Time-series photometry from Flarestar Observatory – Malta

11th Gaia Science Alerts Workshop
18-22 January 2021

Stephen M. Brincat

Flarestar Observatory – location

- San Gwann (Malta)

  +14.4702°E, +35.9103°N, 110m a.s.l.
- Started operation in 1999 as Minor Planet observatory code 171.

The main island is 27 kilometers x 14.5 kilometers, with a total area of 246 square kilometers.

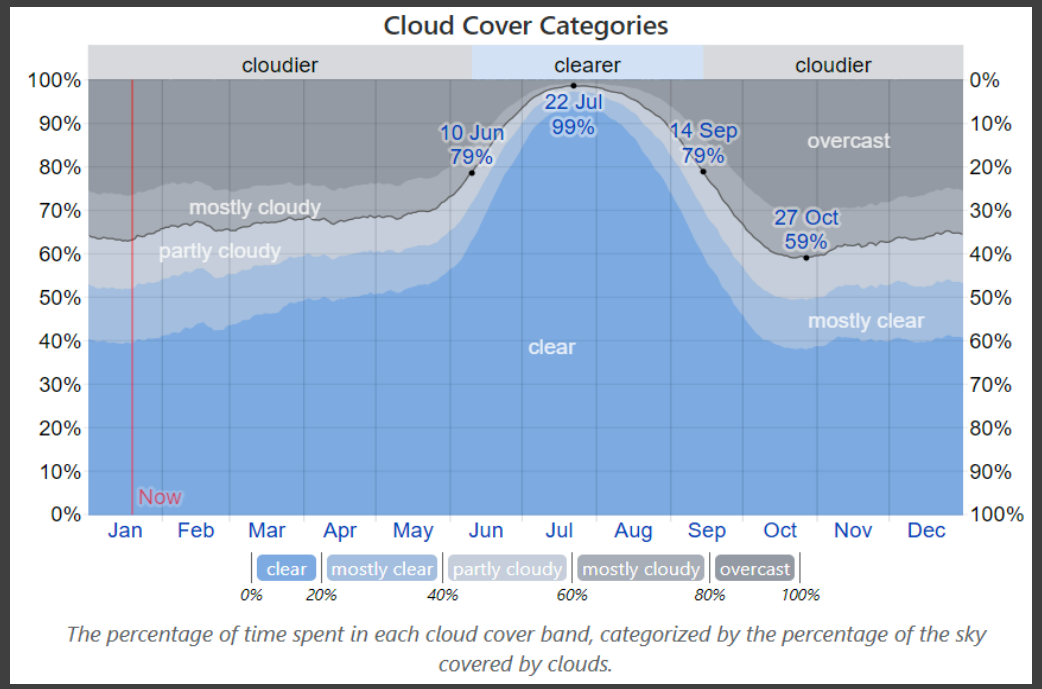
Flarestar Observatory

- 0.25-m Schmidt-Cassegrain telescope.
- Flarestar is remotely controlled and autonomously operated all night long without human intervention, except for roof opening/closure.
- Some failsafe devices installed to intervene in case of clouds or rain.
- 2 night vision cameras installed for remote monitoring.
- ~98 K of variable star observations mostly of CV variable stars.
- ~15 K asteroid observations.

Observatory Parameters

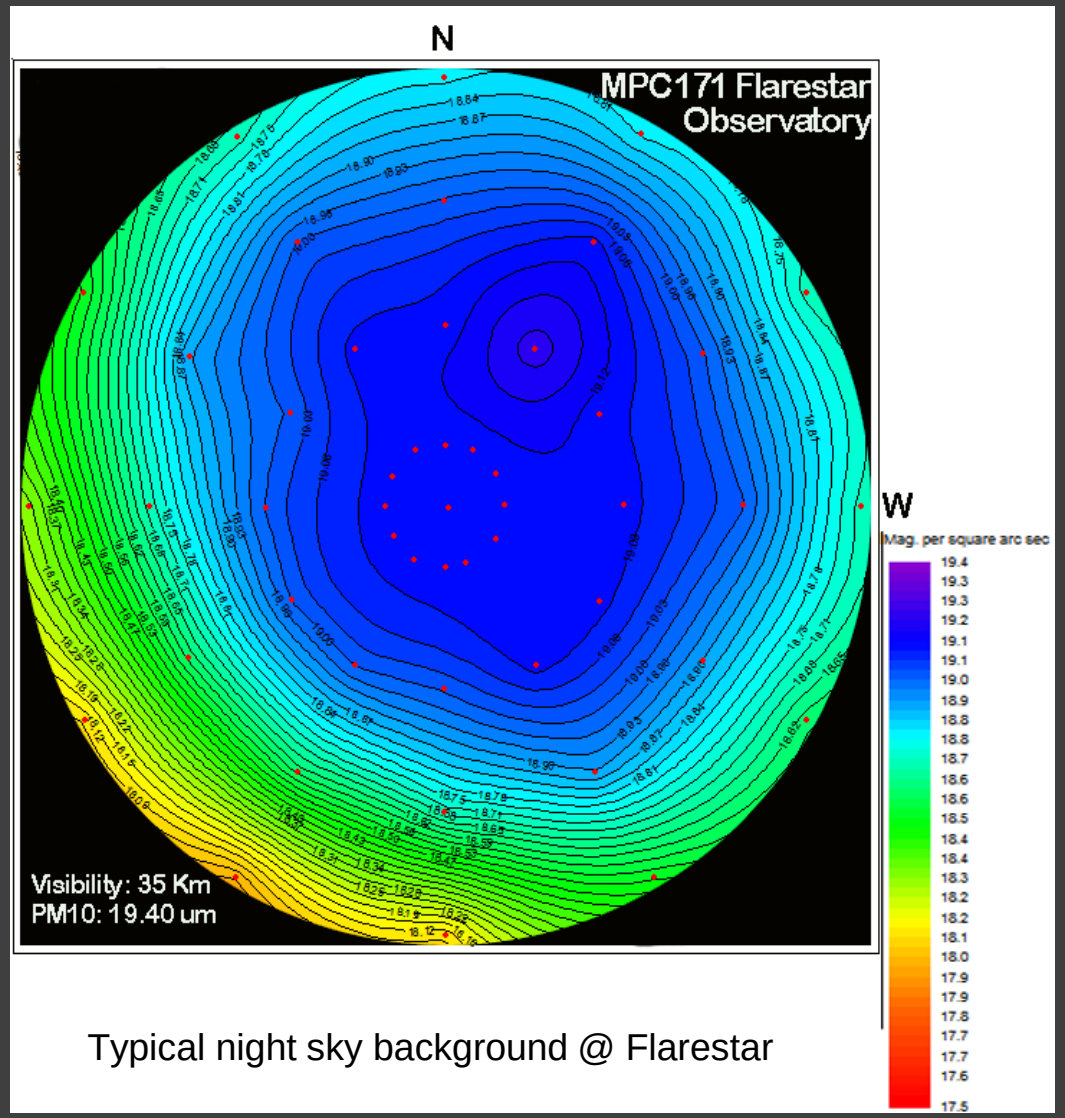
- Telescope:
  - 25-cm Schmidt-Cassegrain,
  - focal length: 1650 mm.
- Mount: EQ8 Pro
- CCD camera:
  - Moravian G2-1600 CCD (KAF1603ME).
  - CCD size: 1536 x 1024 pix, pixel size: 9 μm,
  - Field of view: 25.7’ x 17.13’, image scale: 0.98”/pix.
- Filters:
  - V, Ic (Astrodon) & neutral
- Raw and pipeline reduced data.
  - MPO Canopus
- Operation modes (semi-robotic):
  - Pre-ingested schedule
  - Local/remote operator
- Observatory undergoing upgrading works.

Night sky conditions over Flarestar



The percentage of time spent in each cloud cover band, categorized by the percentage of the sky covered by clouds.

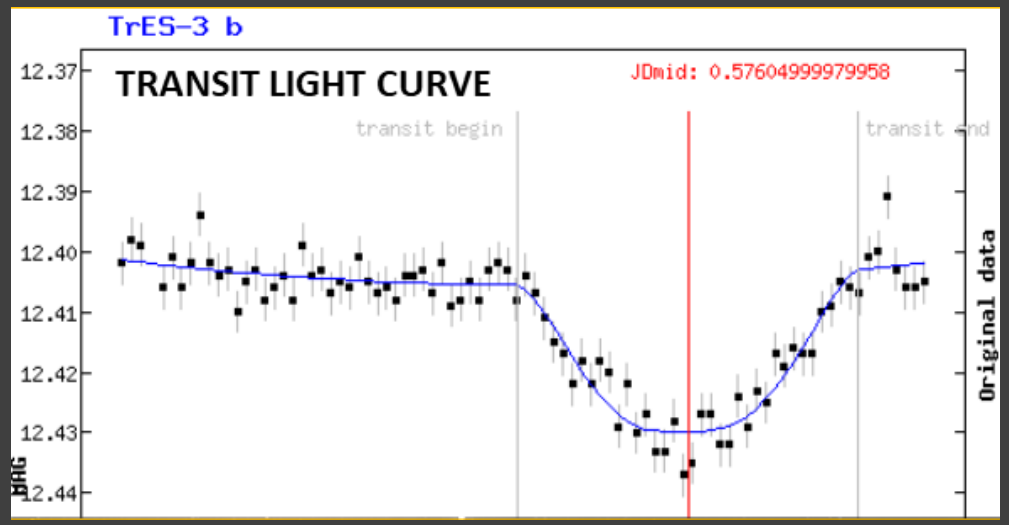
- Night Sky background:
  - Min 18.9 mag/arcsec^2 (V - bandpass)
  - Max 19.44 mag/arcsec^2
- Seeing:
  - Best: < 2.4" arcsec (~ 5% of nights)
  - Average : 2.5 to 3.3" arcsec (~ 75%)
  - Bad: 3.4 to 3.8" arcsec (~ 15%)
  - Worst: > 3.9" arcsec (~ 5%)

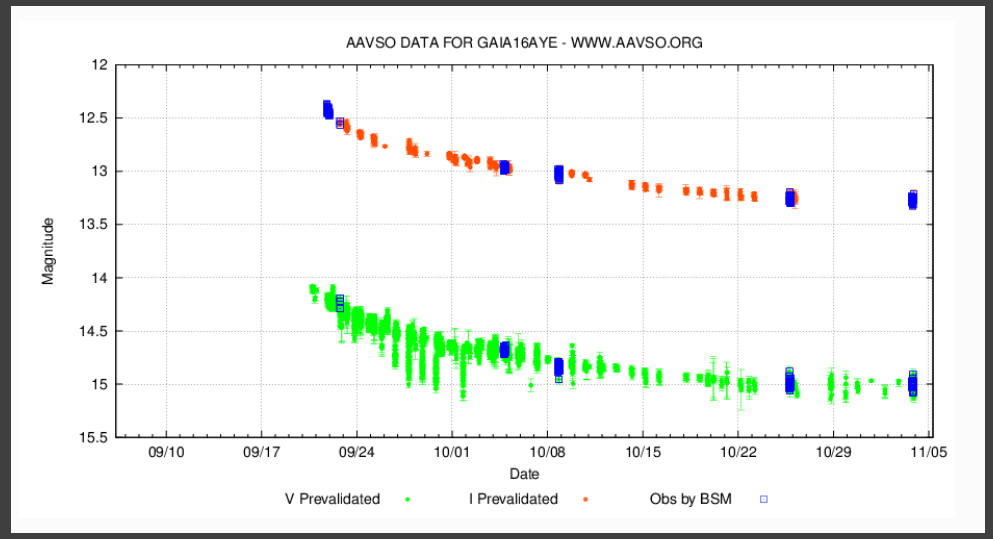


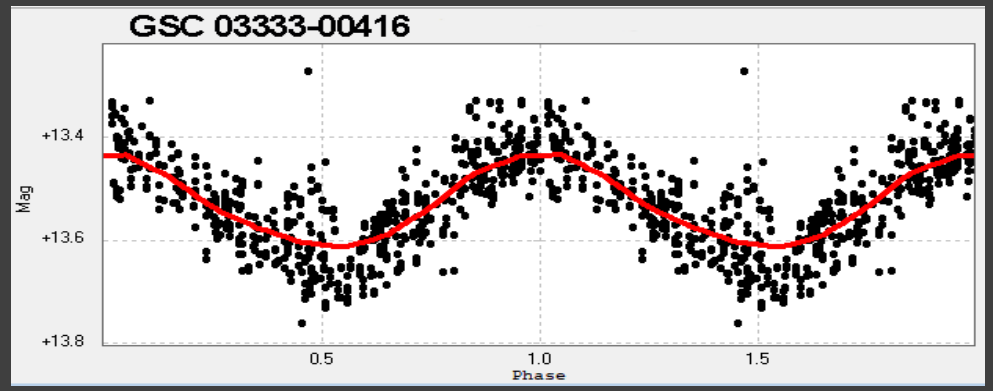
Typical night sky background @ Flarestar

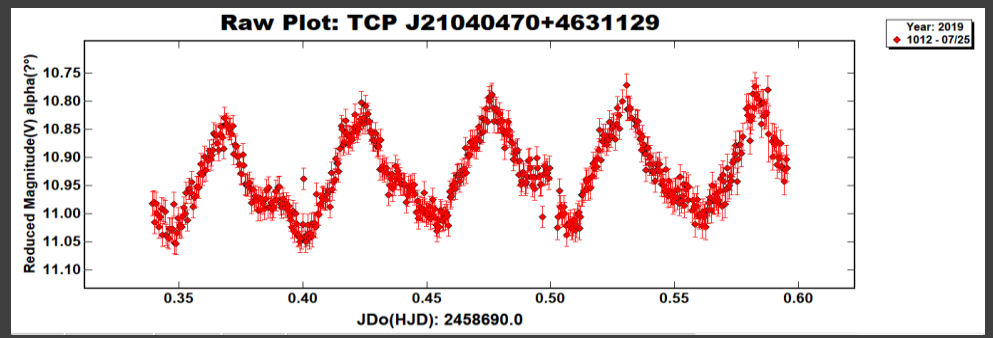
Observing Programs

- Follow-up observations of CV variable stars
- Microlensing
- Asteroid photometry
- Exoplanets, through transit photometry
- Variable star discoveries
- In depth monitoring of some stars



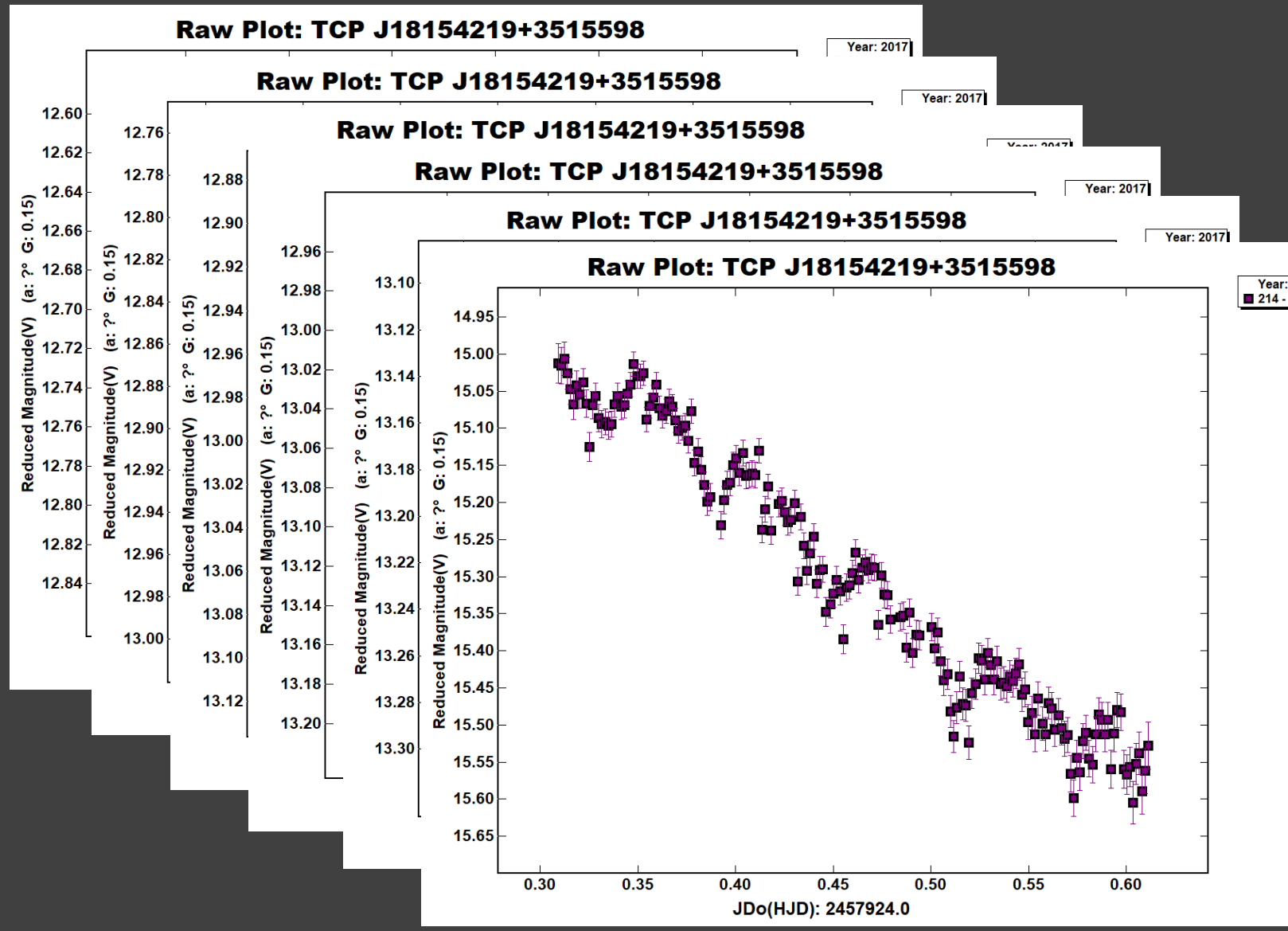






Variable Stars

- Follow-up observations of CV outbursts (CBA & VSNET).
  - Observations with a cadence of <2 minutes for super hump detection.
  - Rapid variation of other objects.
- Observations are usually conducted following notification by astronomers through Alert Notices or direct requests.



UGWZ-type variable star with multiple rebrightenings

Microlensing - *Gaia Alerts follow-up*

- First involvement with microlensing:

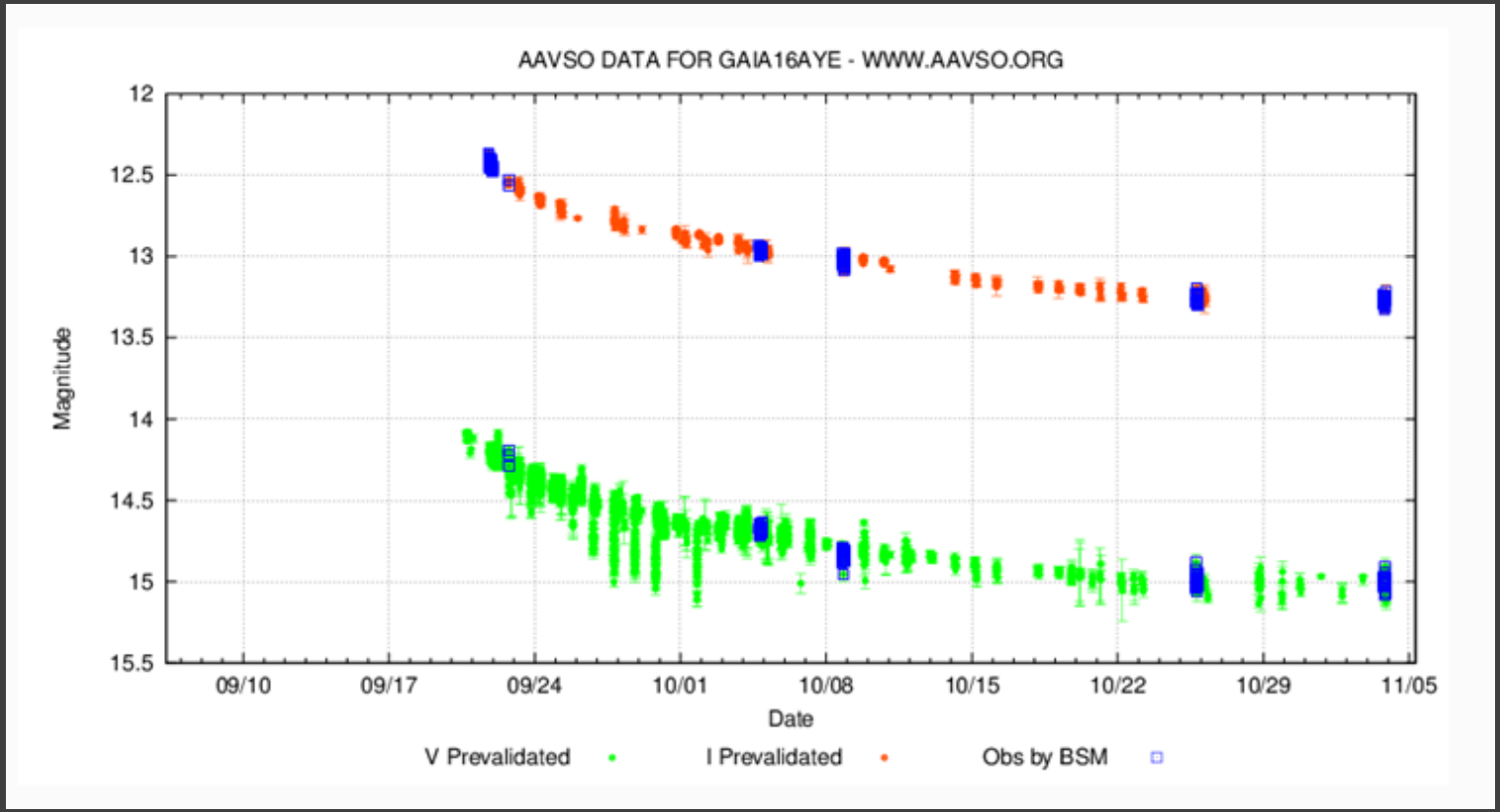
  AAVSO Alert Notice 552 (September 20, 2016) announces an urgent observing campaign to monitor the microlensing event associated with Gaia16aye.

- A number of images for the Gaia transients below have been acquired:

Gaia19bpg	*Gaia20cek*
Gaia19bsy	*Gaia19dqe*
Gaia19drp	*Gaia19bsy*

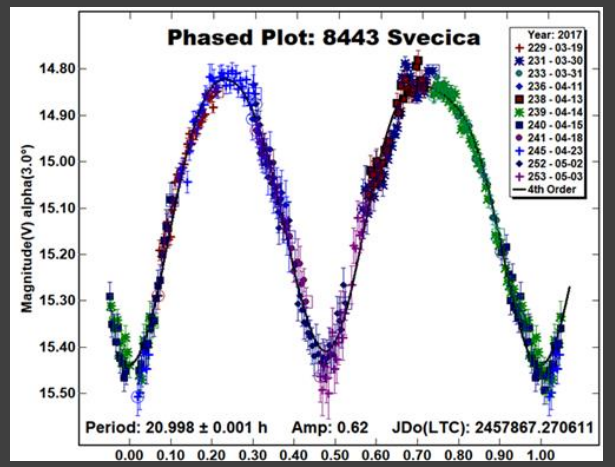
Shall be submitted through BHTOM shortly.

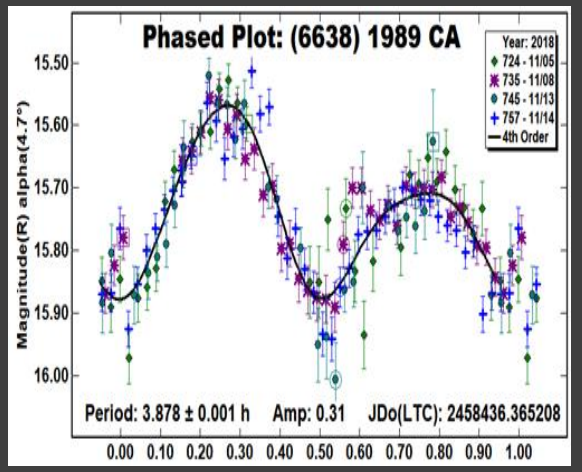
Gaia16aye

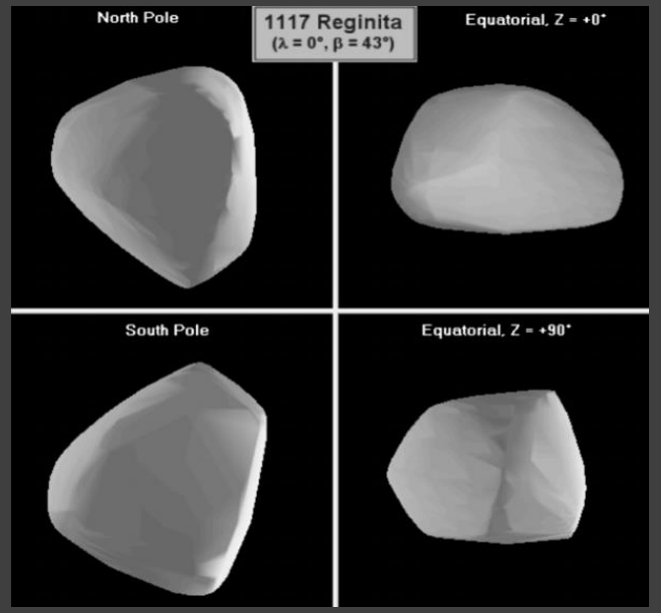


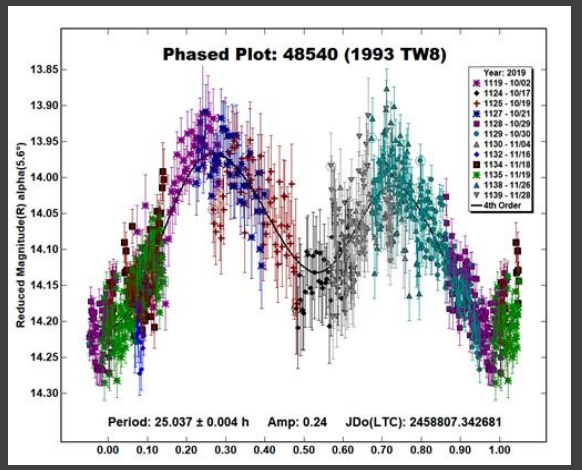
Asteroid Photometry

- In 2000, I started to observe asteroids to derive rotation period.
- During the same year, 1st International Collaboration (2000) with American colleague (Robert Koff) (MPB 27-2000)
- Most targets are asteroids whose rotation period is unknown.
- Objects <16th magnitude (V) are usually targeted with individual exposure times ranging from 60-240 s.
- Nearly half of the observation campaigns are carried out through collaborations.
- All results are submitted to the Minor Planet Bulletin (available through NASA ADS).
- Determined 55 asteroid rotation periods.
- Participated in campaigns to derive asteroid shape through light curve modelling.









REFINING EXOPLANET EPHEMERIDES THROUGH TRANSIT PHOTOMETRY

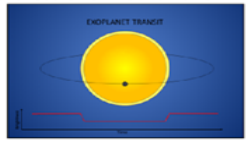
STEPHEN M. BRINCAT

FLARESTAR OBSERVATORY (IAU/MPC Code: 171) MALTA

INTRODUCTION

Exoplanet discoveries have increased dramatically thanks to the transit method. This method has allowed astronomers to acquire additional information such as the density of their internal structure and their size. In order to keep track of transit windows that refers to a specific time period during which a complete transit event can be observed, transit observations are carried out to refine such predictions

Transit observations are important as they will spare precious time on much larger professional telescopes that can probe these systems to derive physical data. With the knowledge that small telescopes can be useful to support professional observatories, we have observed a number of exoplanet transits autonomously for reporting to professional institutions.



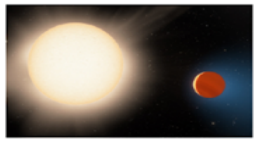


Image Source: Romanyuk (2016).

OBJECTIVE

A number of transit events have been recorded from Flarestar Observatory with the objective to establish, with good confidence levels, the capability of the telescope system at Flarestar Observatory for exoplanet transit work and to utilise an efficient methodology for the transmission of such data.

METHODOLOGY

All of our data was acquired through a 0.25-m Schmidt Cassegrain Telescope (SCT) coupled with a Moravian G2-1600 scientific-grade CCD camera operating at -15º C. All of our images were calibrated through dark subtraction and flat fielding.

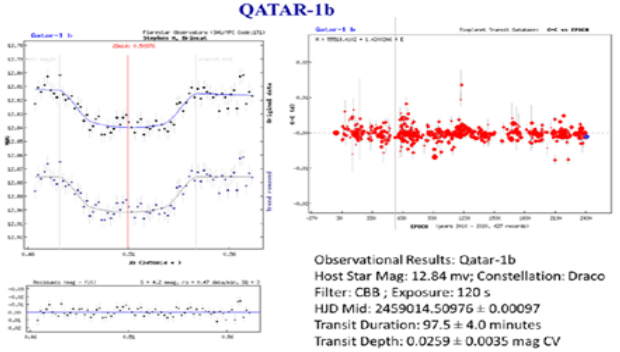
The research-level program MPO Canopus was utilised for image analysis and image processing All of our flux measurements were acquired through the differential aperture photometry technique as employed by the same program. A Clear Blue-Blocking (CBB) filter was used to attenuate any effects by moonlight and to mitigate atmospheric effects caused by changing airmass and varying atmospheric conditions.

RESULTS

The following figures show the transit (eclipse) events of 5 exoplanets as recorded from Flarestar. The light curves of each transit event is shown in raw (black data points) and detrended (in blue) where atmospheric extinction was compensated for. The graphs at the bottom panel for each transit light curve show the residuals of the comparison stars that were used to determine the brightness variations. The O-C plots show the Observed minus Calculated results with the Blue point representing the observations from Flarestar Observatory.

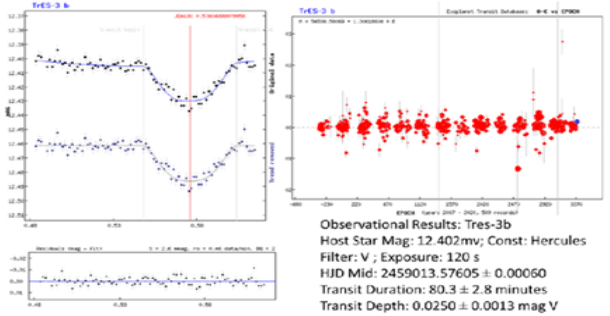
RESULTS (continued)

QATAR-1b



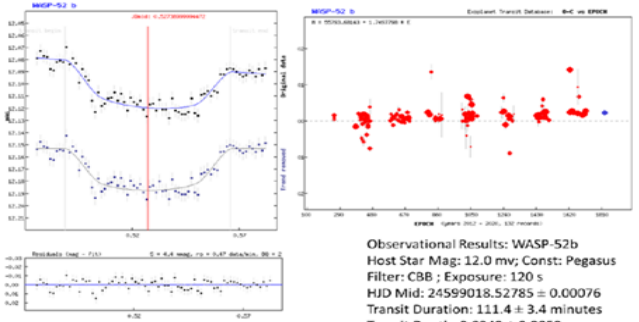
Observational Results: Qatar-1b
Host Star Mag: 12.84 mv; Constellation: Draco
Filter: CBB ; Exposure: 120 s
HJD Mid: 2459014.50976 ± 0.00097
Transit Duration: 97.5 ± 4.0 minutes
Transit Depth: 0.0259 ± 0.0035 mag CV

TRes-3b



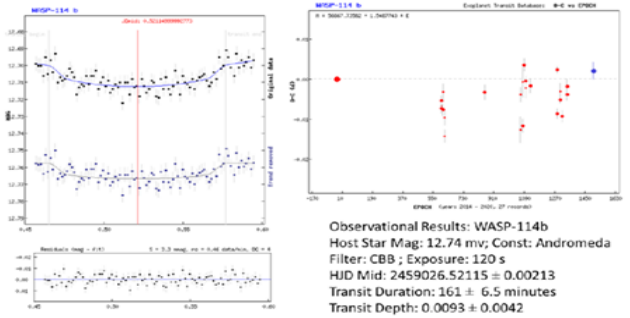
Observational Results: Tres-3b
Host Star Mag: 12.402mv; Const: Hercules
Filter: V ; Exposure: 120 s
HJD Mid: 2459013.57605 ± 0.00060
Transit Duration: 80.3 ± 2.8 minutes
Transit Depth: 0.0250 ± 0.0013 mag V

WASP-52b



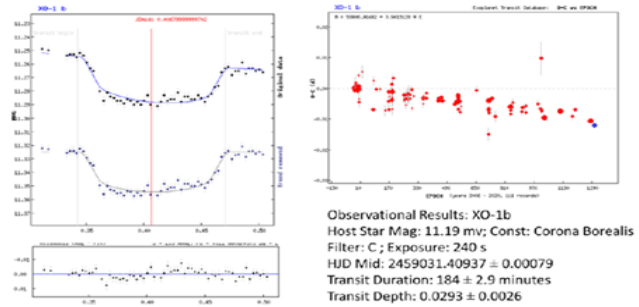
Observational Results: WASP-52b
Host Star Mag: 12.0 mv; Const: Pegasus
Filter: CBB ; Exposure: 120 s
HJD Mid: 24599018.52785 ± 0.00076
Transit Duration: 111.4 ± 3.4 minutes
Transit Depth: 0.0342 ± 0.0059

WASP-114b



Observational Results: WASP-114b
Host Star Mag: 12.74 mv; Const: Andromeda
Filter: CBB ; Exposure: 120 s
HJD Mid: 2459026.52115 ± 0.00213
Transit Duration: 161 ± 6.5 minutes
Transit Depth: 0.0093 ± 0.0042

XO-1b



Observational Results: XO-1b
Host Star Mag: 11.19 mv; Const: Corona Borealis
Filter: C ; Exposure: 240 s
HJD Mid: 2459031.40937 ± 0.00079
Transit Duration: 184 ± 2.9 minutes
Transit Depth: 0.0293 ± 0.0026

CONCLUSION

Our results are consistent with those published and look forward to start utilizing our data for the refinement of exoplanet revolution periods. The results presented here have been accepted and published by the Exoplanet database (Poddaný et al., 2010). The methodology applied at Flarestar Observatory was successful at deriving consistent results that will encourage us to submit exoplanet observations to other institutions. Such work should be beneficial to the professional community to update the ephemeris of exoplanets that will free up monitoring time on large professional telescopes.

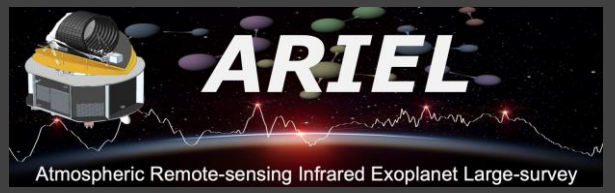
REFERENCES

- Bakos, G., Noyes, R. W., Kovács, G., Stanek, K. Z., Sasselov, D. D., & Domsa, I. (2004). Wide-Field Millimagnitude Photometry with the HAT: A Tool for Extrasolar Planet Detection. *Publications of the Astronomical Society of the Pacific*, *116*(817), 266.
- Poddaný, S., Brát, L., & Pejcha, O. (2010). Exoplanet Transit Database. Reduction and processing of the photometric data of exoplanet transits. *New Astronomy*, *15*(3), 297-301.
- Romanyuk, V. (2016). Space Engine Universe Simulator, available at http://spaceengine.org/.

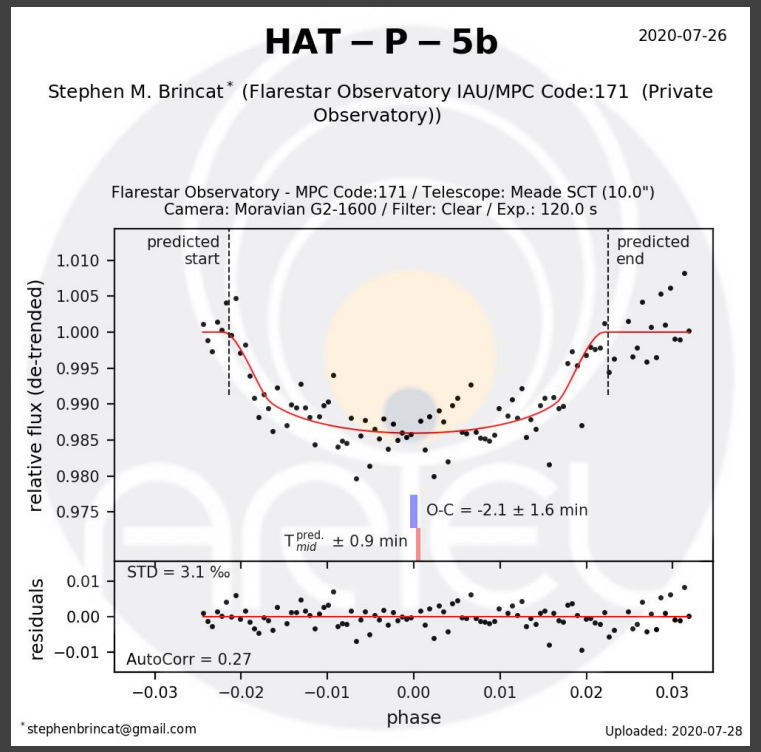
CONTACT

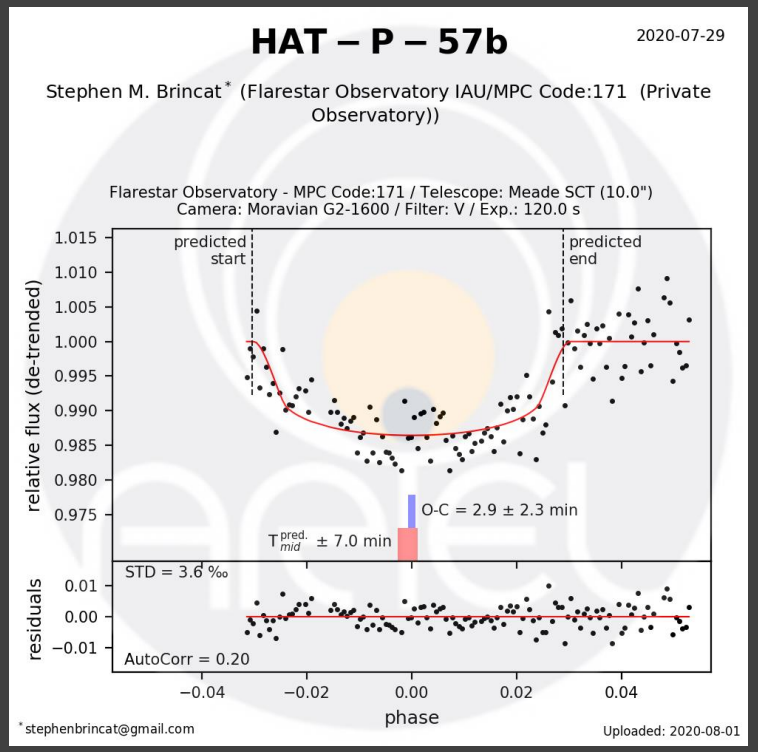
Flarestar Observatory (Malta): *https://flarestar.weebly.com/contact-page.html*

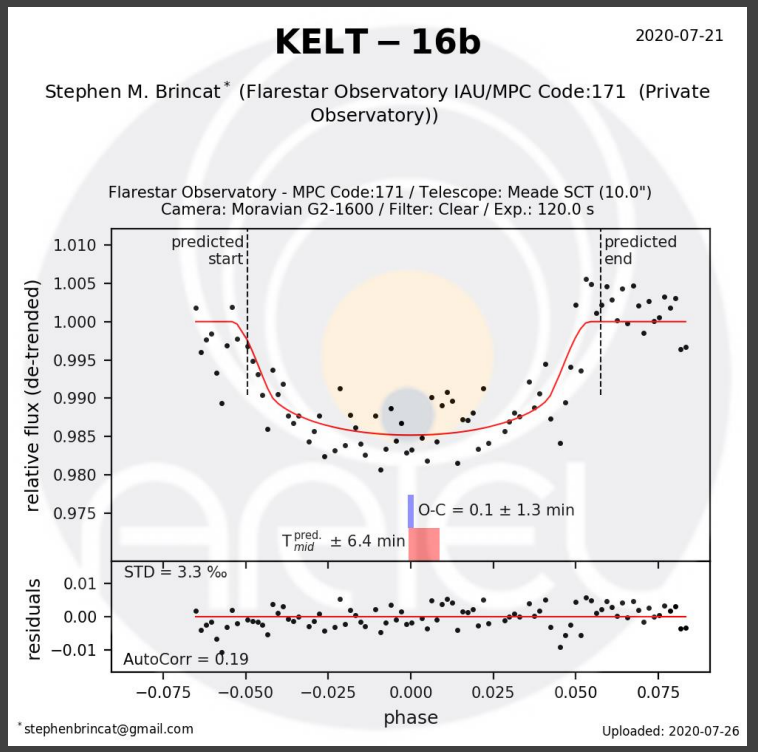
Exoplanets



- Collaborating with Exoclock Project.
- In support for the ARIEL (Atmospheric Remote-sensing Infrared Exoplanet Large-survey)
- ARIEL Dedicated to measuring the chemical composition and thermal structures of hundreds of transiting exoplanets.

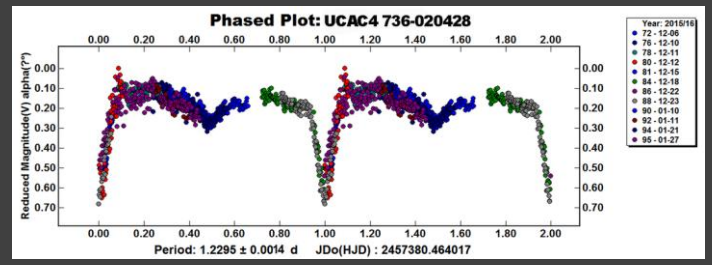


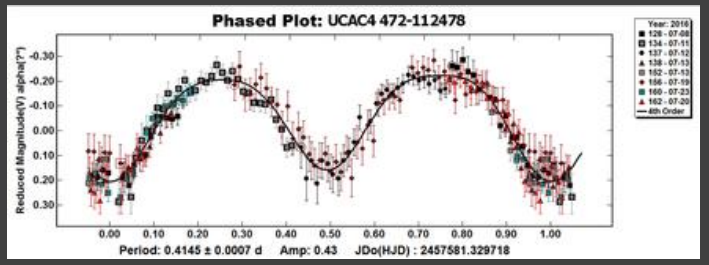


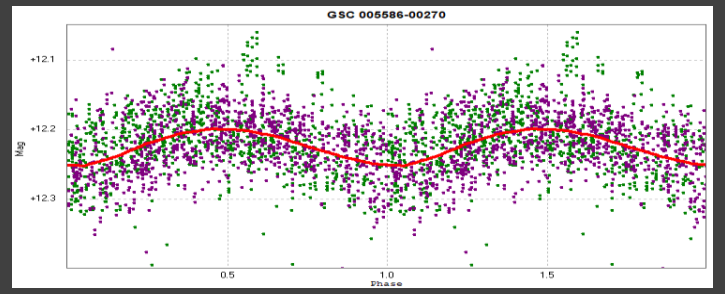


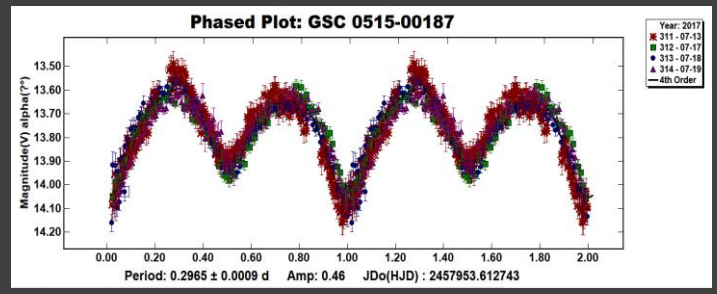
Variable Star Search

- 10 new variable star discoveries (by product of asteroid photometry).
- Reported to AAVSO VSX









Name	AUID	Coords	Const	Type	Period (d)	Mag
UCAC4 403-115663	000-BMP-328	19 18 29.60 -09 25 56.3	Aql	EW	0.498115	15.85 - 16.35 V
UCAC4 472-112478	000-BLY-673	20 03 30.10 +04 12 30.6	Aql	EW	0.4145	15.50 (0.43)clear V
CGCS 5409	000-BNK-470	21 40 08.11 +51 47 38.1	Cyg	L	--	15.3 - 15.4 g
GSC 00515-00187	000-BM-810	20 38 12.96 +03 42 14.8	Del	EW	0.2965	13.60 - 14.10 V
GSC 05586-00371	000-BMC-748	14 55 43.26 -12 30 28.3	Lib	EW/RS	0.441456	13.4 - 13.8 V
GSC 03333-00416	000-BMZ-492	04 23 42.00 +47 53 05.1	Per	SR	133	13.3 - 13.7 V
UCAC4 690-029948	000-BMY-743	04 23 15.45 +47 51 35.5	Per	SR	65	15.7 - 16.0 V
UCAC4 735-019611	000-BLW-283	01 56 10.32 +56 57 56.1	Per	EA	2.1271	16.11 V (0.55)clear
UCAC4 736-020428	000-BLW-284	01 57 54.60 +57 08 31.8	Per	EA	1.2295	15.08 V (0.5)clear
GSC 05586-00270	000-BMH- 248	14 55 50.76 -12 28 15.1	Lib	BY	9.1012	12.07 -12.30 V

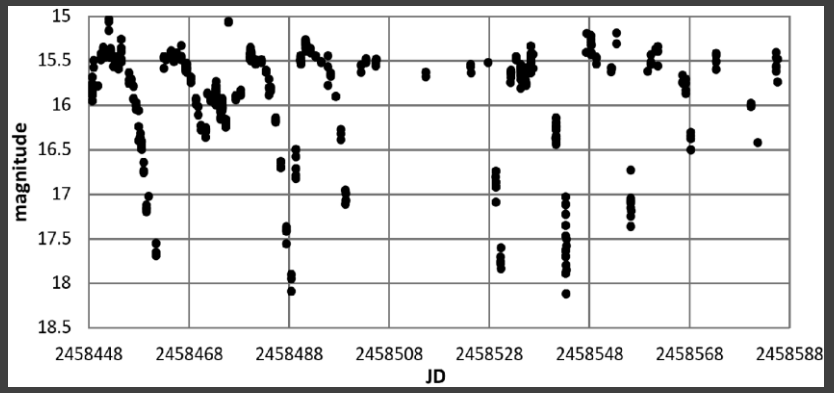
Scientific Collaboration

Informal group

Observatory (Location)	Observer	Telescope	Filters	CCD Sensor	FoV (arcmin)/Binning	Pixel Scale (arcsec/pixel)
Antares Observatory (Fgura, Malta)	Grech W.	0.279-m SCT	C	SBIG STL-11000/ KAI-11000M	45.9 x 30.6 /2x2	1.37
Flarestar Observatory (San Gwann, Malta)	Brincat S.M.	0.254-m SCT	V, Ic	Moravian G2-1600 / KAF 1603ME	25.5 x 17.0 / 1x1	0.99
Tacande Observatory (La Palma, Spain)	Hills K.	0.500-m Optimised Dall Kirkham	B, V	FLI ML3200/ KAF3200ME	35.7 x 24.1 / 1x1	0.98
Znith Observatory (Naxxar, Malta)	Galdies C.	0.203-m SCT	V, Ic	Moravian G2-1600 / KAF 1603ME	30.0 x 20.0/1x1	1.17

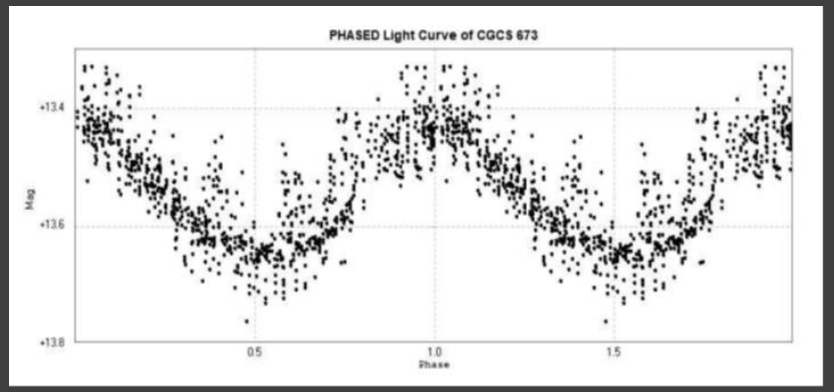
- The Reclassification of NSV 1586 from a Suspected Cepheid Star to a UG Class System.
- - Journal of the American Association of Variable Star Observers (JAAVSO)

2020-06
BIBCODE: 2020JAVSO..48...16B
Source: NASA Astrophysics Data System



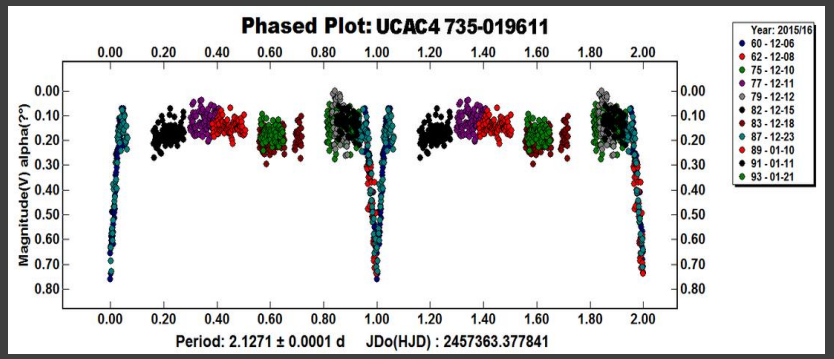
- Carbon Star CGCS 673 identified as a Semi-regular variable star.

2020-06
- Research in Astronomy and Astrophysics
BIBCODE: 2020arXiv200607289B
ARXIV: 2006.07289
Source: NASA Astrophysics Data System



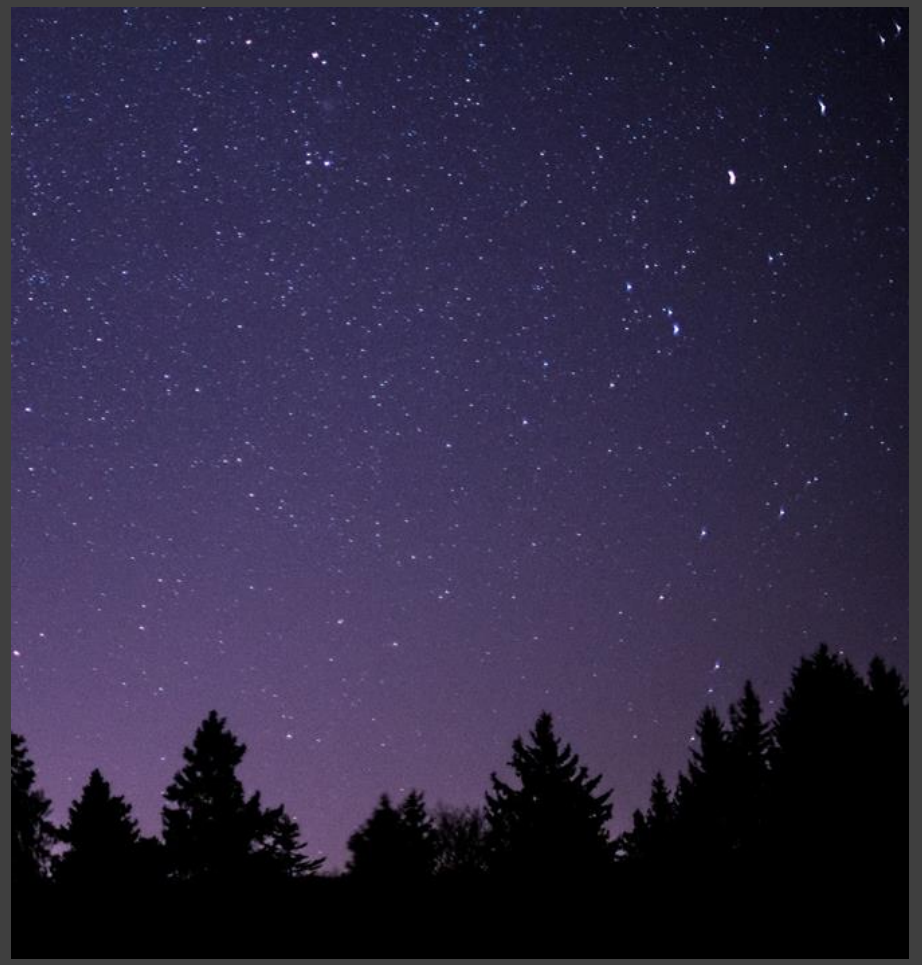
- A new binary star system of EA type in Perseus: UCAC4 735-019611.

- Open European Journal on Variable Stars
2019-01
BIBCODE: 2019OEJV..194....1B
Source: NASA Astrophysics Data System



Conclusion

- Variable stars observations provide an optimal opportunity for amateurs to contribute to scientific research.
- Amateurs have the capability to alter observation programs at will and therefore are readily available for monitoring new interesting transient events.
- My venture in photometry has yielded 40 + refereed papers with Prof. astronomers , thanks to collaboration campaigns.



Thank you for your attention

11th Gaia Science Alerts Workshop
18-22 January 2021