GSC 03390-01921, a new high amplitude δ Sct star in Auriga

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ABSTRACT

Le présent article fournit les éléments de variation de luminosité d'une nouvelle variable de type HADS ou SX Phe découverte dans la constellation du Cocher. Une estimation de la période est fournie complétée par une analyse des variations de l'indice de couleur.

The present paper gives elements for the light variations of a new HADS or SX Phe variable discovered in Auriga further to author's and ASAS-SN observations. An estimate of the period is provided completed by analysis of color index variations.

1. INTRODUCTION

Observation of asteroids sometimes leads to unexpected discoveries. On January 21st 2017, after analyzing photometric measurements of the asteroid (735)-Marghanna (see Fig. 1), the control of luminosity of the stars present in the observed field led to the discovery of a new variable star.

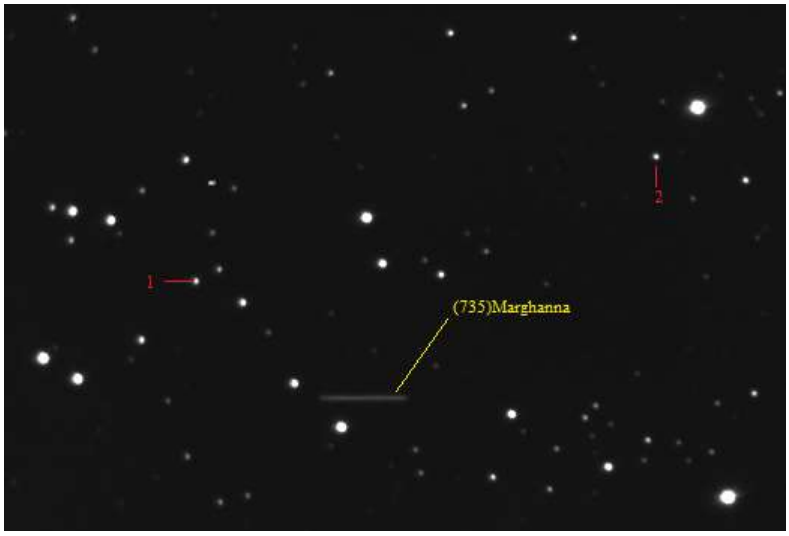


Figure 1: Field of view in Auriga

Star #1 :
Right Ascension = 06h49m20.27s
Declination = +45°38'14.6"
(J2000)

Source equivalent to
GSC 03390-01921
USNO A2.0 1350-6832676
UCAC4 679-45359
GDR2 954057410632485760

Quickly, it became apparent that the star GSC 03390-01921 (No.1 in Figure 1 and 2) was undeniably varying. The star #2 is probably also variable. In figure 2, star #1 is identified by the turquoise spot in the diagram of the rms of measurements vs magnitudes of the stars in the field during a single observation night.

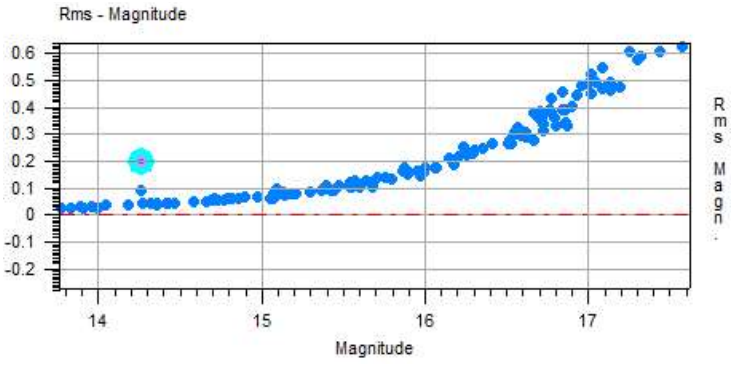


Figure 2: RMS variation related to magnitude

The GSC 03390-01921 light curve with Clear filter is given in Figure 3. By chance, two maxima spaced about 90 minutes apart are visible on this first light curve and give an approximation on the period as well as the shape of variation.

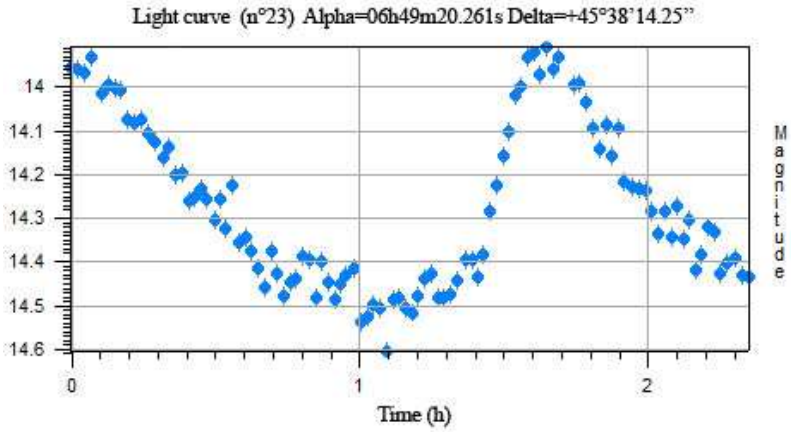


Figure 3: Light curve for GSC 03390-01921 on 21/01/2017

Over time, new observations of this object made possible to improve the light curve and to find elements allowing the calculation of an ephemeris.

A correspondence with Sebastian Otero of the AAVSO provided the necessary help at the time to define the type of variable but also to make a registration of this new variable in the VSX database.

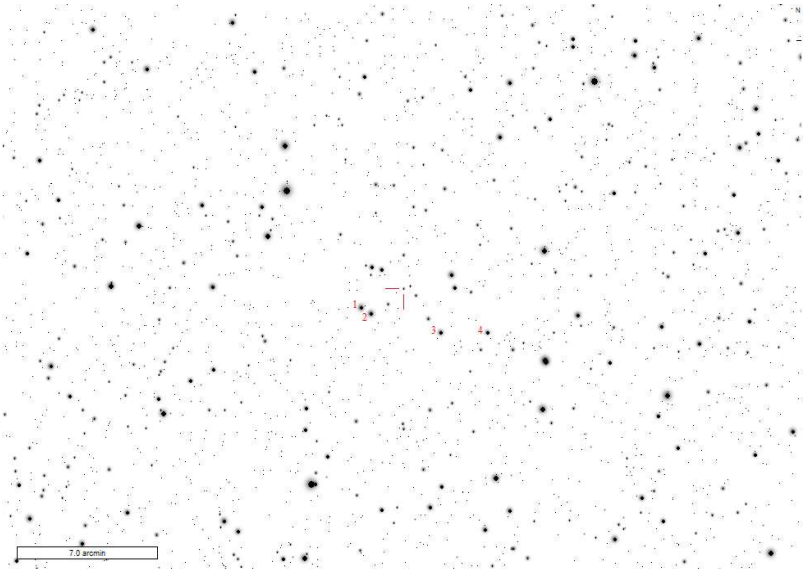
2. OBSERVATIONS

The following table lists the series of images produced since January 2017 for the study. The images were obtained by using a SBIG ST8 CCD camera equipped with Johnson-Cousins R and V filters. These images allowed to extract light curves and to establish times of maxima.

Date	Number of pictures	Filter	Number of maxima	Times of maxima	Optical configuration
21/01/17	105	C	2	HJD2457775 +0.385 +0.449	1
30/10/17	187	R	3	HJD2458057 +0.5636 +0.6302 +0.6962	1
17/02/18	163	R	3	HJD2458167 +0.354 +0.420 +0.487	1
18/02/18	96	R	3	HJD2458168 +0.3465 +0.4136 +0.4786	1
21/02/18	83	R	3	HJD2458171 +0.320 +0.388 +0.453	1
22/02/18	95	V	3	HJD2458172 +0.313 +0.378 +0.445	1
03/02/19	164	R	2	HJD2458518 +0.346 +0.411	1
11/01/21	130	R	1	HJD2459226.476	2
10/02/21	105	V	1	HJD2459256.351	2
09/03/21	175	V	1	HJD2459283.321	2
12/03/21	318	R	2	HJD2459286 +0.294 +0.359	2

Two optical configurations have been used :
1 a Schmidt-Cassegrain 12" at f/11 in Northern France (Obs. Cesson IAU B24)
2 a Schmidt-Cassegrain 11" at f/5.8 in South-East of France (Obs. Dauban IAU A77)

The small size of the CCD sensor associated with the focal length of the telescope does not make it possible to have a photometric reference star in the field. To limit the measurement problems, the same standards were adopted on all the series of images. These standards are shown in Figure 4.



Std.	magV	magR	R.A. (J2000)	DEC (J2000)
1	12.51	12.36	06h49m31.6s	+45°37'29.49''
2	12.74	12.64	06h49m29.3s	+45°37'06.11''
3	12.66	12.56	06h49m09.7s	+45°36'08.81''
4	13.21	13.47	06h48m56.5s	+45°36'08.90''

Here, standard magnitudes are given by NOMAD (Zacharias et al., 2004) using Aladin tool.

All measures have been done with the same aperture radii running scripts in PRISM software.

Figure 4: Standards locations

In addition, the observations made by the ASAS-SN survey (Shappee et al., 2014, Kochanek et al., 2017) make it possible to obtain discrete complementary measurements but not light curves with small time steps. However, as shown in Figure 5, the ASAS-SN site provides a phase diagram and a period for the variables recognized by the survey. In our case we can obtain the following diagrams:

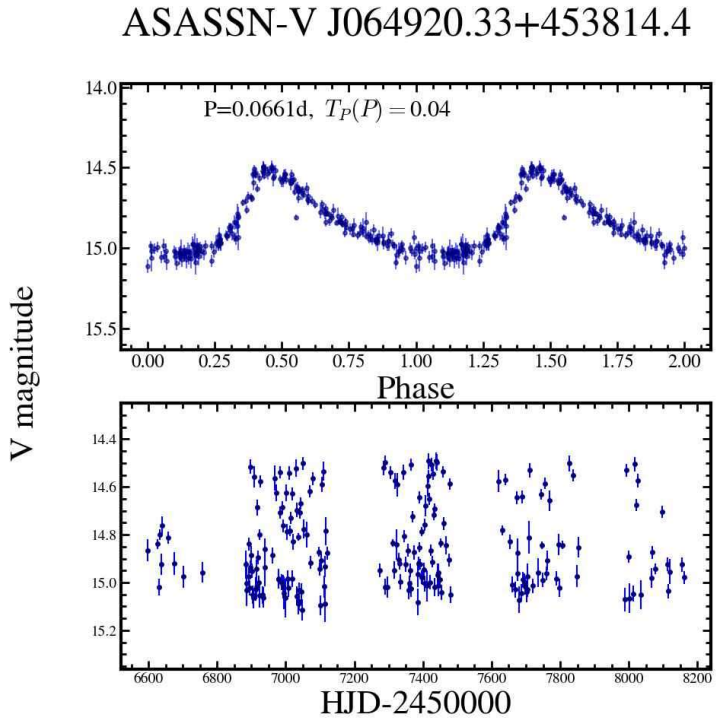


Figure 5: Phase curve and magnitude from ASAS-SN in V filter

3. ANALYSIS

As previously written, the star pulsates at a rapid rate and a few hours of observation can already show several maxima. In addition to the value provided by ASAS-SN, the period could be determined by measuring the time differences between the observed maxima. However, this method is quite imprecise, as often the light curves do not last enough to observe several maxima.

PERANSO software provides tools which allow an analysis of the period of a signal for which there is a cluster of measurement points. One of the difficulties with this tool is to find the right method, then to provide suitable parameters. The FALC analysis (Fourier Analysis of Light Curve) is well adapted to our period determination problem.

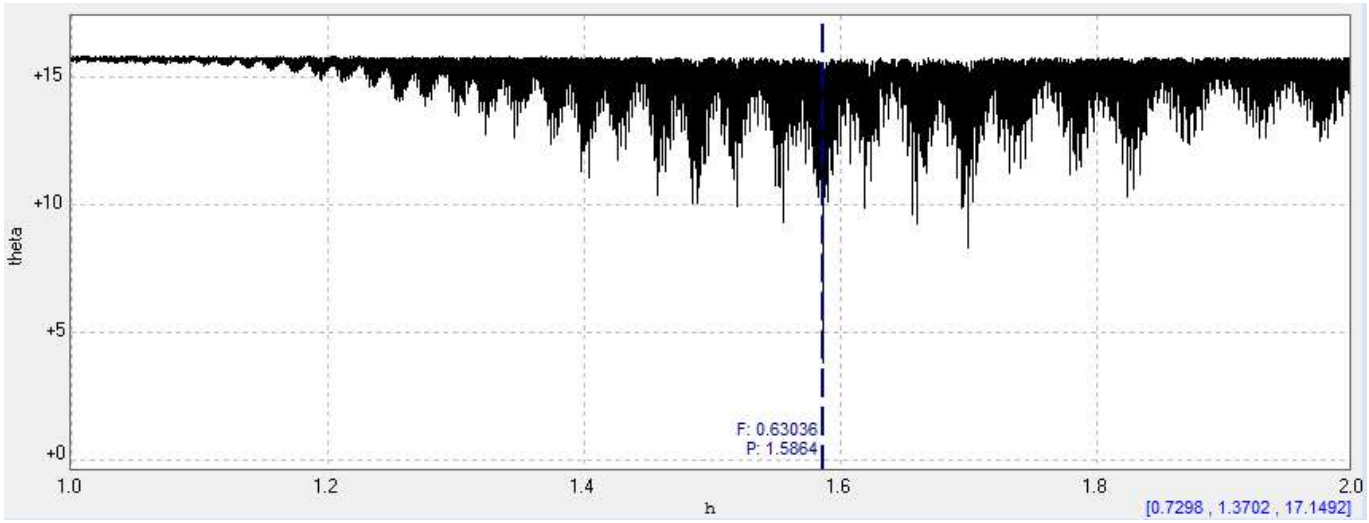


Figure 6: Result of Fourier analysis

All observations including those of ASAS-SN can be analyzed together. The observation period covers more than 2600 days and the Fourier analysis finally gives a period of 1.5864h, i.e. exactly that found by ASAS-SN as shown in Figure 6. The phase diagram given in Figure 7 shows all R, V and ASAS-SN V measures.

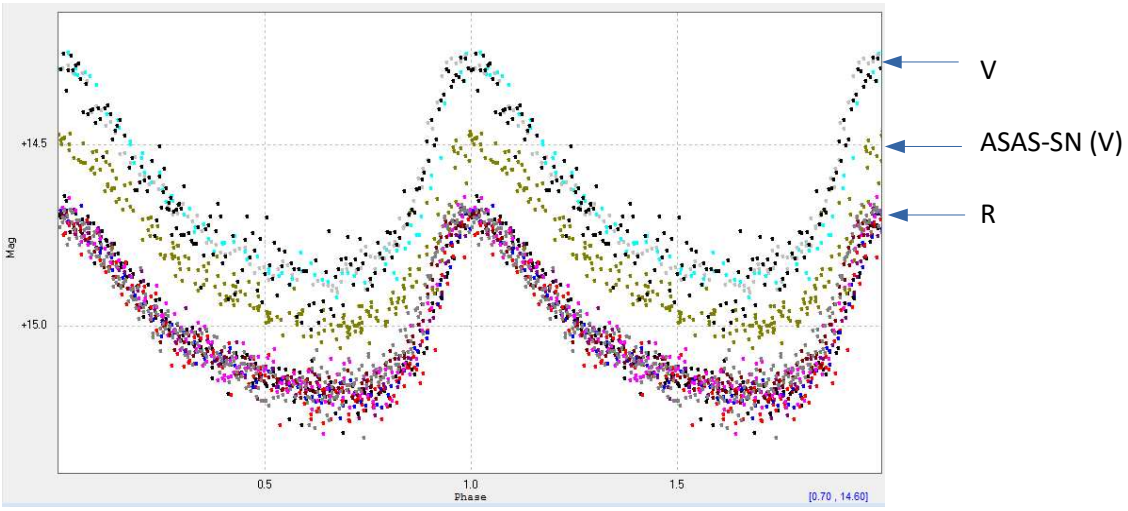


Figure 7: Phase diagram with ASAS-SN, R and V measures

The following figure (Figure 8) shows a V-R phase diagram, build with only V and R measures binned in 40 phase intervals. Interesting things can be raised from it.

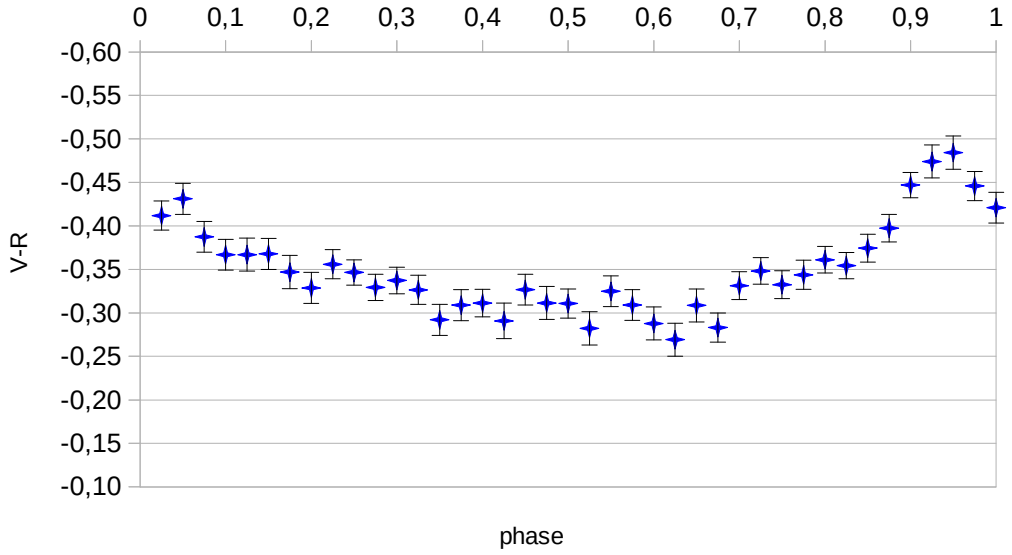


Figure 8: V-R diagram of phase

Diagram in Figure 8 shows a real small continuous variation of the V-R index, and therefore a variation of object surface temperature. The minimum of V-R is not exactly at the maximum of brightness but at phase 0.95. Conversely, the surface of the star is more "red" (colder) towards phase 0.5 and the minimum brightness is rather at phase 0.7. It would be interesting to have spectra at different phases to see how the radial velocity of the surface and therefore its diameter evolve during a period. But the latter is short and the necessary resolution would require the use of a large telescope.

4. AN EPHEMERIS

Further information is given by the Fourier analysis tool :

Freq. Cursor value (h) :	1.5864	+/-	0.0044
Freq. Cursor value (c/h) :	0.63036	+/-	0.00176
False Alarm Probability 1:	N/A	+/-	N/A
False Alarm Probability 2:	N/A	+/-	N/A
Number of obs :	1663		
Time span :	2688.3906	d	
Epoch :	2456598.0084	...	
Number of harmonics:	4		
Default MagError:	0.0001		

From period and epoch, we can provide an ephemeris for the star (used for Figure 7 and 8) :

$$2456598.0084 + 0.06610\ E$$

The period of 0.06610 day is slightly different from that given by AAVSO which was based on a smaller set of measurements.

The AAVSO recorded and classified this new variable with the High Amplitude Delta Scuti (HADS) type. However, the light curve shape and period allow to classify it as a High Amplitude Delta Scuti (HADS) or a SX Phe type, depending on it belongs to the galactic disk population or to the old spherical component of the Milky Way. The light curve alone does not allow to clarify its classification but an analysis of its position and proper motion may help by comparison with other HADS and SX Phe variable stars in the vicinity.

5. ACKNOWLEDGMENTS

Thanks to Sebastian Otero for the help provided during the first discussions with the AAVSO, thus allowing to go a little further than the simple sending of photometric data, to Jean-François Le Borgne for his wise advice on the treatment and the analysis of measurements and to Serge Kuchto for his English expertise.

This research has made use of the following facilities:

- VizieR catalogue access tool, CDS, Strasbourg, France (DOI: 10.26093/cds/vizier). Original description of the VizieR service was published in A&AS 143, 23. (http://vizier.u-strasbg.fr/viz-bin/VizieR)

- SIMBAD database, operated at CDS, Strasbourg, France (Wenger et al., 2000).

- "Aladin sky atlas" developed at CDS, Strasbourg Observatory, France (Bonnarel et al., 2000; Boch and Fernique, 2014)

- International Variable Star Index (VSX) database, operated at AAVSO, Cambridge, Massachusetts, USA.

6. REFERENCES

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