50 Forgotten Miras

Thomas Karlsson
Almers väg 19, 432 51 Varberg, Sweden, tkn@seaside.se

Hans Bengtsson
Sagogången 55, 422 45 Hisings Backa, hkibengtsson@gmail.com

Tomas Wikander
Bogservägen 8, 784 77 Borlänge, Sweden, wikander.tomas@gmail.com

Gustav Holmberg
Karl XI-gatan 8A, 222 20 Lund, Sweden, 5063.gustav.holmberg@gmail.com

Robert Wahlström
Klintens väg 6, 441 41 Alingsås, Sweden, robert.l.wahlstrom@gmail.com

Chris Allen
Jordgubbsgränd 3, 386 31 Färjestaden, Sweden, chris.allen@telia.com

Received August 10, 2016; revised August 25, 2015; accepted August 30, 2016

Abstract We report the results of 4 years observing of 50 poorly studied Mira stars. 247 maxima and 241 minima together with current period elements, ranges, and color indices for the stars are presented. "50 forgotten Miras" is an ongoing observing program run by the Variable star section of the Association of Swedish Amateur Astronomers (SAAF/V) that started in 2012.

1. Introduction

"50 forgotten Miras" is an observation program organized by the Variable star section of the Association of Swedish Amateur Astronomers (SAAF/V; Svensk AmatörAstronomisk Förening, Variabelsektionen) in which 50 poorly studied Mira stars have been observed since 2012-02-15.

During the 20th century, photographic patrol programs where run at several professional observatories (and also by many amateurs). Wide-angle photographic plates were analyzed with blink comparators in order to look for objects that moved or changed brightness. One of the results that came out of these large surveys was a large number of discoveries of new variable stars. They were entered into catalogues with some rudimentary data on periodicity, brightness, and so on, but in many cases they were then left behind. One gets the feeling that variables were discovered en masse in the photographic surveys but in many cases insufficiently followed after discovery. Many of the thousands of known Mira stars therefore have catalogue data that are derived from only old data.

The goal of this program is to revisit 50 of these Miras in order to provide modern data on their variations and update the data in the AAVSO International Variable Star Index (VSX, Watson *et al.* 2006–2016). The method is to observe the program stars regularly to establish light curves, and from the light curves to determine basic parameters such as period, range, and rise duration. V filter observations are most frequent, but some observations have been made in B and R, as well as a large number of visual observations.

The program stars were chosen by Hans Bengtsson following the criteria:

- Variable type is M or M: in GCVS4 (Kholopov 1985).
- Located in the northern hemisphere.
- No or only a few observations in AID (AAVSO International Database) in recent time.
- An estimated V magnitude of 11 to 12 or brighter at maximum.

After the observations began one of the stars had its type changed to SRA in VSX, the carbon star IV Peg.

We have also searched the literature for information on the discovery, history, and earlier observations of the stars. This information is published in a wiki (currently only in Swedish, at http://astronet.se/wiki/index.php/50_bortgl%C3%B6mda_Miror) together with the information in this article.

2. Observing

At the start of the program we contacted the AAVSO Chart and Sequence Team in order to get sequences of comparison stars. For the majority of the stars we swiftly got sequences. Four stars (GM Cam, CL Cyg, AM Dra, and IY Dra) lacked underlying data, at the start of the program, for generating charts. For these stars we used our own sequences with data from the Naval Observatory Merged Astrometric Dataset (NOMAD; Zacharias *et al.* 2011) or the fourth U.S. Naval Observatory CCD Astrograph Catalog (UCAC4; Zacharias *et al.* 2012) until AAVSO could generate sequences.

The program stars have then been observed by members of SAAF/V with different techniques and instruments. Some members used their own telescopes and observed the stars either visually or used photometrical filters and CCD imaging. Other members have used remote telescopes operated by iTelescope.net, the Bradford Robotic Telescope, Sierra Stars Observatory Network, and AAVSONet to take data.

AAVSO's online photometric tool VPHOT (Klingenberg and Henden 2013) was used to measure the stars on both the locally and remotely taken images. No transformation of the measured magnitudes was made. As several different persons, telescopes, filters, and cameras have been involved, one could expect some scatter in the derived magnitudes. By comparing V observations of the same star made within 2.5 days we estimate that the scatter on average are less than 0.1 magnitude with a maximum of 0.5 magnitude. As expected the scatter is lower when the stars are in their brightest phase. For the individual stars the average scatter is between 0.05 and 0.2 magnitude.

Up until 2016-07-01 12 persons have contributed a total of 8,690 observations; of these 98.7% were made by the authors. Of the observations 473 are visual, 1,027 are B, 5,710 are V, 1,471 are R, and 9 are I. From the light curves of the V observations maxima, minima, and range for the stars were recorded. We have also tried to do R and B observations evenly spread over the cycle of each star to see how the color indices B–V and V–R change with phase. Most stars have a good coverage in R over their whole phase, but due to the faintness we lack B observations of most stars at minimum.

In addition to the program stars, several other variables in the same fields were observed, many of them poorly studied in the past. We have made some analysis of these collateral catches. For example we discovered that V2331 Cyg is an eclipsing binary and not an L type variable, as the GCVS entry had (Bengtsson *et al.* 2013). We also found that the catalogue period for the RRAB star KR Lyr was wrong. A new period for the EA star GO Lac was calculated, and we were able to determine a new type and new elements for the stars AM Vul and DO Lac. These discoveries have been reported to VSX.

All observations are available in the Swedish variable observations database, SVO, at http://var.astronet.se. The vast majority are also reported to the AAVSO International Database.

3. Results

The results from our observations 2012–2016 of the 50 Miras are presented in the following tables and figures.

Table 1 shows date and magnitude for 247 maxima and 241 minima. These events were determined by manual examination of the light curves. Dates are JD – 2400000. Magnitudes are V. The O–C values (observed – calculated time of maximum) were calculated using the elements in Table 2. Dates followed by a colon are uncertain, and a double colon indicates very uncertain dates.

Table 2 shows period elements for the 50 stars. All stars have their recent elements listed; for most of the stars this means elements from all found maxima from 1996 forward. For some stars, those that have a fair amount of historical maxima obtained from the literature, elements from all their recorded maxima are also given. The elements were calculated from O–C diagrams so that a straight line fitted to the O–C values will be horizontal and cross the y-axis at zero.

The recent elements in Table 2 are based on all maxima from Table 1 together with maxima determined by us from the Northern Sky Variability Survey (NSVS, Woźniak *et al.* 2004) and the Third All Sky Automated Survey (ASAS-3, Pojmański *et al.* 2013). Also data from Association Française des Observateurs d'Étoiles Variables (AFOEV), Digital Access to a Sky Century @ Harvard (DASCH), the Kepler mission, and maxima published by some other sources were used, see notes under Table 2. A list of all maxima is published on the wiki. The first epoch for the recent elements is based on maxima from NSVS or ASAS-3 if available. For DU Aur, YZ Cam, V363 Cyg, WX Del, AU Gem, V393 Her, and V389 Lac no maximum was found in NSVS or ASAS-3; these stars have their first epoch based on maxima published by AFOEV or from other sources.

Miras are known to have random cycle-to-cycle variations of their period, some also show long-term modulations, and some, more rarely, have a steady decrease or increase in their periods (Willson and Marengo 2012). The size of the random variations is reflected in the O–C values in Table 1. To minimize the effects of the random variations when calculating the elements we chose to use maxima from the last 20 years for the recent elements. The differences in period between the recent elements and elements from all maxima are more likely due to long-term than random variations.

Rise% is the time from minimum to maximum in percentage of the period. This value is calculated only from the maxima in Table 1.

Table 3 shows spectral type from VSX together with V magnitude range and the color indices B–V and V–R from our observations 2012–2016. The color indices are calculated as follows. First, all B–V and V–R values were computed for all instances where there was a B and V or V and R observation from the same observer within one hour in time. All B–V and V–R were then grouped into ten bins of equal width after their period phase. For each bin the mean B–V and V–R was computed and then the mean of the means was determined as the value for the color indices.

The range of the bin means are listed within parentheses in Table 3. In general the variation in V–R is much stronger than the variation in B–V over the cycle. All stars have their lowest V–R value when they are at maximum in V, and their highest V–R value when at minimum. The variation patterns for B–V are more differentiated between the stars, although several stars seem to have the lowest B–V value just before maximum and the highest value after maximum. Figure 1 shows an example of how the color index varies during the cycle. Figure 2 shows color-color and period-color diagrams. The carbon star IV Peg is an outlier in both diagrams. For the rest there seems to be a positive correlation between period and color index, most pronounced for V-R.

We have also searched for humps in the light curves. The stars GS Cyg and V750 Cyg have a marked plateau on their rising branch, and hump events to a lesser degree are noticeable on V393 Her, V389 Lac, DT Ori, and IU Peg. Two other stars, EH Gem and V358 Lac, have a marked shoulder on their rising

Table 1. Maxima and minima of stars observed.

Star	Magnitude	JD max. (2400000+)	O–C	Magnitude	JD min. (2400000+)
YY Aur				<16.4	56150::
YY Aur	10.6	56290	-3	<16.6	56510::
YY Aur	11.3	56623	-7	<15.5	56825:
YY Aur	9.8	56962	-4	<16.7	57180:
YY Aur	11.0	57308	5		
DU Aur	>13.0	56080::	-18	16.7	56245
DU Aur	11.1	56365	-7	<16.4	56535::
DU Aur	11.8	56654	8	<16.3	56780:
DU Aur	10.8	56916	-5	17.0	57076
DU Aur	>13.0	57210::	15	17.5	57355
DU Aur	11.9	57470	1		
V483 Aur	12.3	56044	19	16.8	56190
V483 Aur	12.5	56337	9	16.2	56495:
V483 Aur	11.7	56626	-5	<16.6	56785:
V483 Aur	12.0	56931	-3	17.7	57080
V483 Aur	>12.7	57225::	-12	18.1	57400
TT Cam				17.0	56150::
TT Cam	10.8	56249	6	16.6	56390::
TT Cam	10.8	56505:	9	15.9	56642
TT Cam	10.3	56738	-11	15.8	56900:
TT Cam	10.8	57000	-1	15.6	57150:
TT Cam	10.0	57250:	-4	15.9	57405
UZ Cam				15.1	56090::
UZ Cam	10.7	56180:	-6	15.6	56300:
UZ Cam	10.9	56412	-6	<14.2	56540::
UZ Cam	>13.0	56640::	-10	15.4	56765
UZ Cam	10.5	56890	8	15.2	56985
UZ Cam	10.9	57120	6	15.5	57230:
UZ Cam	10.5	57350:	3	15.6	57468
YZ Cam				<14.5	56110::
YZ Cam	10.6	56303	4	<14.6	56480::
YZ Cam	10.3	56658	-1	16.2	56855:
YZ Cam	10.6	57011	-9	15.9	57215
YZ Cam	10.6	57375	-6		
GM Cam	>13.2	56040:	12	<17.0	56240::
GM Cam	>13.7	56410::	12	18.3	56585:
GM Cam	13.2	56775:	7	17.7	56940:
GM Cam	>13.0	57140:	2	18.1	57320
GM Cam	13.4	57485:	-24		
VZ CMi	11.3	56254	12	15.7	56386
VZ CMi	11.0	56525::	-1	16.0	56668
VZ CMi	>12.0	56810::	-1	16.0	56950:
VZ CMi	10.9	57090	-5	<14.2	57240:
VZ CMi	11.1	57375	-4		
TW Cep				<16.3	56050:
TW Cep	11.3	56161	3	<16.5	56335:
TW Cep	12.0	56437	-3	16.8	56580
TW Cep	11.2	56718	-4	16.9	56879
TW Cep	11.7	56992	-11	17.5	57171
TW Cep	11.7	57295	11	<16.2	57455:
AW Cep	10.9	56130	-4	15.6	56260
AW Cep	11.1	56373	-1	16.4	56505
AW Cep	11.5	56625	11	<15.8	56740
AW Cep	10.5	56850	-4	15.9	56988
AW Cep	11.1	57099	5	16.0	57221
AW Cep	10.9	57333	-2	<15.4	57460:
XY Cyg				15.3	56155
XY Cyg	10.7	56275	3	15.3	56459
XY Cyg	10.5	56581	9	14.9	56755
XY Cyg	10.4	56867	-4	14.7	57040
XY Cyg	10.5	57172	1	15.5	57355
XY Cyg	10.7	57474	4		
CL Cyg				<16.5	56250::
CL Cyg	11.5	56359	-11	<17.3	56580:
CL Cyg	>13.0	56685::	11	18.0	56870
CL Cyg	12.5	56970	-8	17.6	57170
CL Cyg	13.0	57290	9	17.7	57485
GS Cyg	11.5	56221	-8	16.3	56435
GS Cyg	11.3	56632	-8	16.9	56864
GS Cyg	12.0	57060:	8	16.9	57280
GS Cyg	>12.1	57470:	7		
V363 Cyg				17.0	56230
V363 Cyg	11.7	56385	2	16.5	56576
V363 Cyg	10.3	56737	-7	16.7	56950
V363 Cyg	11.2	57100:	-5	16.8	57305
V363 Cyg	11.2	57470:	5		
V462 Cyg				13.6	56179
V462 Cyg	10.8	56380	-7	13.9	56555
V462 Cyg	10.0	56740	-10	13.7	56920
V462 Cyg	10.2	57115	2	14.1	57283
V462 Cyg	9.9	57475	-2		
V663 Cyg				16.3	56240
V663 Cyg	10.8	56370:	-5	16.4	56590
V663 Cyg	>11.9	56730:	-5	16.5	56965
V663 Cyg	>12.0	57100:	5	16.2	57320
V663 Cyg	11.0	57460:	4		
V673 Cyg	11.7	56030:	-17	17.0	56240
V673 Cyg	11.7	56374:	3	17.7	56570
V673 Cyg	11.8	56695:	-1	17.3	56880
V673 Cyg	11.7	57030	10	16.9	57215
V673 Cyg	11.6	57346	2		
V750 Cyg	11.4	56272	10	16.2	56494
V750 Cyg	11.2	56692:	-3	16.3	56910
V750 Cyg	11.6	57120	-7	16.2	57330:
V2072 Cyg	10.9	56143	-2	16.9	56310:
V2072 Cyg	10.4	56454	-8	17.9	56653:
V2072 Cyg	11.8	56779	0	17.5	56960
V2072 Cyg	11.5	57100:	4	17.6	57270
V2072 Cyg	10.9	57420:			
V2330 Cyg				17.0	56250
V2330 Cyg	11.4	56415	1	<17.3	56665:
V2330 Cyg	11.4	56795	-3	17.6	57050:
V2330 Cyg	11.6	57181	0	<17.5	57430:
WX Del				<16.5	56315:
WX Del	12.1	56505	0	17.3	56847
WX Del	10.5	57035:	1	<17.5	57380::
WZ Del	12.7	56144	-3	<17.0	56290:
WZ Del	12.4	56415	9	17.8	56560
WZ Del	12.6	56680::	14	17.9	56805:
WZ Del	12.4	56919	-7	<15.5	57065:

(Table 1 continued on following pages)

Table 1. Maxima and minima of stars observed, cont.

Star	*Magnitude*	*JD max. (2400000+)*	*O–C*	*Magnitude*	*JD min. (2400000+)*
WZ Del	12.7	57175	-10	<17.1	57320:
WZ Del	>14.0	57440::	-5		
AM Dra	9.9	56250	-7	16.5	56470
AM Dra	10.8	56581	-5	16.0	56805
AM Dra	10.0	56930	15	15.2	57111
AM Dra	9.3	57240	-5	15.5	57445
AN Dra	10.1	56060:	-1	15.2	56252:
AN Dra	10.3	56408	-5	14.9	56601
AN Dra	9.5	56767	2	14.9	56960
AN Dra	10.0	57115	-3	15.2	57320
AN Dra	9.8	57475	5		
IY Dra	11.4	56315:	-13	<17.5	56560:
IY Dra	12.0	56711	9	17.4	56920
IY Dra	11.2	57075	-1	18.4	57300
IY Dra	12.5	57453	3		
AU Gem				<15.6	56080::
AU Gem	11.0	56239	6	<15.5	56500::
AU Gem	12.0	56660	4	15.5	56900:
AU Gem	11.4	57085	6	15.1	57323
AU Gem	11.1	57485	-16		
EH Gem	12.3	56195:	12	15.9	56298
EH Gem	12.2	56430:	9	<15.6	56535::
EH Gem	12.1	56657	-1	<15.9	56780::
EH Gem	>12.4	56890::	-5	15.9	57000
EH Gem	12.4	57125	-7	<13.2	57240::
EH Gem	11.9	57364	-5	15.7	57480
VW Her				15.6	56295:
VW Her	11.2	56414	-1	16.2	56575
VW Her	10.8	56698	-3	16.6	56870
VW Her	11.8	56995:	9	16.4	57140
VW Her	11.0	57265	-7	17.2	57433
WX Her				15.0	56195
WX Her	11.8	56285:	15	15.3	56384
WX Her	11.9	56453	-3	15.3	56580:
WX Her	12.0	56650:	8	16.0	56735
WX Her	12.0	56833	5	16.2	56920
WX Her	11.9	57020:	6	15.7	57111
WX Her	12.0	57190	-10	15.5	57288:
WX Her	12.0	57370:	-16	15.2	57470
BI Her	12.1	56151	12	<15.5	56260:
BI Her	12.6	56348	0	17.4	56457
BI Her	12.4	56563	7	15.8	56678:
BI Her	12.6	56769	4	17.6	56875
BI Her	13.1	56973	-1	17.3	57090
BI Her	11.8	57173	-9	<17.2	57300:
BI Her	>13.0	57390:	-1	17.4	57493
CZ Her	11.2	56203	-7	16.3	56423
CZ Her	10.7	56519	-12	16.0	56737
CZ Her	11.1	56850	-3	16.2	57080
CZ Her	11.9	57194	19	<16.1	57390:
CZ Her	10.9	57500	3		
GP Her	11.3	56163	3	15.7	56290
GP Her	10.7	56420	3	16.0	56562
GP Her	11.0	56670	-4	15.8	56812
GP Her	10.5	56929	-1	15.7	57075
GP Her	11.0	57192	5	15.6	57322
GP Her	10.4	57450	7		
V393 Her				17.0	56180
V393 Her	12.2	56358	18	16.8	56615:
V393 Her	11.6	56760	-11	16.4	57025:
V393 Her	11.5	57190	-11	16.1	57450
TU Lac				16.1	56220
TU Lac	10.3	56354:	-6	17.0	56500:
TU Lac	10.7	56640	2	17.9	56780:
TU Lac	10.8	56924	7	16.9	57065:
TU Lac	10.5	57195:	-1	16.7	57340
TU Lac	>13.0	57470::	-4		
AS Lac	12.0	56176	5	16.5	56287
AS Lac	12.1	56375:	-15	16.9	56500
AS Lac	12.0	56609	1	<15.0	56710:
AS Lac	11.1	56815	-11	16.6	56950
AS Lac	12.2	57040	-4	17.5	57160:
AS Lac	12.7	57276	14	17.2	57374
AS Lac	>13.9	57490::	9		
V358 Lac				15.8	56185
V358 Lac	10.8	56340	-1	15.7	56516
V358 Lac	10.3	56671	3	15.7	56845
V358 Lac	10.4	56998	2	16.0	57160:
V358 Lac	10.4	57322	-2		
V389 Lac				13.6	56217
V389 Lac	11.1	56368	16	13.6	56470
V389 Lac	10.9	56616	1	<13.0	56725:
V389 Lac	11.3	56870	-9	13.5	56990
V389 Lac	11.0	57135:	-7	13.5	57260
V389 Lac	10.9	57397	-9	13.6	57520:
BI Lyr	11.8	56136	-16	<16.5	56295:
BI Lyr	12.1	56400	-6	16.9	56552
BI Lyr	12.1	56660:	0	17.5	56810
BI Lyr	11.6	56917	2	17.8	57060
BI Lyr	12.2	57174	5	17.7	57315
BI Lyr	12.2	57430:	6		
BK Lyr	11.9	55990:	10	16.3	56130
BK Lyr	11.7	56240	7	<16.2	56385:
BK Lyr	12.4	56494	8	16.6	56630
BK Lyr	11.7	56738	-1	16.1	56876
BK Lyr	12.0	56988	-4	16.3	57125
BK Lyr	11.4	57245	0	<16.3	57395:
BK Lyr	12.2	57487	-11		
EQ Lyr				17.0	56090
EQ Lyr	12.6	56225	-7	16.7	56382
EQ Lyr	11.8	56524	-7	<16.5	56690
EQ Lyr	12.5	56830	-1	17.3	56980:
EQ Lyr	12.6	57132	2	17.0	57285
EQ Lyr	12.2	57425	-5		
ER Lyr	10.5	56014	-3	14.4	56120
ER Lyr	10.6	56209	-6	15.4	56315:
ER Lyr	10.9	56415	2	15.0	56511
ER Lyr	10.3	56618	8	15.2	56710
ER Lyr	10.8	56813	5	15.5	56908
ER Lyr	10.6	57010	4	15.0	57105
ER Lyr	10.3	57200	-4	15.7	57303:
ER Lyr	>11.1	57395:	-6	15.1	57495

(Table 1 continued on next page)

Table 1. Maxima and minima of stars observed, cont.

Star	*Magnitude*	*JD max. (2400000+)*	*O–C*	*Magnitude*	*JD min. (2400000+)*
IX Lyr				17.6	56105
IX Lyr	12.2	56220	-2	17.3	56385
IX Lyr	11.2	56501	-7	17.3	56665:
IX Lyr	11.9	56790	-4	17.6	56955
IX Lyr	11.9	57085	5	17.2	57254
IX Lyr	12.1	57368	2		
KL Lyr				16.4	56040
KL Lyr	11.5	56154	-2	<16.0	56260:
KL Lyr	11.7	56365	-6	16.9	56480
KL Lyr	12.1	56587	0	17.1	56700:
KL Lyr	11.6	56820	18	16.7	56922
KL Lyr	>12.8	57030:	13	16.3	57139
KL Lyr	12.0	57225	-8	15.6	57350:
KL Lyr	11.5	57430:	-18		
OP Lyr	11.6	56150	8	<17.0	56335:
OP Lyr	12.6	56447	6	17.2	56630:
OP Lyr	11.5	56730	-9	17.3	56920
OP Lyr	12.1	57030:	-7	17.6	57220
OP Lyr	12.9	57335	-1		
AI Oph				<16.8	56215:
AI Oph	11.7	56427	11	16.2	56620:
AI Oph	11.9	56825	-5	16.0	57020:
AI Oph	11.2	57237	-7	16.8	57454
DT Ori	12.0	56247	-2	<15.6	56470::
DT Ori	11.0	56665	1	16.0	56880:
DT Ori	11.6	57085	6	16.1	57310:
DT Ori	11.0	57495	1		
IU Peg	11.2	56169	-17	<17.0	56475:
IU Peg	11.8	56640	10	17.1	56913
IU Peg	>12.8	57090::	16	16.7	57370
IU Peg	11.7	57520	2		
IV Peg	10.0	56244	6	11.6	56345:
IV Peg	9.7	56445	-7	11.4	56565
IV Peg	9.8	56665	-1	12.3	56770
IV Peg	10.1	56897	17	11.9	56985
IV Peg	>10.8	57100::	6	11.8	57200:
IV Peg	9.8	57305	-3	11.9	57410:
IV Peg	9.8	57520:	-2		
AC Vul				16.5	56244:
AC Vul	12.2	56365	1	17.0	56490
AC Vul	11.2	56607	9	<16.0	56730:
AC Vul	11.8	56843	11	16.2	56965
AC Vul	11.7	57065	-1	16.1	57205
AC Vul	11.2	57310	11	16.1	57430:
DX Vul				16.1	56165
DX Vul	11.4	56310:	1	16.0	56465
DX Vul	11.7	56604	-1	15.8	56760
DX Vul	11.1	56898	-4	<15.0	57050:
DX Vul	11.2	57201	3	16.0	57355
DX Vul	10.8	57500	6		

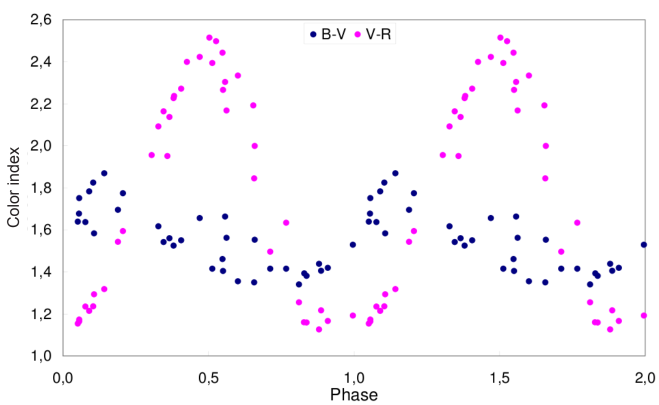

Figure 1. An example of a Phase-Color diagram for one star, UZ Cam.

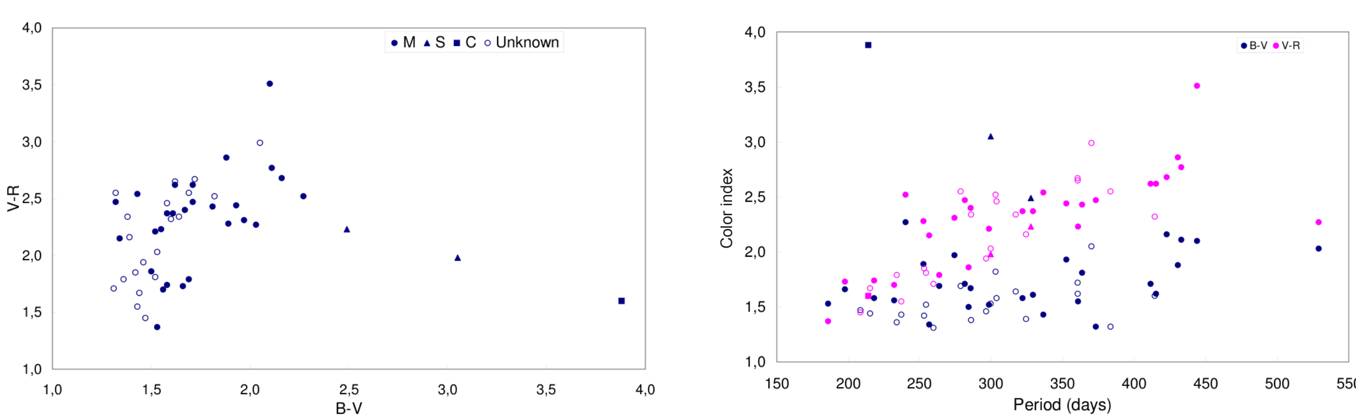

Figure 2. Color-Color and Period-Color diagrams. The shapes of the symbols in the right panel have the same meaning as in the left panel.

Table 2. Elements based on maxima from Table 1, NSVS, ASAS-3, and the other sources (see note at end of table).

		Recent elements			Elements from all maxima	
Star	*Source*	*Period*	*Epoch*	*Rise%*	*Period*	*Epoch*
YY Aur	1,7,8	336.4	2450911	38	337.3	2416494
DU Aur	1,7	274.3	2450886	45	275.5	2415054
V483 Aur		303.0	2451480	47		
TT Cam		252.6	2451444	40		
UZ Cam	9,10,11	232.1	2451312	49	232.3	2413630
YZ Cam	2	360.7	2431771	48		
GM Cam		370.1	2451587	49		
VZ CMi		284.2	2453116	49		
TW Cep		281.5	2451373	42		
AW Cep	3	240.1	2451332	47		
XY Cyg	1,2,9,12,13,14,15	299.6	2450280	40	300.0	2414879
CL Cyg		303.7	2451511	36		
GS Cyg	1	411.4	2451292	47		
V363 Cyg	1	360.5	2451697	44		
V462 Cyg	1,4,9,16	363.5	2450207	53	372.5	2412509
V663 Cyg		360.4	2451329	38		
V673 Cyg	17,18	324.3	2451507	42	327.0	2427916
V750 Cyg	1,19	432.9	2450201	47	433.4	2428093
V2072 Cyg		317.1	2451388	44		
V2330 Cyg		383.4	2451430	37		
WX Del	2	529.0	2430584	36		
WZ Del		259.6	2451474	45		
AM Dra		329.2	2451319	37		
AN Dra	3,9	352.5	2451478	45	354.7	2414206
IY Dra		373.8	2451469	41		
AU Gem	5,1	422.7	2435521	39	423.5	2416850
EH Gem		237.1	2452627	52		
VW Her		285.6	2451560	43		
WX Her		185.9	2451437	45		
BI Her		208.5	2451344	44		
CZ Her		321.9	2451381	34		
GP Her		256.6	2451285	47		
V393 Her	1	430.5	2450313	38		
TU Lac		278.6	2451345	49		
AS Lac		218.2	2451371	48		
V358 Lac	20	327.7	2451425	48	327.5	2437351
V389 Lac	1,6	263.6	2449498	55		
BI Lyr		254.4	2451318	43		
BK Lyr	1	253.0	2450667	43		
EQ Lyr	4	299.6	2451438	47		
ER Lyr	1,4,9	197.7	2450284	50	196.3	2414198
IX Lyr	1	285.9	2450504	42		
KL Lyr	1	215.3	2450343	48		
OP Lyr	1	298.4	2450771	37		
AI Oph		414.3	2451444	51		
DT Ori		415.2	2452927	47		
IU Peg		443.9	2451303	37		
IV Peg		214.0	2451530	51		
AC Vul		233.9	2451452	48		
DX Vul		296.4	2451270	48		

Note. Elements based on maxima from Table 1, NSVS, ASAS-3, and the following sources: 1) AFOEV; 2) Whitney 1960; 3) Rätz 2002; 4) Kepler; 5) Kukarkin 1957; 6) Dahlmark 1996; 7) Kurochkin 1951; 8) Splittgerber 1970; 9) DASCH; 10) Chernova 1951; 11) Fuhrmann 1981, 12) Wolf and Wolf 1905; 13) Graff 1921; 14) Beyer 1936; 15) Huth 1967; 16) Tramell 1987; 17) Rohlfs 1950; 18) Nikolaev 1988; 19) Wenzel 1953; 20) Romano and Perissinotto, 1975.

Table 3. Spectral type from VSX together with V magnitude range and the color indices B–V and V–R from our observations 2012–2016.

Star	*Sp.type*	*Maximum Magnitude*	*Minimum Magnitude*	*B–V*	*V–R*
YY Aur	M5e	9.8	<16.7	1.43 (1.4 – 1.5)	2.54 (1.5 – 3.5)
DU Aur	M6	10.8	17.5	1.97 (1.7 – 2.1)	2.31 (1.4 – 3.3)
V483 Aur		11.7	18.1	1.82 (1.6 – 2.0)	2.52 (1.6 – 3.5)
TT Cam	M0–M7	10.0	17.0	1.89 (1.8 – 2.0)	2.28 (1.4 – 3.0)
UZ Cam	M3	10.5	15.6	1.56 (1.4 – 1.8)	1.70 (1.2 – 2.4)
YZ Cam	M8	10.3	16.2	1.55 (1.3 – 1.8)	2.23 (1.5 – 2.9)
GM Cam		13.0	18.3	2.05 (2.0 – 2.1)	2.99 (2.1 – 3.3)
VZ CMi	M0	10.8	16.0	1.50 (1.3 – 1.7)	1.86 (1.3 – 2.3)
TW Cep	M6.5	11.2	17.5	1.71 (1.6 – 1.8)	2.47 (1.7 – 3.1)
AW Cep	M8	10.5	16.4	2.27 (2.1 – 2.5)	2.52 (1.8 – 3.2)
XY Cyg	S:e	10.4	15.5	3.05 (2.7 – 3.4)	1.98 (1.3 – 2.4)
CL Cyg		11.5	18.0	1.58 (1.5 – 1.7)	2.46 (1.9 – 3.2)
GS Cyg	M6e–M10e	11.3	16.9	1.71 (1.5 – 2.1)	2.62 (2.3 – 2.9)
V363 Cyg		10.3	17.0	1.62 (1.3 – 2.0)	2.65 (1.8 – 3.0)
V462 Cyg	M7e	9.9	14.1	1.81 (1.6 – 2.0)	2.43 (1.9 – 2.8)
V663 Cyg		10.8	16.5	1.72 (1.5 – 2.1)	2.67 (1.8 – 3.0)
V673 Cyg		11.6	17.7	1.39 (1.1 – 1.6)	2.16 (1.6 – 2.6)
V750 Cyg	M5ea	11.2	16.4	2.11 (1.9 – 2.4)	2.77 (2.1 – 3.2)
V2072 Cyg		10.4	17.9	1.64 (1.4 – 1.8)	2.34 (1.4 – 3.0)
V2330 Cyg		11.4	17.6	1.32 (1.2 – 1.5)	2.55 (1.7 – 3.0)
WX Del	M7	10.5	<17.5	2.03 (2.0 – 2.1)	2.27 (1.7 – 2.7)
WZ Del		12.4	17.9	1.31 (1.3 – 1.4)	1.71 (0.9 – 2.2)
AM Dra	M8	9.3	16.5	1.61 (1.4 – 1.8)	2.37 (1.6 – 3.0)
AN Dra	M5	9.5	15.2	1.93 (1.6 – 2.4)	2.44 (1.6 – 3.1)
IY Dra	M8.5	11.2	18.4	1.32 (1.1 – 1.7)	2.47 (1.5 – 3.2)
AU Gem	M10	11.0	<15.6	2.16 (1.7 – 2.9)	2.68 (2.2 – 3.0)
EH Gem		11.9	<15.9	1.43 (1.3 – 1.6)	1.55 (1.0 – 2.1)
VW Her	M3/4	10.2	17.2	1.67 (1.5 – 2.2)	2.40 (1.6 – 3.1)
WX Her	M1e	11.8	16.2	1.53 (1.2 – 1.9)	1.37 (0.9 – 1.8)
BI Her		11.8	17.6	1.47 (1.2 – 1.7)	1.45 (1.0 – 2.3)
CZ Her	M8/9	10.7	16.3	1.58 (1.4 – 2.0)	2.37 (1.6 – 3.0)
GP Her	M7/8	10.4	16.0	1.34 (1.2 – 1.5)	2.15 (1.4 – 2.8)
V393 Her	M8	11.5	17.0	1.88 (1.5 – 2.5)	2.86 (2.4 – 3.4)
TU Lac	M	10.3	17.9	1.69 (1.5 – 2.0)	2.55 (1.6 – 3.6)
AS Lac	M2	11.1	17.5	1.58 (1.4 – 1.7)	1.74 (1.1 – 2.6)
V358 Lac	S	10.3	16.0	2.49 (2.3 – 2.8)	2.23 (1.7 – 2.8)
V389 Lac	M7	10.9	13.6	1.69 (1.5 – 1.8)	1.79 (1.3 – 2.1)
BI Lyr		11.6	17.8	1.52 (1.4 – 1.6)	1.81 (1.0 – 2.7)
BK Lyr		11.4	16.6	1.42 (1.3 – 1.5)	1.85 (1.2 – 2.5)
EQ Lyr		11.8	17.3	1.53 (1.3 – 1.8)	2.03 (1.3 – 2.9)
ER Lyr	M5e	10.3	15.7	1.66 (1.5 – 1.9)	1.73 (1.1 – 2.4)
IX Lyr		11.2	17.6	1.38 (1.2 – 1.5)	2.34 (1.4 – 2.9)
KL Lyr		11.5	17.1	1.44 (1.3 – 1.6)	1.67 (1.1 – 2.4)
OP Lyr	M7:	11.5	17.6	1.52 (1.4 – 1.7)	2.21 (1.4 – 2.8)
AI Oph		11.2	<16.8	1.60 (1.5 – 1.8)	2.32 (1.6 – 3.1)
DT Ori	M10	11.0	16.1	1.62 (1.3 – 1.9)	2.62 (1.8 – 3.2)
IU Peg	M7	11.2	17.1	2.10 (1.9 – 2.2)	3.51 (3.1 – 3.7)
IV Peg	C5.2e	9.7	12.3	3.88 (3.3 – 4.2)	1.60 (1.3 – 1.9)
AC Vul		11.2	17.0	1.36 (1.1 – 1.6)	1.79 (1.1 – 2.6)
DX Vul		10.8	16.1	1.46 (1.2 – 1.6)	1.94 (1.4 – 2.7)

branch just before maximum. Thus, 8 out of 50 stars have humps, which is more or less the same proportion found in an earlier study, where 73 out of 450 miras (16 %) showed hump events (https://www.aavso.org/lpv-humps).

Two of the stars that have shown large variations in their period are UZ Cam and V462 Cyg (Karlsson 2013). The period for UZ Cam has varied from 240 days in 1948 to 224 days in 1975. For V462 Cyg the period has varied from 382 days in 1980 to 362 days in 2016.

4. Acknowledgements

We would thank the Chart and Sequence Team at AAVSO for their work on quickly developing charts and photometric sequences for the program stars; the organizations that run the remote telescopes at iTelescope.net, the Bradford Robotic Telescope, Sierra Stars Observatory Network, and AAVSONet; DC-3 Dreams and Bob Denny for ACP Expert that makes capturing lots of variable stars easy.

This research has made use of the AFOEV database, operated at CDS, France.

Some of the data presented in this paper were obtained from the Mikulski Archive for Space Telescopes (MAST). STScI is operated by the Association of Universities for Research in Astronomy, Inc., under NASA contract NAS5-26555. Support for MAST for non-HST data is provided by the NASA Office of Space Science via grant NNX09AF08G and by other grants and contracts.

This paper includes data collected by the Kepler mission. Funding for the Kepler mission is provided by the NASA Science Mission directorate.

We have also used data from DASCH, Digital Access to a Sky Century @ Harvard.

References

Bengtsson, H., Hallsten, P., Hemlin, A., Holmberg, G., Karlsson, T., Wahlström, R., and Wikander, T. 2013, *J. Amer. Assoc. Var. Star Obs.*, **41**, 264.

Beyer, M. 1936, *Astron. Nachr.*, **259**, 101.

Chernova, T. S. 1951, *Perem. Zvezdy*, **8**, 21.

Dahlmark, L. 1996, *Inf. Bull. Var. Stars*, No. 4329, 1.

Fuhrmann, B. 1981, *Mitt. Veränderl. Sterne*, **9**, 8.

Graff, K. 1921, *Astron. Nachr.*, **213**, 161.

Huth, H. 1967, *Mitt. Veränderl. Sterne*, **4**, 150.

Karlsson, T. 2013, *J. Amer. Assoc. Var. Star Obs.*, **41**, 348.

Kholopov, P. N., *et al.* 1985, *General Catalogue of Variable Stars*, 4th ed., Moscow.

Klingenberg, G., and Henden, A. A. 2013 VPHOT photometric analysis tool (http://www.aavso.org/vphot).

Kukarkin, B. V. 1957, *Perem. Zvezdy*, **12**, 33.

Kurochkin, N. E. 1951, *Perem. Zvezdy*, **8**, 351.

Nikolaev, S. E. 1988, *Perem. Zvezdy*, **22**, 781.

Pojmański, G., Szczygiel, D., and Pilecki, B. 2013, The All-Sky Automated Survey Catalogues (ASAS3; http://www.astrouw.edu.pl/asas/?page=catalogues).

Rätz, M. 2002, *BAV Mitt.*, **151**, 1.

Rohlfs, E. 1950, *Mitt. Veränderl. Sterne*, No. 121, 1.

Romano, G., and Perissinotto, M. 1975, *Mem. Soc. Astron. Italiana*, **46**, 259.

Splittgerber, E. 1970, *Mitt. Veränderl. Sterne*, **5**, 140.

Trammell, S. R. 1987, *J. Amer. Assoc. Var. Star Obs.*, **16**, 95.

Watson, C., Henden, A. A., and Price, C. A. 2014, AAVSO International Variable Star Index VSX (Watson+, 2006–2016; http://www.aavso.org/vsx).

Wenzel, W. 1953, *Astron. Nachr.*, **281**, 179.

Whitney, B. S. 1960, *Astron. J.*, **65**, 381.

Willson, L. A., and Marengo, M. 2012, *J. Amer. Assoc. Var. Star Obs.*, **40**, 516.

Wolf, M., and Wolf, G. 1905, *Astron. Nachr.*, **168**, 275.

Woźniak, P. R., *et al.* 2004, *Astron. J.*, **127**, 2436.

Zacharias, N., Finch, C., Girard, T., Henden, A., Bartlett, J., Monet, D., and Zacharias, M. 2012, The Fourth U.S. Naval Observatory CCD Astrograph Catalog (UCAC4; http://arxiv.org/abs/1212.6182).

Zacharias, N., Monet, D., Levine, S., Urban, S., Gaume, R., and Wycoff, G. 2011, The Naval Observatory Merged Astrometric Dataset (NOMAD, http://www.usno.navy.mil/USNO/astrometry/optical-IR-prod/nomad/the-nomad1-catalogue).