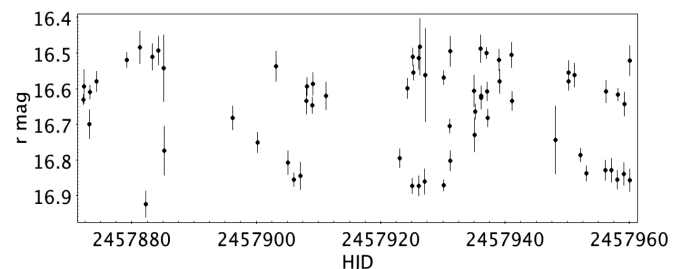


Figure 30. Light curve of SSTSL2 J194231.40-102150.5.

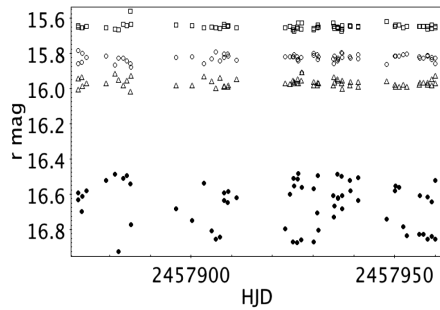


Figure 31. Light curve of SSTSL2 J194231.40-102150.5 (solid circle) and its comparison stars (c1, open circle; c2, square; c3, triangle). Error bars are omitted.

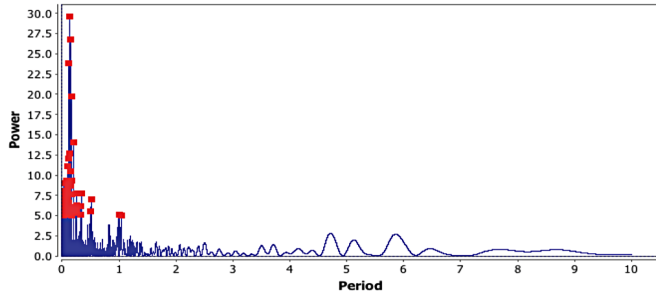


Figure 32. Power spectrum for SSTSL2 J194231.40-102150.5. Period is in days.

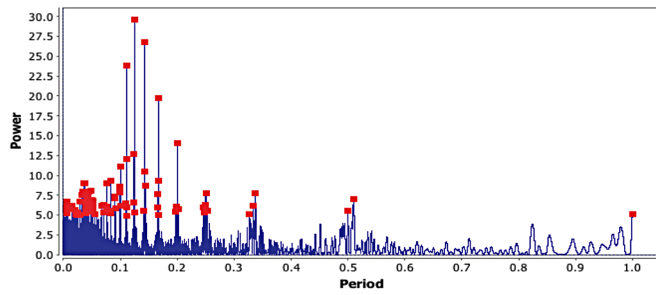


Figure 33. Power spectrum for SSTSL2 J194231.40-102150.5. Period is in days.

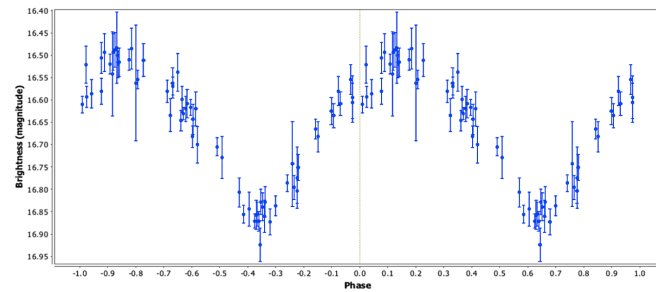


Figure 34. Phase plot of SSTSL2 J194231.40-102150.5 phased to a period of 0.12497 days. Brightness (vertical axis) is in r magnitude.

3.15. 2MASS J18180055-5443534

This object was imaged in the field of ESO182-G010. It is classified as an infrared source in NED. The cross-identifications of the object are listed in Table 22. Figure 35 is a light curve of 2MASS J18180055-5443534, which was imaged from HJD 2457864 to 2457960. Figure 36 is a light curve of the variable star candidate and its comparison stars. Information about the comparison stars is listed in Table 23. The variability of the object is evident; the brightness range over the observed period

Table 22. Cross-identifications of 2MASS J18180055-5443534. Positional data were taken from NED and IRSA.

Identification	R. A. (2000) h m s	Dec. (2000) ° ' "
2MASS J18180055-5443534	18 18 00.559	-54 43 53.20
USNO-B1.0 0352-0775609	18 18 00.54	-54 43 53.21

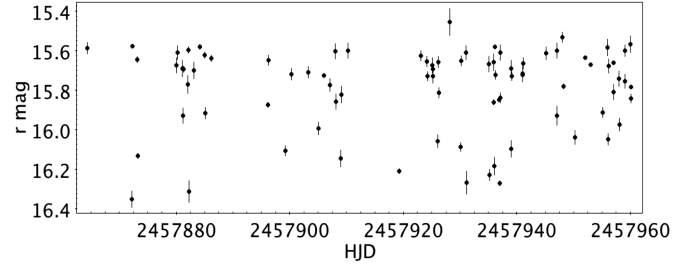


Figure 35. Light curve of 2MASS J18180055-5443534.

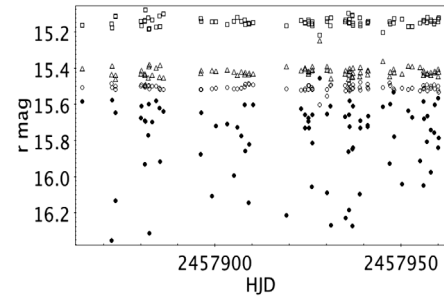


Figure 36. Light curve of 2MASS J18180055-5443534 (solid circle) and its comparison stars (c1, open circle; c2, square; c3, triangle). Error bars are omitted.

Table 23. Comparison stars for 2MASS J18180055-5443534. Data were taken from APASS.

Name ¹	Record No. ²	R. A. (2000) h m s	Dec. (2000) ° ' "	r	r error
Comparison 1	58642670	18 18 19.02	-54 35 20.07	15.557	0.056
Comparison 2	58642652	18 17 53.64	-54 35 36.27	15.15	0.044
Comparison 3	58642371	18 18 21.25	-54 45 15.57	15.373	0.018

Notes: 1. in this paper; 2. in APASS.

is ~0.8 magnitude. Due to our sparse measurements, we were not able to reach a conclusion on the periodicity of the object. Further observations should be conducted on this target.

4. Conclusion

The results described here are preliminary; most variable sources discussed in this paper suffer from a lack of observational data, resulting in several open-ended conclusions on periodicity. Additional observations of these targets should be able to reveal their complete behavior of variability. As we have confirmed the objects' variabilities in brightness in this paper, the next step would be to uncover the cause of variability of these objects and categorize them into appropriate classes of variables. We would welcome the participation of AAVSO observers in this effort. We hope to make the photometric data and images of

the survey available through a data archive in near future. In the meantime, interested researchers may contact the authors to obtain the data.

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