BAV Journal

2020 No. 34 ISSN 2366-6706

Bundesdeutsche Arbeitsgemeinschaft für Veränderliche Sterne e.V.

http://bav-astro.de

The new eclipsing binary UCAC3 221-061173, a system with eccentric orbit

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April 2020

Abstract: One *new variable star (UCAC3 221-061173) is presented, which was found in a search for new variable stars in the fields of several known variables. ASAS-SN has independently discovered the variability of this object, but incorrectly assigned it to a different star.*

Introduction

During the investigation of several known variable stars, one further variable was found in their surroundings, which is new to our knowledge (not included in AAVSO VSX and GCVS).

The new variable was discovered on images taken with a 102mm TeleVue-Refractor in the year 2014 by Peter Frank.

Further detailed observations were made using a 400mm ASA Astrograph (W. Moschner, Nerpio/ Spain) and the 102mm TeleVue-Refractor (P. Frank, Velden/Germany) in 2020 and earlier, which are discussed subsequently in detail:

Fr309 Gem = UCAC3 221-061173 = Gaia DR2 3372748761405563904

Observations

The discovery observations were carried out with a 102mm/f5.0 TeleVue-Refractor (Velden/Germany) and a SIGMA 1603 CCD-Camera containing a cooled Kodak KAF1603ME chip. Normally, the exposures were 90 s resp. 120 s through an IR & UV cut-off filter.

Further observations of the new variable were carried out between November 2016 and February 2020 with the discoverer telescope in Velden and with a robotic telescope 400 mm f/3.7 ASA Astrograph (Nerpio, Spain) equipped with a cooled FLI Proline 16803 CCD-Camera and partly a V-filter or an IR & UV cut-off filter. The exposure times were 120 seconds. The telescope was controlled from Lennestadt via internet.

Data analysis

Muniwin [1] and self-written programs by Franz Agerer and Lienhard Pagel were used for the analysis of the frames, after bias, dark and flatfield correction of the exposures. The weighted average of five comparison stars was used.
The period analysis was performed with Peranso (Anova) [2], and the magnitudes of the variable star (at maximum brightness) were obtained from the Gaia DR2 Catalog [4].
The elements which we present were first calculated with the method of Anova and then refined with the method of least squares, by taking all O-C values into account (see tables below). The given amplitudes are uncorrected instrumental values.

Explanations:

HJD = heliocentric UTC timings (JD) of the observed minima
mag = (raw instrumental) magnitude

G-band mean magnitude (Vega) = 350-1000 nm
Integrated BP mean magnitude (Vega) = 330- 680 nm
Integrated RP mean magnitude (Vega) = 640-1000 nm

Explanations to the light curve:
The colors of the symbols denote different nights.

All coordinates are taken from the Gaia DR2 catalogue [4].

The coordinates (epoch J2000) are computed by VizieR, and are not part of the original data from Gaia (note that the computed coordinates are computed from the positions and the proper motions).

Fr309 Gem

= UCAC3 221-061173
= Gaia DR2 3372748761405563904
= USNO-A2.0 1050-03859207

Right ascension: 06h34m20.9980s (J2000)
Declination: +20° 20' 17.247" (J2000)
Barycentric right ascension: 098.58748722464° (ICRS, Epoch 2015.5)
Barycentric declination: +20.33811606842° (ICRS, Epoch 2015.5)

Gaia DR2 Catalog:
14.0332 mag G-band mean magnitude (Vega)
14.3435 mag Integrated BP mean magnitude (Vega)
13.6973 mag Integrated RP mean magnitude (Vega)

C1 = UCAC3 221-060973 C2 = UCAC3 221-060966 C3 = UCAC3 221-061053
C4 = UCAC3 221-060746 C5 = UCAC3 221-061291 K1 = UCAC3 221-060783

Amplitude: Min I: 0.43 mag (instr.) Min II: 0.33 mag (instr.)
Type: EA type eclipsing binary

Min I = HJD 2458521.4617 + 2.7090888*E
±0.0011 ±0.0000033

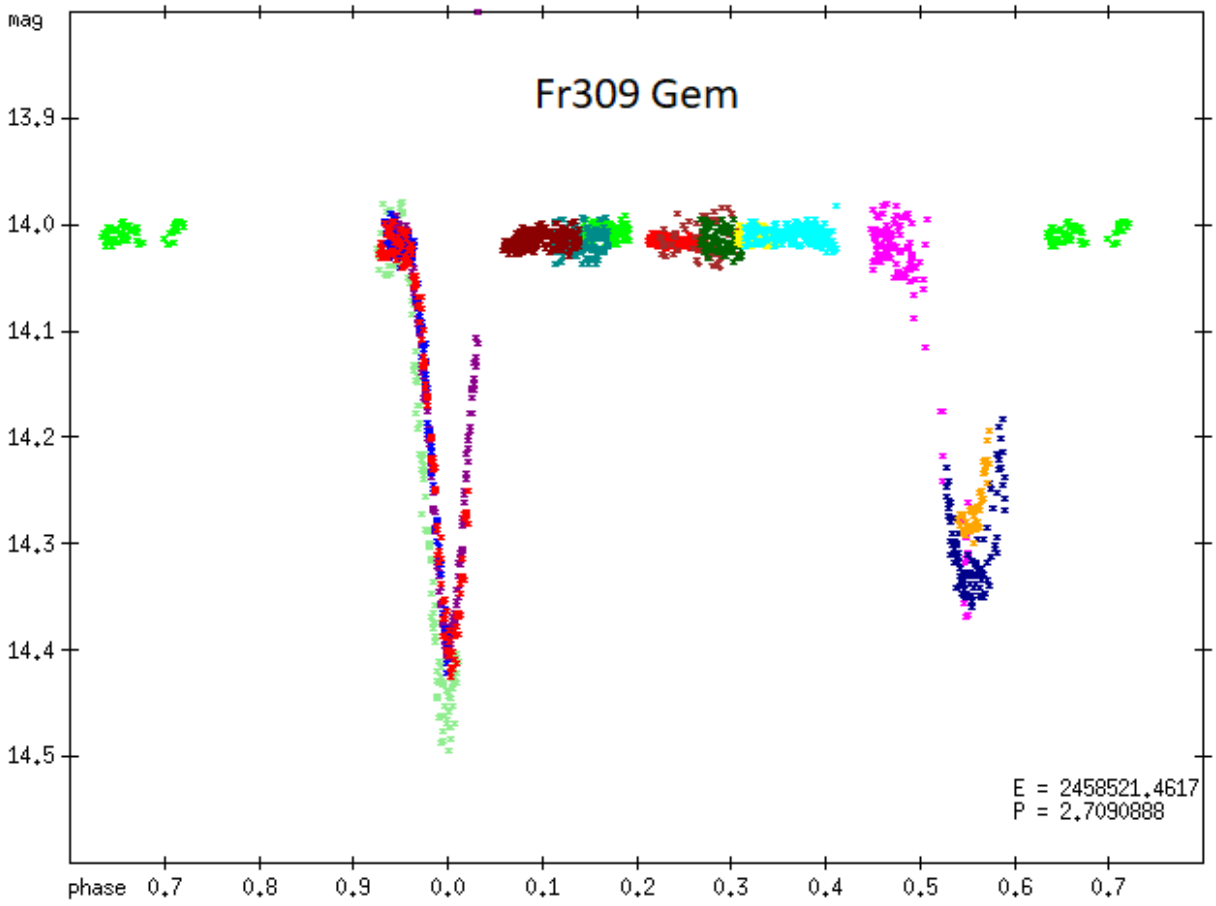

Fig 1: Phased light curve of Fr309 Gem = UCAC3 221-061173 using the ephemeris given by the authors. The vertical axis shows raw instrumental magnitudes. A FLI Proline 16803 + partly a V-filter or an IR & UV cut-off filter (2016-2020) was used. Presented elements were calculated by taking into account all minima (see tables below) with the method of least squares.

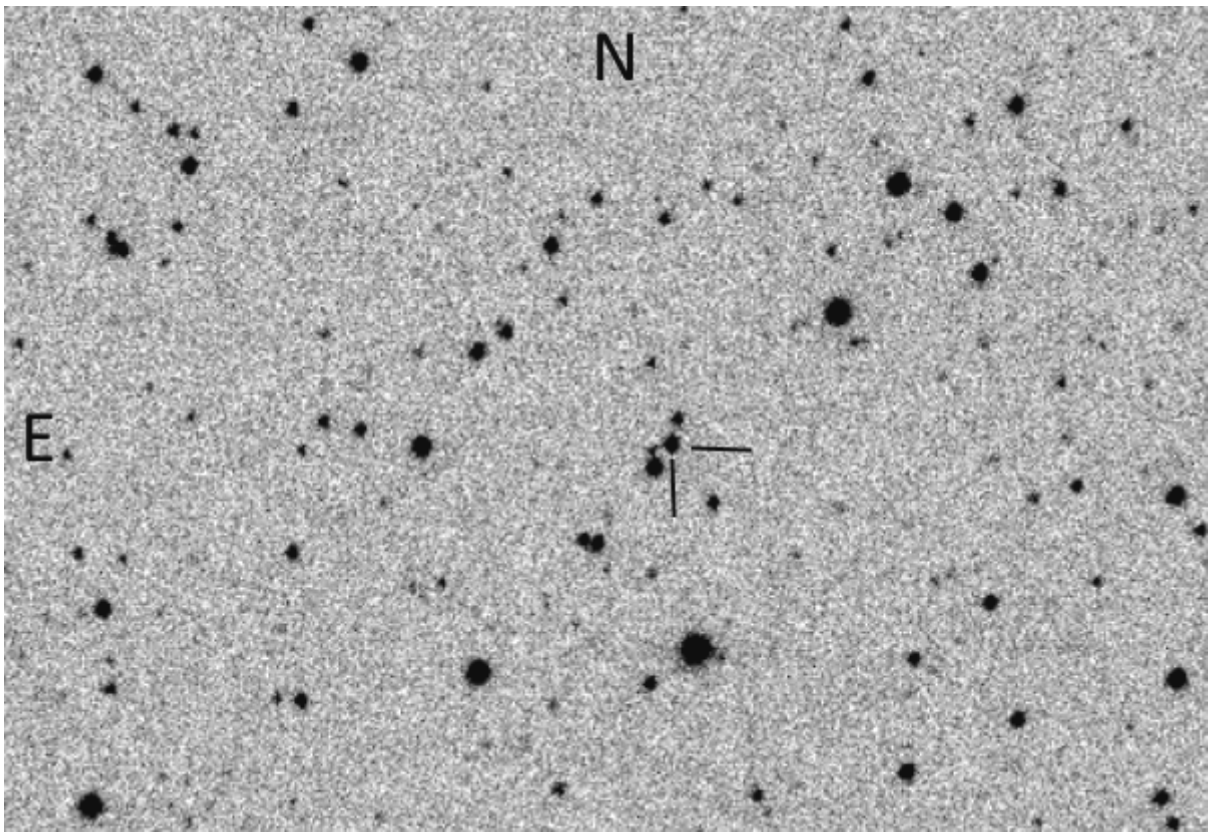

Fig 2: Fr309 Gem = UCAC3 221-061173 in the field of KM Gem; image size: 10.0' x 6.8'.
Image from ASA Astrograph 400 mm f/3.7

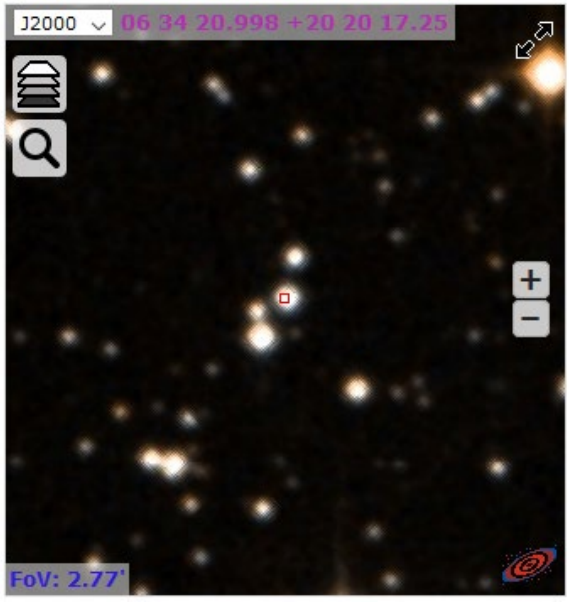

Fig. 3a:
Fr309 Gem = UCAC3 221-061173
Gaia DR2 3372748761405563904
Image from VIZIER

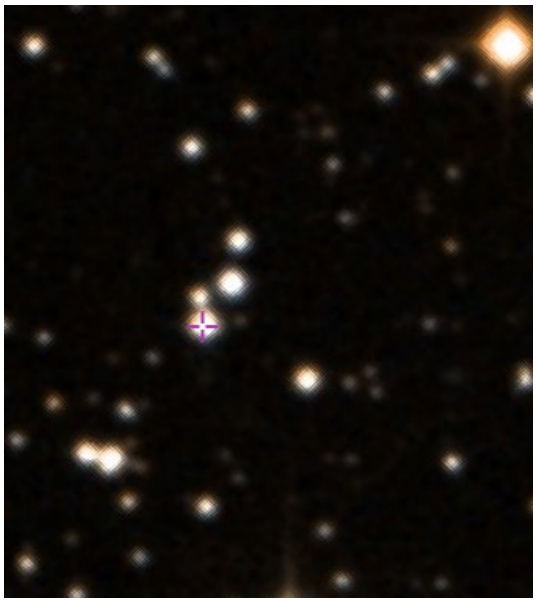

Fig. 3b:
ASASSN-V J063421.55+202005.2
Star marked at ASAS-SN
Gaia DR2 3372748757108360448
Image from VIZIER

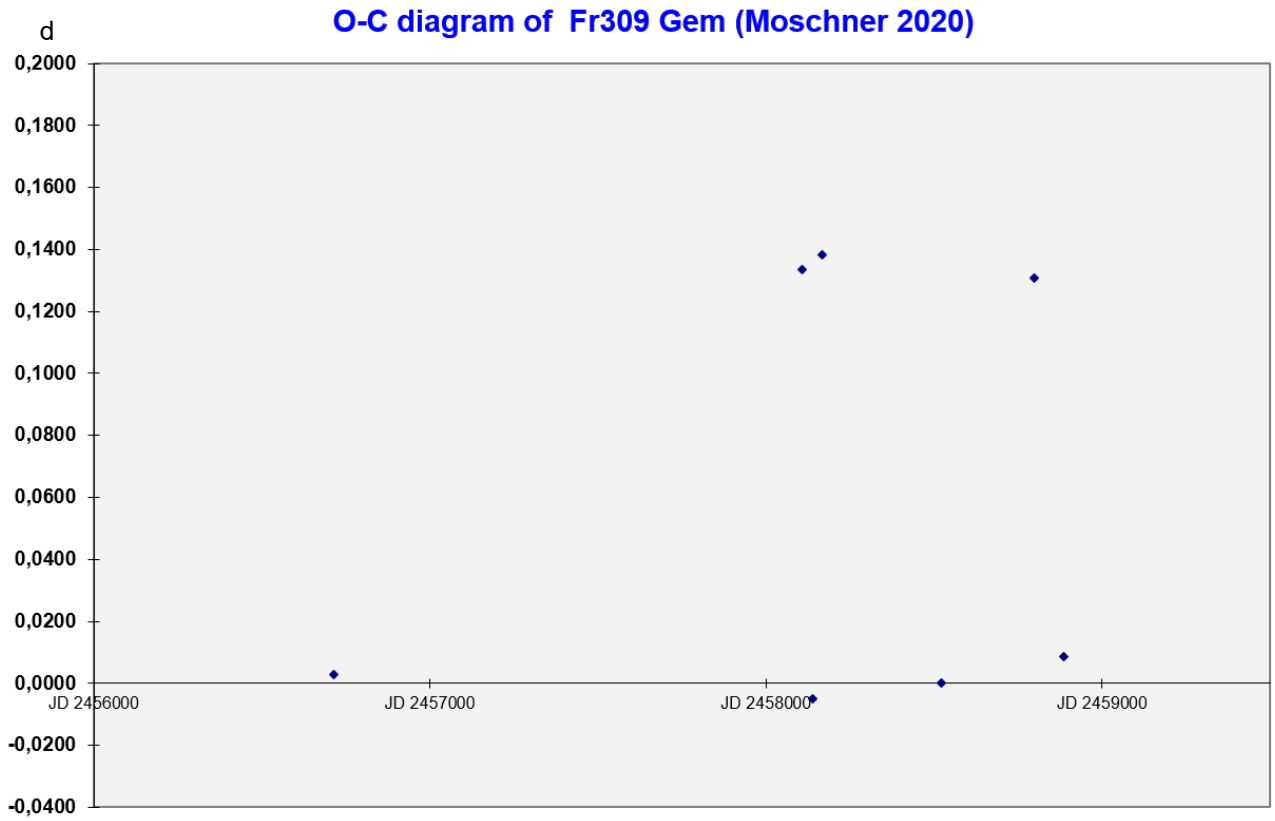

Fig 4: O-C-diagram for Fr309 Gem = UCAC3 221-061173 using the ephemeris given by the authors.

Table 1: Fr309 Gem = UCAC3 221-061173. O-C using the ephemeris given by the authors.

Observer	HJD-Date Minimum	Type	Epoch	O-C (d)	Source
P. Frank	2456714,5023	I	-667	0,0028	
W. Moschner	2458105,7500	II	-153,5	0,1334	
W. Moschner	2458139,4753	I	-141	-0,0049	
W. Moschner	2458165,3548	II	-131,5	0,1382	
W. Moschner	2458521,4617	I	0	0,0000	
W. Moschner	2458796,5650	II	101,5	0,1307	
W. Moschner	2458884,4882	I	134	0,0086	

Remarks:
In the phased light curve (Fig. 1) of Fr309 Gem, the secondary eclipse occurs at phase (approximately) 0.55 instead of 0.5 for a system with a non-eccentric orbit. In other words, the two stars do not have circular orbits about the centre of mass of the system, but instead have elliptical eccentric orbits.

For the phased light curve partly a V-filter or an IR & UV cut-off filter (2016-2020) was used. The difference in brightness was compensated for manually and the reference point was always the maximum light of the variable with the IR & UV cut-off filter. This was not possible for the part of the light curve including the secondary minimum, so that the depth of the minimum is associated with a small degree of uncertainty.

In the O-C diagram of Fr309 Gem (Fig. 4) the eccentric position of the secondary minima is clearly evident. All three secondary minima were either recorded in bad weather conditions or are incomplete. In the cases of incomplete coverage the times of the secondary minima were estimated. All three secondary minima together clearly prove the eccentric position at phase 0.55.

The Variable Stars Database of the ASAS-SN project [3] lists an EA star with a very similar period and brightness close to the coordinates of Fr309 Gem:

ASASSN-V J063421.55+202005.2 (98.58981, 20.33478)
Gaia DR2 3372748757108360192
Period: 2.70897 d
Amplitude: 0.09 mag

The ASAS-SN position refers to a nearby star of similar brightness with the identification of Gaia DR2 3372748757108360448. We suspect that both stars were located in the ASAS-SN measuring aperture and that the variable star is in fact Gaia DR2 3372748761405563904 = Fr309 Gem. The object Gaia DR2 3372748757108360192 listed in the ASAS-SN Variable Star Catalogue does not exist.

The above mentioned issue explains why the amplitude given in the ASAS-SN catalogue (0.09 mag) is too small and why the star is registered too bright with an apparent magnitude of 13.42 mag (G). By entering the coordinates of Fr309 Gem in the VSX database of AAVSO, an EA star can be obtained at a distance of 0.24 '. A Gaia DR2 ID was not specified. The ASAS-SN position differs by 0.24' from the actual position of the variable star.

In summary, the relatively short focal length of the ASAS-SN telescopes can lead to misidentifications in star-rich areas such as the Milky Way. These cases can be solved with larger telescopes and longer focal lengths.

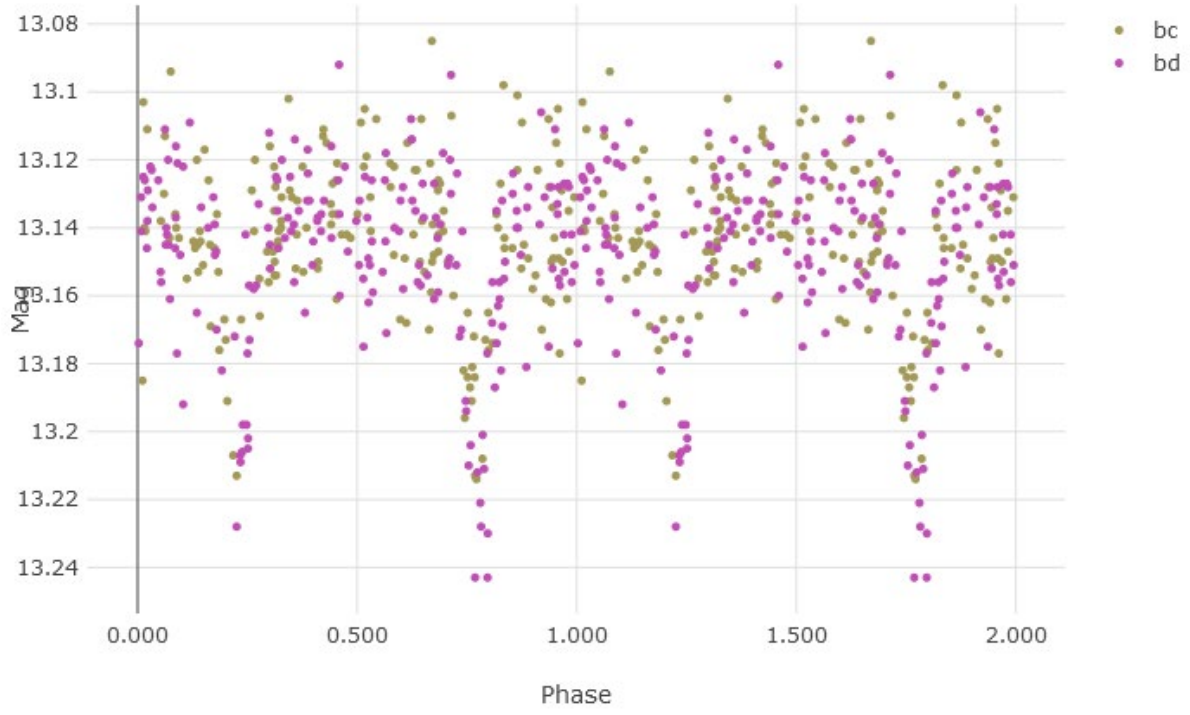

Fig. 5: phased light curve of ASASSN-V J063421.55+202005.2 using the ephemeris:
Min I = HJD 2458159.93552 + 2.70897*E (Source ASAS-SN Variable Stars Database)

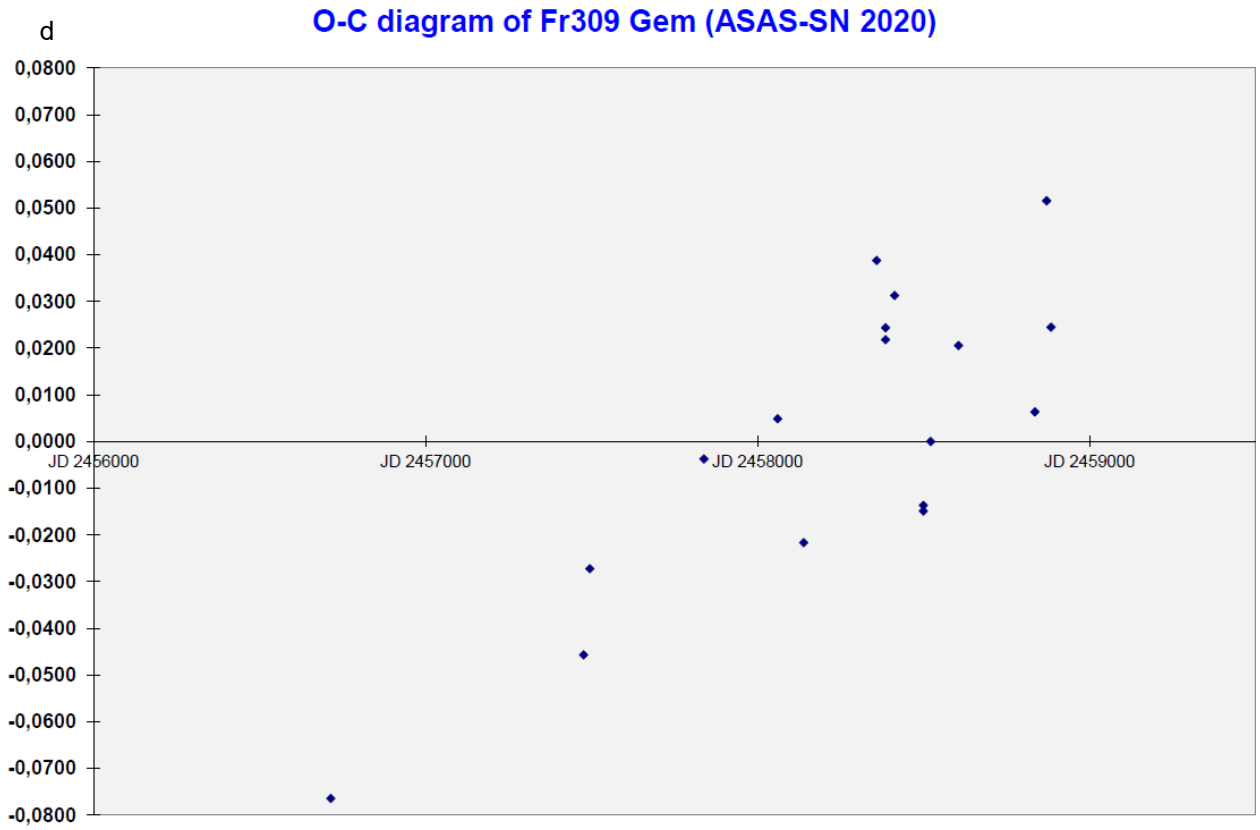

Fig. 6: O-C-diagram from Fr309 Gem = UCAC3 221-061173 using the ASAS-SN ephemeris:

Min I = HJD 2458159.93552 + 2.70897*E

In this O-C diagram, 13 times of minimum brightness from ASAS-SN data were inserted.
Only the Min I are shown here.

Acknowledgements

This research has made use of the SIMBAD database, operated at CDS, Strasbourg, France, the International Variable Star Index (VSX) database, operated at AAVSO, Cambridge, Massachusetts, USA and the ASAS All Star Catalogue operated by the Ohio State University.

The authors thank David Motl for providing his MuniWin photometry program, Franz Agerer (BAV) and Lienhard Pagel (BAV) for providing their personal data analysis programs.

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