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A NEW BINARY STAR SYSTEM OF EA TYPE IN PERSEUS: UCAC4 735-019611

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Abstract: Discovery of a new binary star system (UCAC4 735-019611 = USNO-B1.0 1469-0068570 = 2MASS J01561032+5657563) in the Perseus constellation is presented. It was discovered during asteroid photometric work. The shape of the light curve and its characteristics (period of 2.12701 ± 0.00001d, amplitude of V=0.55 mag, initial minimum period epoch HJD 2457363.37784) indicates that the new variable star is an eclipsing binary of Algol (EA) type. We registered this variable star in the International Variable Star Index (VSX) and its AAVSO UID is 000-BLW-283.

1 Introduction

In search for new variable stars, we decided to study a dense star field located at RA(J2000) = 01h 57m 05s, and DEC(J2000) = +57°02'40" in the constellation of Perseus (Fig. 1). The chosen area is situated around 25 minutes west of the famous Double Cluster in Perseus (NGC 869 and NGC 884). The star field density at this location is rather high as it is not far from the Galactic equator, with the following galactic coordinates: Longitude 116.47790°; Latitude -5.27606°.

2 Observation

At RA 01h56m10.32s and DEC +56°57'56.1" the star designated by the Fourth U.S. Naval Observatory CCD Astrograph Catalogue (Zacharias et al., 2012) as UCAC4 735-019611 was identified as a possible variable star candidate by Flarestar Observatory. Its variability was identified after images were acquired and analysed through the Variable Star Search routine by MPO CANOPUS (Warner, 2017) according to a set of parameters as described in Furgoni (2013 a,b), for which results are depicted through a flux against RMS graph that displays potential targets according to their standard deviation amongst the rest of the stars. Data gathered on subsequent nights revealed that the suspected variable star was indeed variable in nature and hence it was reported to the American Association of Variable Star Observeres (AAVSO) VSX database for its inclusion. The star was confirmed as a new variable star and was designated by VSX as AUID 000-BLW-283. A campaign to obtain further data was initiated.

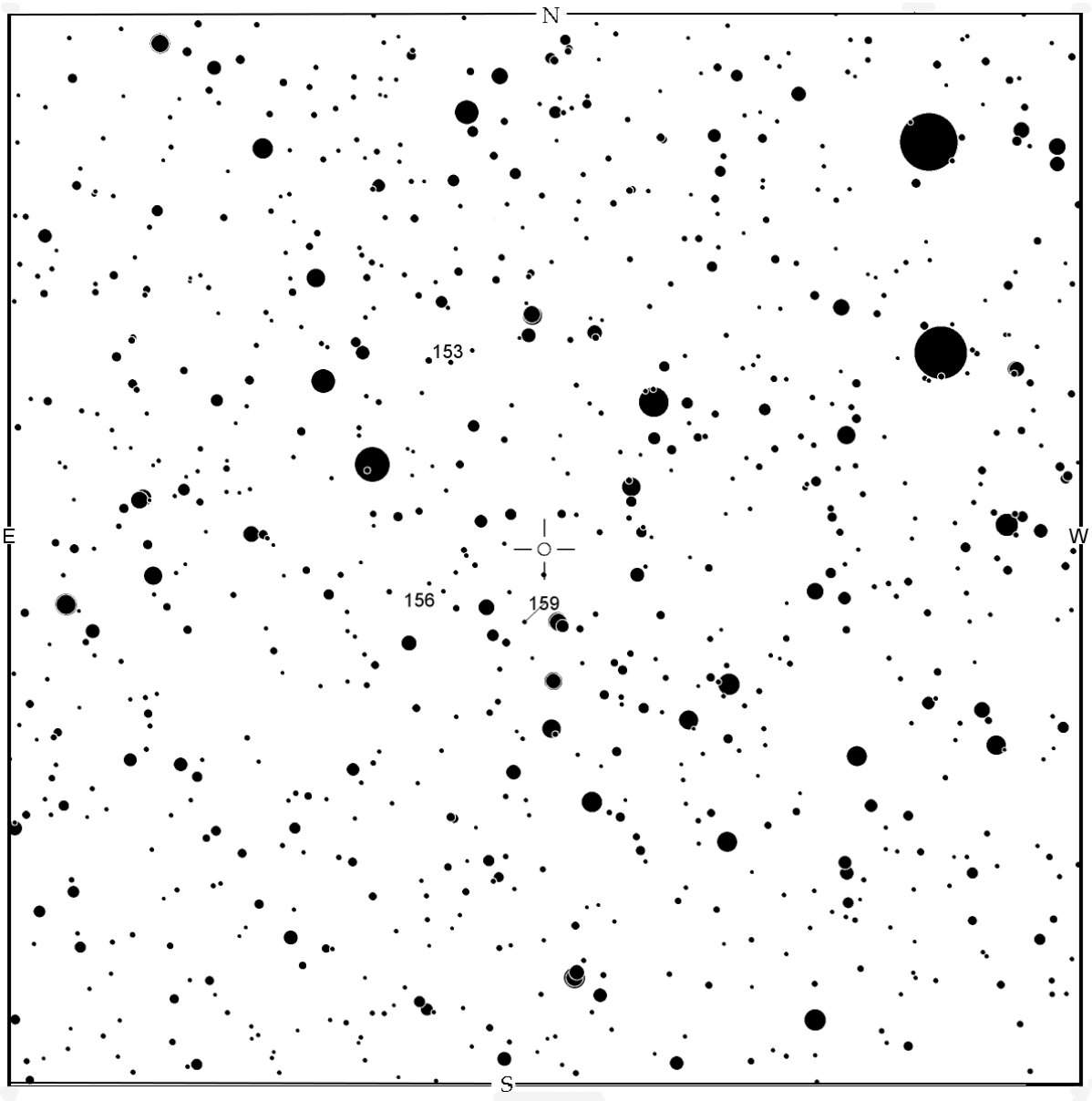

Figure 1: UCAC4 735-019611 (center) finder chart. AAVSO chart number X16269AT. Field of view is 20 arcminutes with North up and East to the left. The comparison stars used are labelled 153, 156 and 159 (see Table 2).

All photometric data to derive the nature of its variability was acquired from Flarestar Observatory (MPC Code: 171) at San Gwann, Malta. In order to obtain improved light elements (see below) Znith Observatory (Naxxar, Malta) and Antares Observatory (Fgura, Malta) submitted additional observations to refine the period of the variable star using the Observed minus Calculated (O-C) times of the minima (Table 1).

All observatories throughout this study utilised the astronomical WCS coordinate system for plate solving to ensure that target stars were well centered in the field of view with minimal edge distortion. Clear-filtered images were calibrated against the V (visual) standard in order to obtain CV magnitudes. V and I (Cousins, 1974) flux intensities were directly

transformed and calibrated on the AAVSO comparison star sequence (Table 2). All images were calibrated through flat-fields and dark frames.

Table 1: Equipment used for observations.

Observatory	Telescope	CCD Sensor	FoV (arcmin)/Binning	Pixel Scale (arcsec/pixel)
Brincat, S. M. (BSM) / Flarestar Observatory	0.25-m SCT	Moravian G2-1600 / KAF 1603ME	25.5 x 17.0 / 1x1	0.99
Galdies, C. (GCHB) / Znith Observatory	0.20-m SCT	Moravian G2-1600 / KAF 1603ME	30.0 x 20.0/ 1x1	1.17
Grech, W. (GW)/ Antares Observatory	0.28-m SCT	SBIG STL-11000/ KAI-11000M	45.9 x 30.6 / 2x2	1.37

Differential aperture photometry through a clear-filter was obtained from all observatories. The APASS catalog list the star magnitude as 16.113 in V, whilst the colour index of the star is B-V=0.878. The maximum magnitude is thus being given as 16.11 mag with a maximum amplitude of 0.55 (in V).

Table 2: Comparison stars used for UCAC4 735-019611 based on AAVSO Chart X16269AT.

Star (AUID)	Label	RA	DEC	Mag (V)+ (error)	Colour (B-V)	Ic
000-BLY-239	159	01:56:13.05	56:56:34.1	15.852(0.024)	0.594(0.024)	14.944(0.261)
000-BLY-238	156	01:56:24.69	56:57:07.4	15.598(0.019)	0.837(0.033)	14.451(0.091)
000-BLY-237	153	01:56:26.09	57:01:27.6	15.276(0.040)	0.850(0.075)	14.344(0.132)

Photometry to establish the (O-C) values were taken during the year 2017 from all observatories listed in Table 1. From all three observatories we obtained 8 minimum times using the Kwee and van Woerden (1956) method. The times of minima are reported in Table 3. The initial epoch in this study was given as:

$$\text{HJD Min I} = 2457363.3778 + 2.1271\ E. \quad (1)$$

Using all the times of minima, an improved ephemeris was determined by the least-squares solution as shown below:

$$\text{HJD Min I} = 2458099.3207 + 2.12701(1)\ E. \quad (2)$$

Fig. 2 shows the O-C diagram using equation 2 above. There is no evidence of any significant period change. Several more times of minima over a number of years are needed to confirm whether a period change is observed in this system.

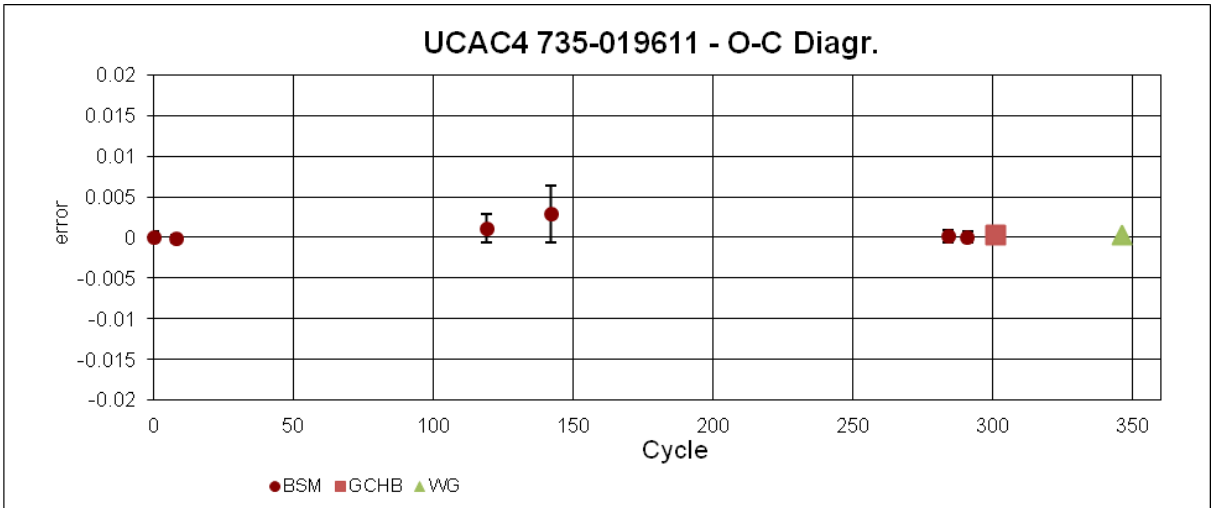

Figure 2: UCAC4 735-019611 Observed minus Calculated (O-C) diagram.

Table 3: Calculated times of minima and O-C residuals using equation 2.

Type	ToM (HJD + 2400000)	Error	O-C Linear
I	57363.3755	0.0007	-0.0024
I	57380.3940	0.0005	0.00012
I	57616.4949	0.0018	0.00289
I	57665.3974	0.0035	-0.0159
I	57967.4527	0.0008	0.00398
I	57982.3342	0.0007	-0.0036
I	58003.6061	0.0010	-0.0018
I	58099.3187	0.0010	-0.0046

3 Data analysis

Data acquired were analysed using MPO CANOPUS (Warner, 2017) to allow the calibration of data from several nights to obtain the periodicity of the variable star. Results shown in Fig. 4 are the phase-folded observation data from several nights. Fig. 5 shows a typical eclipse based on data collected during two different nights. These results were transformed into a light curve through MPO CANOPUS that employs the FALC routine (Harris et al., 1989) for period analysis.

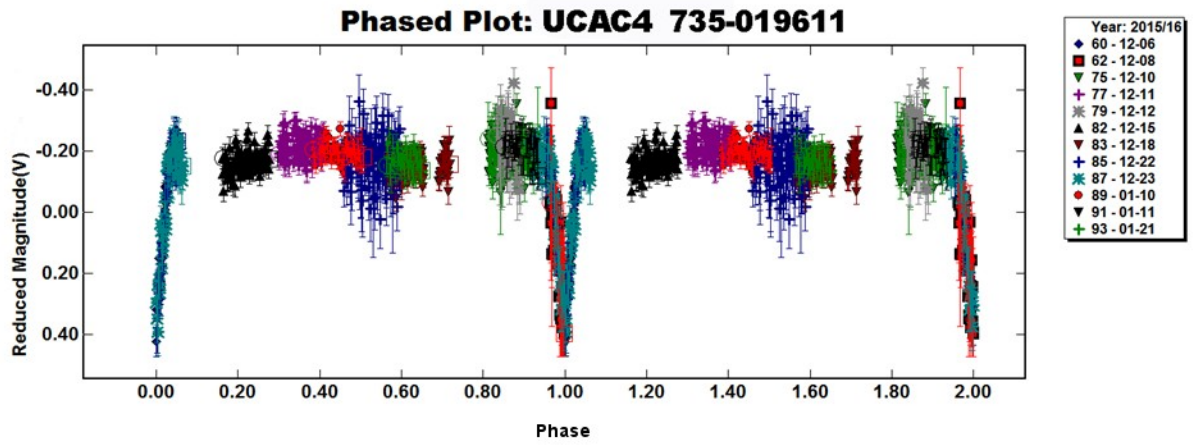

Figure 4: Data of UCAC4 735-019611 (C filter) obtained from Flarestar Observatory in 2015 and 2016 phased according to equation 2.

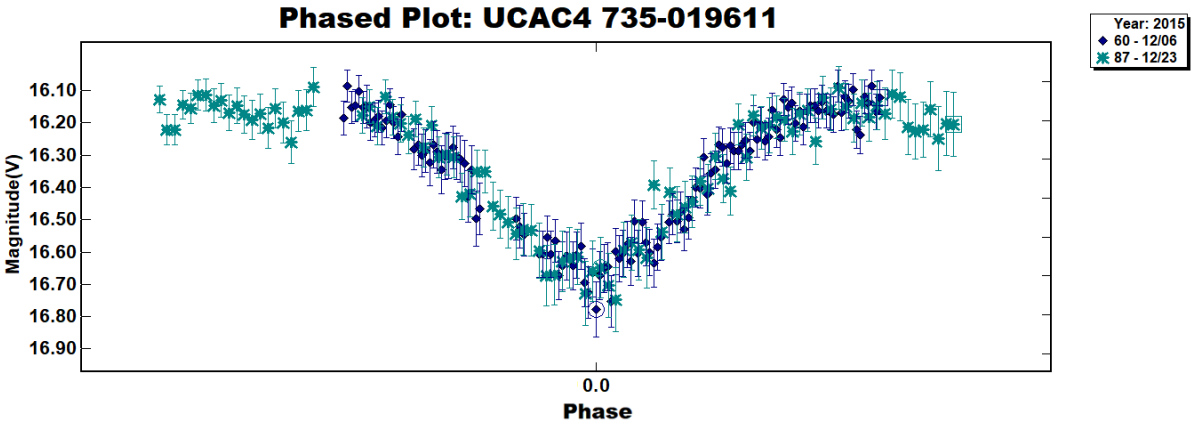

Figure 5: The primary eclipse of UCAC4 735-0191611 as observed on the 6th (label 60) and 23rd (label 87) December 2015 at Flarestar Observatory.

Fig. 6 shows the period spectrum using the FALC routine (Warner, 2016; Harris et al., 1989) of UCAC4 735-019611 with the range of periods along the X-axis while the RMS error values of the Fourier analysis are displayed along the Y-axis. The lowest data point represents the period with the best fit that has the lowest RMS error. The plot indicates that the best period fit is that of 2.12701 ± 0.00001d.

4 Results

The shape of the light curve shows distinct moments of the beginning and ending of eclipses, basic flatness at maximum magnitude, as well as the absence of secondary eclipses. On this basis, we suggest that this system is an Algol (EA) type eclipsing binary. Table 4 shows the essential data of this newly discovered variable star as extracted from the GAIA DR2 (Brown et al., 2018) and UCAC4 catalogue (Zacharias et al., 2012). We used the magnitudes derived from the APASS cataog as a reference framework to derive the maximum magnitude of the star as 16.11 mag with an amplitude of 0.55 mag in V.

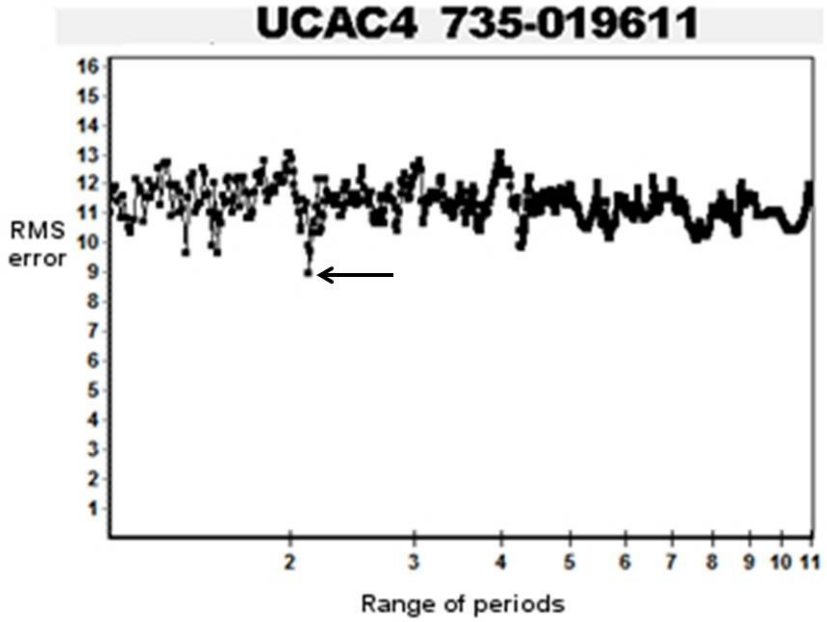

Figure 6: Period Spectrum for UCAC4 735-019611 showing the best period fit for period of 2.12701 days. The X-axis shows the range of of periods while the Y-axis shows the RMS error value of the Fourier analysis (Harris et al., 1989)

Table 4: Essential data of the variable star UCAC4 735-019611.

ID (UCAC4 Catalogue)	UCAC4 735-019611
Other identifications	2MASS J01561032+5657563 USNO-B1.0 1469-0068570 GAIA DR2 Source I.D. 504941717111774592
VSX Names and AAVSO AUID	000-BLW-283
Coordinates (UCAC4, J2000)	
Right Ascension [J2000]	01h 56m10.32s,
Declination [J2000]	+56° 57' 56.1"
Period (days)	2.12701 ± 0.00001d
Epoch	2458099.3207
Maximum magnitude (V)	16.11 mag
Minimum magnitude (V)	16.66 mag
Maximum Amplitude (V)	0.55 mag
Suggested var. type	EA
Eclipse Duration	9 %
Distance (pc)	1370 ± 210

5 Conclusion

Through the analysis obtained via the Fourier analysis algorithm (Harris et al., 1989) implemented in MPO Canopus, we have obtained a period of 2.12701 ± 0.00001d. Our results indicate that this system is an eclipsing binary of an Algol type (EA).

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