

NEW VARIABLE STARS DISCOVERED IN THE FIELD OF THE CLASSICAL CEPHEID EK MON

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GOALS

This work was undertaken as part of a program to detect and document period changes and light curve variations for Cepheid variables. These changes will be interpreted in terms of evolution across the instability strip. Since our data analysis automatically provides brightness and position measurements for all measurable objects in the field, we also evaluate these brightness measurements to search for possible new variable stars.

OBSERVATIONS

Observations are requested using the LCO web-based request system. Requests are scheduled at one of the observatories, and the observer receives email when the images are ready for download. Images are automatically reduced using the LCO data pipeline BANZAI. Corrections are applied for bias, dark, flat field, and bad pixel masking. Positions and brightness are measured for all detected objects in each image.

Target objects are analyzed for variability, and light curves are derived using *astrosource*. Objects that appear in all images of the data set are evaluated for variability and the least variable objects are selected as comparison stars and used for ensemble photometry. Differential magnitudes with respect to the ensemble are derived for all objects in each image. Variability is evaluated by comparing results for each image in the data set.

If requested, calibrated magnitudes can be derived for the ensemble. Then calibrated magnitudes are available for target object light curves.

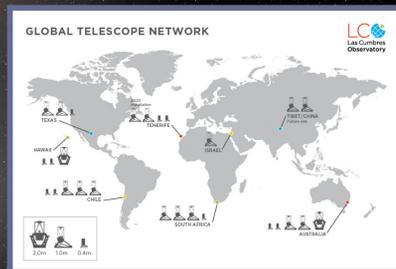


LCO 0.4m telescope

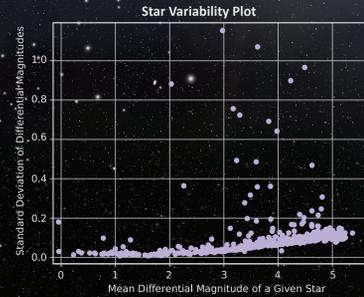
INSTRUMENTATION

Data for this work have been obtained using the Las Cumbres Observatory (LCO) through their Global Sky Partners program. This facility has a global array of 10 observatory sites in both hemispheres consisting of 2 meter, 1 meter, and 0.4 meter telescopes. The data for this project were obtained using the 0.4 meter telescopes. The 0.4m telescopes are 16-inch Meade Schmidt-Cassegrain systems with an LCO designed custom mount.

The cameras are SBIG STL6303, the field of view is 29x19 arcminutes with a pixel scale of 0.57 arcsec/pixel. The filters used for this work are the Bessel V and SDSS ip.

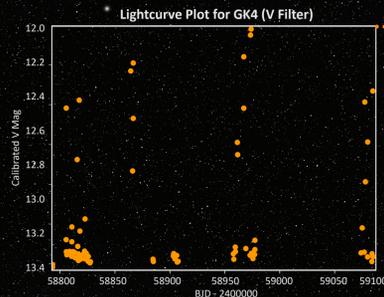


Location of observatories and telescopes of the Las Cumbres Observatory



Star Variability for the EK Mon field. This shows the statistical fluctuations for all stars in the EK Mon field. The lower limit is the location of non-variable stars. Stars above this limit are possible variables. We have examined these possible variables to identify the new variables we have discovered.

Variable Stars Observed in the EK Mon Field								
New Variables								
Designation	Name	Coordinates (2000)	Maximum (V)	Amplitude	Type	Epoch (BJD)	Period (d)	Notes
GK1		6:52:23.6588 -02:20:52.602	13.38	1.94	var	58808.65416	0.99756	possible pulsation or rotation
GK2		6:52:43.0665 -02:21:23.74	15.30	0.78	EW	58905.96245	1.99508	
GK3		6:52:17.6338 -02:27:46.078	12.19	3.09	outbursts			recurrence 120 days, possible CV
GK4		6:53:14.4363 -02:30:32.877	12.01	1.38	outbursts			recurrence 120 days, alternating large and small, possible CV
GK5		6:52:35.0683 -02:20:19.139	12.24	0.42	EA	58831.0861	50.34717	eclipses nearly same depth
GK6		6:52:55.9152 -02:38:02.597	14.94	0.62	var	58801.62537	0.99748	possible pulsation or rotation
GK7		6:52:50.7484 -02:24:44.210	14.13	1.56	EA (eccentric orbit)	59105.61226	199	secondary eclipse at phase 0.4
GK8		6:53:10.9884 -02:20:38.134	12.36	3.09	outbursts			recurrence 147 days, possible CV
GK9		6:52:45.1867 -02:18:40.563	15.63	0.29	RRc	58983.34544	0.48868	variable light curve
GK10		6:52:19.6782 -02:39:24.127	94	3.26	outbursts			recurrence 100 days, possible CV
GK11		6:52:28.6658 -02:39:45.115	13.59	0.39	CW	58978.13374	58.407	type II Cepheid, bump on rising branch
Known Variables								
Designation	Name	Coordinates (2000)	Maximum (V)	Amplitude	Type	Epoch (BJD)	Period (d)	Notes
EK Mon		6:52:46.0911 -02:27:30.298	10.68	0.59	DCEP	59094.79804	3.95848	VSX period 3.957941 d
GKa	GDS J0652598-022732	6:52:59.8711 -02:27:34.68	14.24	0.23	var			58.21 d period not confirmed, possible period 0.334 d
GKb	ASAS J065244-0231.8	6:52:44.0019 -02:31:45.85	10.73	0.23	var	58979.35429	0.333915	SR with EW eclipses
GKc	ASAS J065251-0236.9	6:52:50.9957 -02:36:52.332	10.78	0.23	var			multiple periods; 49.403 d and 0.482 d



The light curve determined by *astrosource* for the newly discovered variable GK4. This object exhibited four outbursts of about one magnitude separated by approximately 120 days.

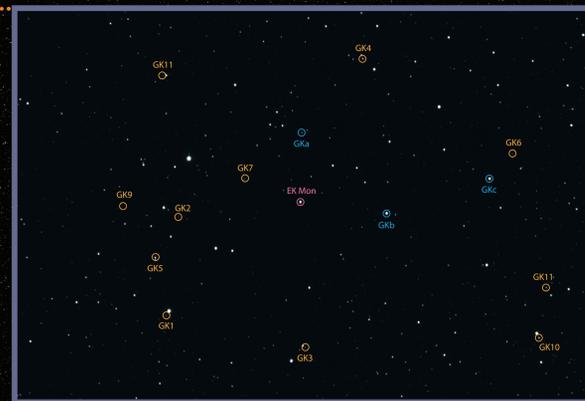
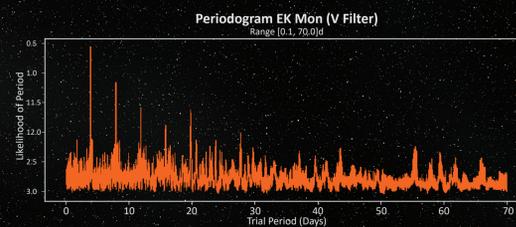
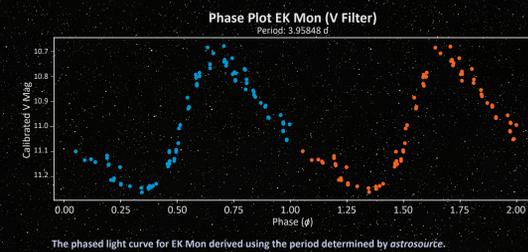


Image of the EK Mon field from one of the LCO 0.4m telescopes. The blue designations are the previously known variables in the field, the orange designations are the newly discovered variables



Periodogram for EK Mon data as derived by *astrosource* using the PDM technique. The highest peak corresponds to the period determined for EK Mon. This period is consistent with the period provided by VSX.

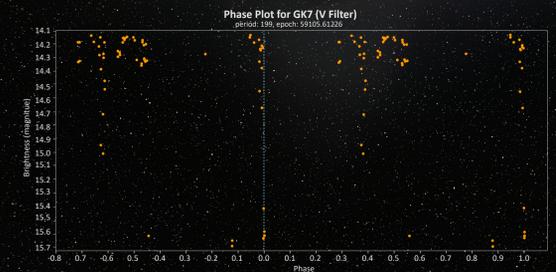


The phased light curve for EK Mon derived using the period determined by *astrosource*.

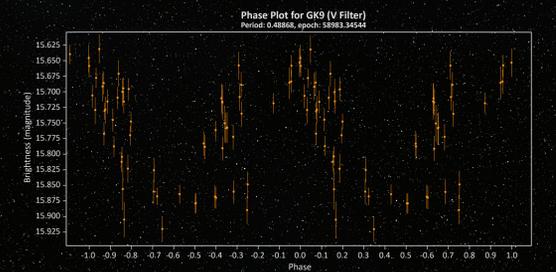
PERIOD SEARCH

If requested, *astrosource* will search for periods for target objects. Period search parameters are obtained by examining the time distribution in the data set. Period search parameters can also be set manually. The adopted search algorithms are Phase Dispersion Minimization (PDM) and String-Length (SL). Period likelihood plots and data are generated.

Period likelihood plots serve as a starting point for manual period searches using Date Compensated Discrete Fourier Transform (DCDFT) analysis in AAVSO VStar.



The phased light curve for the newly discovered Algol variable GK7. The period is approximately 199 days, the amplitude of the primary eclipse is 1.5 magnitudes, and the orbit is eccentric since secondary eclipse occurs at phase 0.4



The phased light curve for the newly discovered RR Lyrae variable GK9 (type RRc). The amplitude is about 0.3 magnitude and the period is 0.48868 days. The period was determined using VStar and DCDFT. The light curve does not appear to repeat exactly from one cycle to the next.

CONCLUSIONS

We have discovered 11 new variable stars after examining 588 stars for variability. The stars examined were recorded in 120 V-filter images of the field of the classical Cepheid EK Mon, and were obtained using the Las Cumbres Observatory. The new variables reported here showed prominent and recognizable variability. We also evaluated the previously known variables in the field as reported by the VSX. Our discoveries include two Algol type eclipsing systems (EA), one with an eccentric orbit; a W Uma type contact binary (EW); an RR Lyrae pulsating system (RRc); a type II Cepheid (CW); four objects exhibiting multiple outbursts or flares (possible CVs); and two prominent rotating or pulsating systems with periods of approximately one day. The numbers of objects discovered, and the types of variability are consistent with results from large scale variability surveys such as SuperWASP and ASAS-SN. We are continuing to obtain images of this field to improve the quality of the light curves and periods, and to document possible long term changes. The results of this preliminary survey indicate there are many variable stars waiting to be discovered if you are willing to look for them.

References

- Astrosource*: automating optical astronomy measurement, calibration and analysis for variable stellar sources from provided photometry, Michael Fitzgerald et al. preprint Journal of Open Source Software (2020) https://www.oursolarsiblings.com/wp-content/uploads/2020/08/Fitzgerald2020_JOSSPaper.pdf
- Las Cumbres Observatory Global Telescope Network. T. M. Brown et al. (2013) Publications of the Astronomical Society of the Pacific 125, 1031 (2013)
- LCO Global Sky Partners. <https://lco.global/education/partners/>

